Perception and Action in Complex Environments

First PACE Thematic Workshop
"Making a sense of a rich world: multimodal integration in complex environments"

Marseille
26-29 January 2016

This thematic workshop is organized in the framework of the project PACE (Perception and Action in Complex Environments), an Innovative Training Network funded by the Marie Skłodowska-Curie program of the European Union. The PACE network gathers a broad range of expertise from experimental psychology, cognitive neurosciences, brain imaging, technology and clinical sciences.

int institut de neurosciences de la timone

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The PACE Project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642961

PERCEPTION AND ACTION IN COMPLEX ENVIRONMENTS

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Event concept

The issue of how humans form coherent, valid, and robust percept by processing sensory stimuli (delayed and corrupted by noise) from various modalities is a central question in cognitive science, behavioural science, and neuroscience. The goal of this workshop will be to provide insights on how this challenging problem is solved by the brain. Speakers that will attend this workshop will present various approaches to address the issue of multi-sensory integration (MSI), and multi-modal integration, not only for perception but also for action.

The first session **Theoretical approaches for MSI** will focus on identifying the key problems inherent to MSI, and present the main approaches currently employed to address those problems.

Examples on how multiple sources of information, sometimes redundant, sometimes conflicting, are flexibly combined to allow coherent percept of the body and/or the environment will be discussed in the second session, **MSI for perception**.

A **keynote speech** by Dora Angelaki will close the first day of the training.

The third session **MSI for action** will address the issue of how accurate movements can be achieved despite noise and delays in sensory information.

Finally, the session **MSI across the lifespan** will focus on changes and/or deficits in children, elderly and patients.

This session will be followed by a **visit of INT** institute and labs.

An informal **poster session** at the end of the second day will offer to the ESRs the opportunity to present their research project, which of course will still be at an early stage, and to discuss opportunities for secondments with PACE PIs.

During first **hands-on** sessions, essential **Psychophysical methods** will be discussed and the students will be introduced to the widely used open source statistical **software R**.

During the second hands-on session, the associated partner BKIN will provide a 1/2-day training on the programming of the **KINARM Exoskeleton Lab** (2 KINARM Exoskeleton robots for the upper limbs coupled with 2D virtual/augmented reality display) produced by BKIN to manipulate proprioceptive and visual sensory inputs.

A **PACE internal meeting** will close the workshop, allowing network members and ESRs to debrief and plan future steps of the project.

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Sessions on 27-28 January will take place at INT - Salle Henri Gastaut, floor -1

Day 1 – Wednesday 27 January 2016	
10:00	**Theoretical approaches for MSI – part I** • Alexandre Pouget (University of Geneva) *Neural basis of multisensory integration.* • Pascal Mamassian, CNRS Director of Research, Head of CNRS LSP Unit *Bayesians inference, noise and correlation*
11:30	*Coffee break*
12:00	**Theoretical approaches for MSI – part II** • Robert J Van Beers, PhD, MOVE Research Institute Amsterdam, VU University Amsterdam *Roles of cue precision and cue accuracy in multisensory integration* • Guillaume Masson, INT - CNRS *Fixational saccades and visual scenes: noise or sensory information ?*
13:30	*Lunch break*
15:00	**MSI for perception** • Marc Ernst, Research Group Leader, Max Planck Institute *Getting in Touch with Multisensory Integration* • Manuel Vidal, Researcher, CNRS-INT *When did I hear that flash? Timing audiovisual events: from perception to (re)action* • Jeroen Smeets, VU University Amsterdam *The inconsistencies that arise from sensory integration.*
17:15	*Coffee break*
17:45 **18:45**	**Keynote lecture** • Dora Angelaki, Chairman/Professor, Department of Neuroscience, Baylor College of Medicine *Visuo-vestibular integration for self-motion perception*
19:00	*End of first day*

Day 2 – Thursday 28 January 2016	
9:30	**MSI for action – part I** • Sam Sober, Assistant Professor, Department of Biology, Emory University *Flexible strategies for sensory integration during motor planning* • Andrew Welchman, Wellcome Trust Senior Research Fellow, Cambridge University *Seeing depth: computations and cortical networks*
11:00	*Coffee break*
11:30	**MSI for action – part II**

	• Joan López-Moliner, Institute of Neurosciences, University of Barcelona *Temporal error signals in interception* • Anna Montagnini, CNRS-INT *Dynamic integration of different sources of motion information for eye-tracking.*
13:00	*Lunch break*
14:30	**MSI across life span – part I** • Opher Donchin, Senior Lecturer, Ben Gurion University of the Negev *The cerebellar role in correcting reach errors: hierarchical processing or multi-sensory integration* • Monica Gori, Researcher, Italian Institute of Technology *The development of multi-sensory integration in children*
16:00	*Coffee break*
16:30	**MSI across life span – part II** • Meir Plotnik, PhD Sheba Medical Centre *Multisensory integration for Gait coordination* • Petra Siemonsma, Medior Research Scientist, Netherlands Organisation for Applied Scientific Research (TNO) *Multisensory integration and aging*

Hands-on-session open to PACE network members and PhD Program students (limited places)

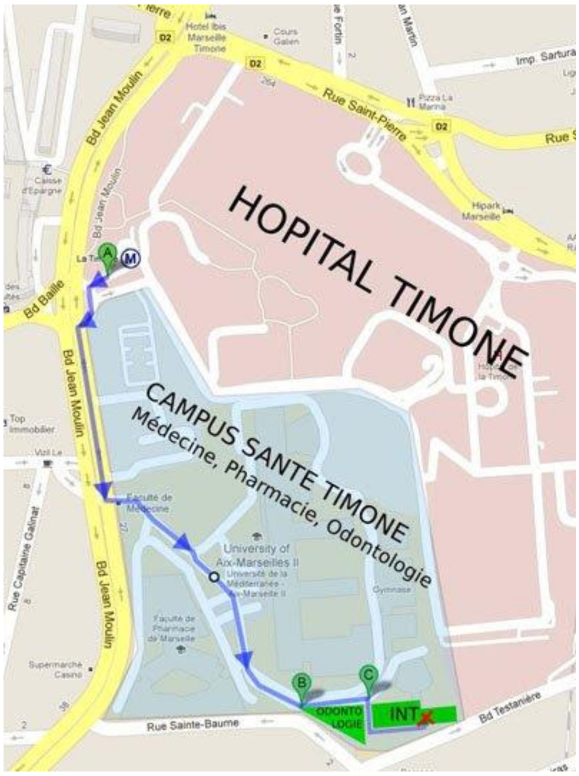
Day 3 – Friday 29 January 2016	
9:00 **R+1**	**Hands-on: Psychophysics and R introductory course – part I** Gabriel Baud-Bovy, Team Leader, Italian Institute of Technology *Psychophysical methods : methods to compute sensory thresholds and to build psychophysical scales and statistical computing using R (open source software)*
10:30	*Coffee break*
11:00 **R+1**	**Hands-on: Psychophysics and R introductory course – part II** Gabriel Baud-Bovy, Team Leader, Italian Institute of Technology
12:30	*Lunch break*
14:00 **R+1**	**Hands-on: Technical skills** Video conference with Duncan McLean, Senior Software Developer, BKIN Technologies Ltd. *Harnessing the power of KINARM Labs for conducting experiments in Multi-Sensory Integration: An introduction to programming custom tasks for KINARM Labs*
16:00	*Coffee break*
16:30 **R+1**	**PACE partners meeting** *(PACE network only)*
19:00	*End of TW1*

PERCEPTION AND ACTION IN COMPLEX ENVIRONMENTS

<u>Where</u>

Institut de Neurosciences de la Timone
Faculté de Médecine
27, boulevard Jean Moulin
13005 Marseille – France

At the entrance door, either ring one of us using the intercom of using our mobile number.



<u>How to reach us</u>

From the airport to Saint Charles railway station

Take the bus shuttle to Saint-Charles Railway Station. Departure is every 15 minutes from Terminal MP1 and it takes 25 minutes to reach the station. Return ticket: 13.10 EUR

Schedule: www.navettemarseilleaeroport.com

From the Saint Charles railway station or the Old Port

Subway Line 1 (blue)

Direction "La Fourragère"

Stop "La Timone"

Exit "Hopital de la Timone"

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Neural Basis of Multisensory Integration

Alexandre Pouget, University of Geneva

Behavioral experiments have established that humans, primates and rodents can perform near optimal multisensory integration. I will present experimental evidence that insect larvae are also capable of a similar feat and I'll propose a theory of optimal multisensory integration by single neurons based on a particular type of code known as probabilistic population code. This theory predicts that neurons should combine their inputs linearly with specific weights that depend on the reliability of each cue, a prediction consistent with the response of multisensory neurons in area MSTd.

Bayesians inference, noise and correlation

Pascal Mamassian, CNRS and Ecole Normale Supérieure, Paris

The integration of multiple senses is nowadays well conceived within a probabilistic framework (Ernst & Banks, 2002). Within this framework, the uncertainty of each sensory signal determines the strength with which a sense will interact with others. In this presentation, I will focus on two issues: how do uncertainties affect the processing time of each sense and their interaction, and to what extent can we estimate our performance within and across modalities? The answer to the first question relies on an accumulation of evidence model where correlation between sensory modalities and multisensory decision noise have to be taken into account. The answer to the second question relies on a confidence force-choice paradigm.

Roles of cue precision and cue accuracy in multisensory integration

Robert J. van Beers, Vrije Universiteit Amsterdam

According to the traditional model, multisensory integration of redundant information amounts to determining a weighted average, where each cue's estimate is weighted by its precision (the inverse of the variance). This suggests that the accuracy of each cue (its bias) is irrelevant for determining the cue weights. However, when we interact with the environment, cue accuracies are relevant because biases in our estimates can lead to motor errors, such as missing an object we want to grasp. This raises the question how our brain responds if it detects that a multisensory estimate is biased. There are at least two possibilities: individual cues can be recalibrated to remove or reduce biases, or the cue weights can be changed, suggesting that they are no longer determined by the cue precisions only. Evidence has been reported for both possibilities. In this presentation, I will summarize the results of studies that dealt with this issue, and identify the key issues that we do and those that we do not yet understand about this aspect of multisensory integration.

Fixational saccades and visual scenes: noise or sensory information ?

Guillaume Masson, CNRS-INT

Guillaume Masson, Andrew Meso, Claudio Simoncini, Julie Quinet, Laurent Goffart & Anna Montagnini, Institut de Neurosciences de la Timone, CNRS & Aix-Marseille Université

During free viewing of natural scenes, our eyes exhibit a continuous combination of large and small exploratory movements. The traditional view is that large saccades shift the line of sight from one particular feature to the next while miniature eye movements stochastically interrupt visual fixation. However, recent neurophysiological studies have proposed instead that small and large saccades correspond to different instances of a continuum of foveating saccades. I will present a series of experiments conducted in human and monkeys investigating how the pattern of fixational saccades is modulated by the statistical properties of the visual scene. Using naturalistic textures, we first investigated the impact of their mean spatial frequency and spatial frequency bandwidth. In both humans and monkeys, the fixation pattern change with these statistics. At low spatial frequency and small bandwidth, saccades were larger and biased in direction. At high spatial frequency, they were smaller and isotropic in direction. The directions of microsaccades were driven by the most salient textons. A single saliency map extracting information at multiple spatial scales determines both the

fixation stability and local exploration of the visual scene. We further investigate this behavior using random dot patterns with, or without symmetry axes. In humans, we observed that the pattern of fixation was biased along the symmetry axes, regardless the perceptual performance of the participant when discriminating the orientation of the axis. Both microsaccade direction and end-points were strongly oriented along the axis of symmetry. These results support the view that fixation behavior is a stochastic process that can be biased by the salient features of the visual scene.

Seeing depth: computations and cortical networks

Andrew Welchman, Wellcome Trust Senior Research Fellow, Cambridge University

Human perception is remarkably flexible: we experience vivid 3-D structure under diverse conditions from the seemingly random dots of a 'magic eye' stereogram to the aesthetically beautiful, but obviously flat, canvasses of the Old Masters. How does the brain achieve this apparently effortless robustness? Using modern brain imaging methods we are beginning to unpick how different parts of the visual cortex support 3-D perception, tracing different computations in the dorsal and ventral pathways. In this talk I will describe work that combines behaviour, fMRI, TMS and computational analysis. By integrating these methods, we are beginning to glimpse the network of brain activity that supports this remarkable ability.

Getting in Touch with Multisensory Integration

Marc Ernst, Research Group Leader, Max Planck Institute

Vision is by far the best studied sensory modality. Compared to this, our knowledge about the sense of touch is very limited. On the one hand, this is due to the complexity involved in generating stimuli for the sense of touch in a controlled and largely automatic fashion. That is, for rendering better haptic stimuli, we would need a significant advance in haptic display technology. On the other hand, this is due to the complexity integral to the sense of touch. E.g., the sense of touch is inherently multisensory, and for a coherent representation of the external world the brain has to constantly combine tactile information with proprioceptive and kinesthetic information. Further, the sense of touch not only receives information about the world passively, but gathers information actively. And finally, compared to the eye, the primary organ of the human sense of touch–the hand–has many more degrees of freedom (28 for each hand compared to 3 for the eye). Despite these challenges, the human brain has to continuously integrate and perceptually organize the incoming information in order to form a robust and stable representation of the external world with which we interact. In this talk I will briefly review some of our recent studies on the integration of information in the sense of touch. Furthermore, I will draw analogies in the processing of information between vision and touch, and demonstrate that many of the illusions well known in vision caused by eye movements have an analog in touch when we actively explore and scan objects with our hands. These results demonstrate the existence of common mechanisms in visual and haptic motion perception and for achieving spatial constancy. I will end my talk by outlining some of our recent findings of exploiting the redundancy of the motor system during manual interactions.

When did I hear that flash?
Timing audiovisual events: from perception to (re)action

Manuel Vidal, CNRS INT

When processing audiovisual events, unimodal signals are transmitted and processed at different speeds, reaching the brain areas for sensory integration at different moments. In order to perceive synchronicity, these signals must be realigned in time. I will describe two recent projects related to this temporal integration flexibility, going from perception to motor control. In the first project I manipulated the audiovisual offset between events to quantify reciprocal sensory attractions in the temporal dimension. Flashes were perceptually shifted toward beeps in an asymmetrical fashion, revealing a stronger attraction of visual events by future auditory events than past. Conversely, beeps were never shifted in time by flashes. Although audition dominates for timing, when breaking the modality appropriateness vision can take over as well, showing that the natural preference is not hardwired. In the second project we explored how irrelevant signals near target onset modulate motor reaction time. Subjects had to perform quick saccades towards targets appearing left/right with short beeps delivered centrally (SOA from –240ms to +240ms). Synchronous beeps speeded-up saccades suggesting an increased alertness. Early beeps reduced further latencies while late beeps increased them, compatible with the audiovisual interactions found earlier. Replacing the beeps with short background luminosity decreases resulted in slower saccades just before and after visual synchrony much as in forward and backward masking. The absence of modulation with this visual signal shows that the initial effect was not related to priming but rather to low-level audiovisual integration. Replacing ocular with manual responses (left/right press) resulted in a regular increase of reaction times reaching the *no beep* baseline for an SOA of +240ms. The modulation observed with this slower motor system (350ms) was compatible with the much faster saccades (150ms). In conclusion, sounds falling within the temporal binding window of visual events modulate motor reactivity (ocular or manual), even if non-informative about the target direction or timing.

Perception and Action in Complex Environments

Multisensory benefits in self-motion perception

Dora Angelaki , Chairman/Professor, Department of Neuroscience, Baylor College of Medicine

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

Flexible strategies for sensory integration during motor planning

Samuel Sober PhD, Emory University, Atlanta

When planning goal-directed reaches, subjects must estimate the position of the arm by integrating visual and proprioceptive signals from the sensory periphery. These integrated position estimates are required at two stages of motor planning: first to determine the desired movement vector, and second to transform the movement vector into a joint-based motor command. We quantified the contributions of each sensory modality to the position estimate formed at each planning stage using a virtual reality environment to dissociate visual and proprioceptive feedback and computational models to determine the relative weighting of sensory input at each planning stage. We found that the two arm position estimates rely on different combinations of visual and proprioceptive input, suggesting that the brain weights sensory inputs differently depending on the computation being performed. We further showed that the relative weighting of vision and proprioception at each planning stage depends both on the sensory modality of the target and on the information content of the visual feedback, and that these factors affect the two stages of planning independently. The observed diversity of weightings demonstrates the flexibility of sensory integration and suggests a unifying principle by which the brain chooses sensory inputs so as to minimize errors arising from the transformation of sensory signals between coordinate frames.

The inconsistencies that arise from sensory integration

Jeroen Smeets, VU University Amsterdam

Our senses provide incomplete and noisy information about the world orotund us. On the other hand, the information is redundant. One might think that what we perceive is the situation that best matches this noisy information, given our knowledge about the world. In other words, perception is the unconscious inference about the situation that most likely caused the sensory state. This approach is frequently very successful, and can explain why our perception is in some situations inconsistent with the outside world. This approach, however, cannot explain that in some situations, perception is inconsistent with itself. I will provide an account for this inconsistency, based on the notion that perception is about giving answers to questions about the world, rather than building a representation of it. This view on perception is discussed with examples like the perisaccadic mislocalisation of flashes and the effect of visual illusions influence on saccades and hand movements.

Temporal error signals in interception

Joan López-Moliner, Institute of Neurosciences, University of Barcelona

When we repeatedly hit a moving target, we can make adjustments based on prior errors (e.g. start moving later if we were early previously). First I will present the two temporal error signals that are, at least, available: a temporal error related to the target speed and a second error signal that is related to the speed of the hand movement (motor error). I will show evidence that the motor-related temporal error is used to make temporal adjustments on the next trial. Second, I will try to answer the question about which fraction of the observed temporal error is used to program the adjustment on the next trial. Because different types of random noise (e.g. in the movement initiation and motor execution) contribute to the temporal error, the internal programming of next movement's adjustment should discount part of the error. To answer this question Kalman filters (KF) were fitted to the time series based on the the time of action initiation (TAI). The previous temporal error served as control input whose coefficient provides an estimate of the fraction of the observed error that is effectively used to determine the new internal adjustment. On average, this fraction was about 0.14: the internal adjustments of the TAI accounted for the 14% of the total temporal error in the previous trial. Finally we simulated the internal adjustments as corresponding variations in the initial state of a diffusion process and the arrival times as the TAI. Variations between 12 and 16% in the initial state led to adjustments in TAI that corresponded to near full corrections of the temporal error as observed in the experiment. The internal timing of timed actions seems then tuned to propagated motor noise.

Dynamic motion integration for tracking eye movements

Anna Montagnini, CNRS-INT

The accurate smooth visual tracking of a moving object is a human remarkable skill that allows us to reduce the relative slip and instability of the object's image on the retina, thus granting a stable, high-quality vision. In order to optimize tracking performance across time, a quick estimate of the object's global motion properties needs to be fed to the oculomotor system and dynamically updated. Together with the unavoidable sensorimotor delays, the main limiting factor for accurate and timely visual tracking is the uncertainty in the sensory input, such as under variable conditions of motion properties or visibility, as well as in presence of intrinsically ambiguous retinal information. Concurrently, tracking performance can be greatly improved by taking into account extra-retinal, predictive information.

I will present past and ongoing work of our team, including some experimental paradigms whereby the presence of visual motion uncertainty required the dynamic integration of visual and predictive information for accurate smooth tracking. Human behavioral data are modeled within the framework of dynamic probabilistic inference, which seems to provide a comprehensive theoretical ground across different contextual conditions and time-scales.

The cerebellar role in correcting reach errors: hierarchical processing or multi-sensory integration

Opher Donchin, Senior Lecturer, Ben Gurion University of the Negev

When we consider sensori-motor integration, we must do so within the context of a specific model of sensori-motor control. The model that is driving most current research assigns specific roles to different areas of the brain --- sensori-motor integration, for instance, is still largely considered a function fo the parietal cortex. However, there are aspects of this model that are simply inconsistent with how we know the brain is wired. Using evidence from our own research on subjects with cerebellar degeneration, I will highlight the idea that the cerebellum, and the basal ganglia, do not serve one specific role motor function, but rather serve multiple roles as befits their connections to multiple levels of the cortical hierarchy. This will, in turn, raise the question of whether there is a single locus of sensori-motor integration or, perhaps, multiple parallel mechanisms. I will end by pointing out the relevance of this research to the process of aging.

The development of multi-sensory integration in children

Monica Gori, Researcher, Italian Institute of Technology

During the first years of life, sensory modalities communicate with each other and the absence of one sensory input impacts on the development of other modalities [1, 4]. Our researches have highlighted that blind persons have problems in understanding the relation between sounds presented in space [7] and tactile information about object orientation [8]. This result came from a prediction of our cross-sensory calibration theory [1, 4] developed since 2008. This theory emerged from the observation that children start to integrate multisensory information (such as vision and touch) only after 8-10 years of age [9]. Before this age, sensory modalities communicate and the more robust sense teaches (calibrates) the others. In the absence of the calibrating modality, the other modalities result impaired as well. Thus, children with visual disability have problems in understanding the haptic or auditory perception of space [7, 8], children with motor disabilities have problems in understanding the visual dimension of objects [10], deaf children have problems in understanding visual-auditory time perception and adults with Parkinson disease have problems in understanding curvature trough haptic perception [7, 11]. It is interesting to note that children with acquired disability before three years of age do not show any impairment [10], suggesting this calibration occurs in the first period of life. For this reason early rehabilitative technological solutions are of the utmost importance. To date the technology available [e.g. 12] is not suitable for young children with sensory motor impairments such as visual disability. Early-onset of blindness adversely affects psychomotor, social and emotional development [14]. In 2002 children below 15 years of age with visual impairment worldwide were about 1.4 million [13]. On the basis of our research, we developed a new set of rehabilitative devices for very young visual disabled children. In the talk I'll present our scientific studies and the ABBI device (Audio Bracelet for Blind Interaction; abbiproject.eu): a new rehabilitative solution to improve spatial, mobility and social skills in visually impaired children.

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Multisensory integration for Gait coordination

Meir Plotnik, PhD Center of Advanced Technologies in Rehabilitation, Sheba Medical Center, Dept. Physiology and Pharmacology & Sagol School for Neuroscience, Tel Aviv University

Gait coordination in the animal kingdom and among humans requires activation of multiple muscles in harmony to create rhythmic locomotion. Apart of moving the organism from place to place, the motor system has to maintain postural stability while gaiting, i.e., avoiding falls and maintaining stable propagation of the center of mass (COM), a task which is rather complicated in humans who have only bipedal defined base of support, which is relatively distant from the COM.

In my talk I will introduce basic mechanisms of human locomotion and discuss the known contributions of sensory input to postural stability. Then I will survey two recent studies that exemplify how sensory input can be integrated into gait control and affect significantly gait features. The role of the visual system will be presented by showing the results from a pilot study that was carried with the participation of young adults (n=11) who were tested in virtual reality (VR) facility. Uphill/downhill walking simulation was created when the VR facility platform was pitched up or down along with synchronous elevation of a projected road scenery. After walking straight and level (15 s), the condition either did not change or changed in synchronized visual-platform manipulation; or conflicting visual-platform conditions. We found that conflicting visual flow related to path inclination can modulate gait speed, even when no change in actual inclination occurs.

I will also describe how enhancing the sensory role in gait coordination can be used for the rehabilitation of impaired gait. Adequate neural plasticity, which is achieved by motor learning procedures, is a key to successful rehabilitation. Subjects with Parkinson's disease (n=15) who suffer from the freezing of gait (FOG) symptom were trained during multi session (i.e., 18 sessions) training program to pace and coordinate their gait with the assistance of rhythmic auditory stimulation, appearing only when exposed to a FOG provoking situation. Objective measures (i.e., FOG episodes duration and frequency) showed that the FOG burden was significantly reduced after this motor learning based treatment. The talk will end with raising points for discussion regarding the use of advanced technologies to better employ sensory integration for improving impaired gait.

Multisensory integration and aging

Petra Siemonsma, Medior Research Scientist, Netherlands Organisation for Applied Scientific Research (TNO)

In this interactive presentation concepts aging and their underpinnings are reviewed. These concepts of aging shape our view of the problem and also give focus for our solutions. Solutions such as treatment, therapy or preventive activities. In turn, knowledge of the problem and possible solutions will help us to develop appropriate diagnostic tools and measures for evaluation. Aim of the interactive presentation is to develop a shared understanding of aging, of its impact on a relatively healthy population of older adults, and on possible way of detecting early signs of aging.

PERCEPTION AND ACTION IN COMPLEX ENVIRONMENTS

Psychophysical methods
Methods to compute sensory thresholds and to build psychophysical scales and statistical computing using R (open source software)

Gabriel Baud-Bovy, Team Leader, Italian Institute of Technology

In the first part of the session, we will do a quick overview of R language, and capabilities to do reproducible research, graphics and basic statistics (ANOVA and regression). In the second part we will analyze the results of a psychophysical experiment with R. Additional material will be provided before the session and during the workshop.

Harnessing the power of KINARM Labs for conducting experiments in Multi-Sensory Integration:
An introduction to programming custom tasks for KINARM Labs

Duncan McLean, Senior Software Developer, BKIN Technologies Ltd.

During this session, Duncan McLean, Senior Developer at BKIN Technologies will provide a condensed version of the training provided to new KINARM users. He will provide an overview of BKIN's platforms and examples of the types of experimental paradigms that you can create with a KINARM Lab. He will give a brief overview on how to use Dexterit-E, the software that controls KINARM Labs including subject management, running and modifying task protocols and exporting data. As time allows, he will touch on the basics of Custom Task Programming in MathWorks Simulink® and Stateflow®.

Several of the custom tasks referenced during the presentation will be available for participants to experience in the KINARM Exoskeleton Lab at INT.

Materials:

- PDF of handouts from presentation
- Custom Tasks available on KINARM Lab (Malfait/Danion Lab)