The HealthPAC project received its funding from the EU 7th Framework Programme Marie-Curie FP7-PEOPLE-2013-ITN under IDP Grant agreement nr. 604063

Name ESR and number in HP: Antonella Pomante, #12
Nationality: Italy
Research work-package (select): WP 4 (FEEL), WP 5 (SEE)
Starting date ESR: 1 Sept 2014
Supervisor and co-supervisor: Prof. Dr. Pieter Medendorp and Dr. Luc Selen
Host-institution - Department: Radboud University Nijmegen - Donders Center for Cognition (DCC)

RESEARCH

RESEARCH PROJECTS AND RESULTS FROM **01/01/2014** UNTIL **31/12/2017**

For each project give title, its goal, the main results and conclusions, with a representative photo/figure which we can use on the website! Indicate, where appropriate, Milestone/Deliverable number (Annex 1 pp 25-26).

Project 1: Perception of the dynamic visual vertical during sinusoidal linear motion.

The vestibular system provides information for spatial orientation, including the percept of verticality. However, due to the intrinsic properties of the vestibular receptors, this information is ambiguous: because the otoliths sense the gravito-inertial force, they cannot distinguish gravitational and inertial components. As a consequence, prolonged linear acceleration of the head can be interpreted as tilt, referred to as the somatogravic effect. Previous modeling work suggests that the brain disambiguates the otolith signal according to the rules of Bayesian inference, combining noisy canal cues with the a priori assumption that prolonged linear accelerations are unlikely. A prediction based on this modeling framework is that the noise of the vestibular signals affects the dynamic characteristics of the tilt percept during linear whole-body motion. To test this prediction, we devised a novel paradigm to psychometrically characterize the dynamic visual vertical – as a proxy for the tilt percept – during passive sinusoidal linear motion along the inter-aural axis (0.33 Hz motion frequency, 1.75 m/s^2 peak acceleration, 80 cm peak-to-peak displacement). While subjects (n=10) kept fixation on central body-fixed light, a line was briefly flashed (5 ms) at different phases of the motion, the orientation of which had to be judged relative to gravity. Consistent with the model's prediction, results show a phase-

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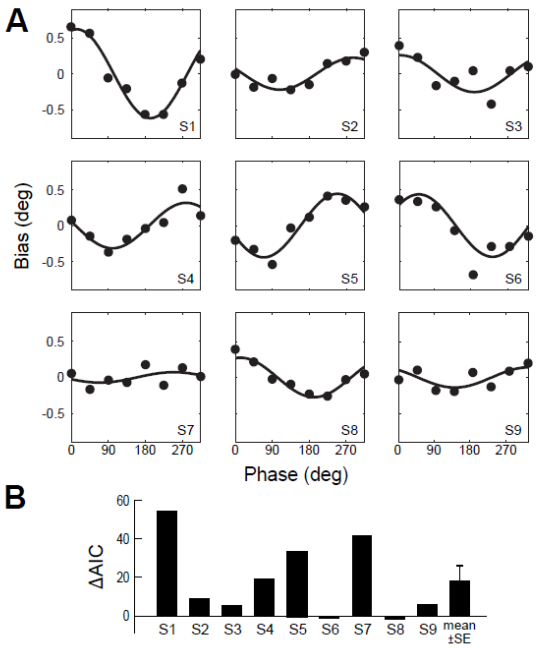
dependent modulation of the dynamic visual vertical, with a subject-specific phase-shift with respect to the imposed acceleration signal. Our findings support a direct link between the noise components in the vestibular system and the characteristics of dynamic visual vertical.



A: Bias as a function of phase for all subjects**.** *Black dots*: independently fitted psychometric curves for each phase. *Continuous line*: assumption of a sinusoidal modulation of the bias with the phase. Data and fits are offset-corrected. B: *Model comparison*: Difference between Akaike Information Criterion (AIC) values of constant and sinusoidal model for each subject. Positive values indicate that the sinusoidal model provides a better description of the data.

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Project 2: **Eye Movements in Darkness Modulate Self-Motion Perception**

During self-motion, humans typically move the eyes to maintain fixation on the stationary environment around them. These eye movements could in principle be used to estimate self-motion, but their impact on perception is unknown. We had participants judge self-motion during different eye-movement conditions in the absence of full-field optic flow. In a two-alternative forced choice task, participants indicated whether the second of two successive passive lateral whole-body translations was longer or shorter than the first. This task was used in two experiments. In the first (n = 8), eye movements were constrained differently in the two translation intervals by presenting either a world-fixed or body-fixed fixation point or no fixation point at all (allowing free gaze). Results show that perceived translations were shorter with a body-fixed than a world-fixed fixation point. A linear model indicated that eye-movement signals received a weight of ~25% for the self-motion percept. This model was independently validated in the trials without a fixation point (free gaze). In the second experiment (n = 10), gaze was free during both translation intervals. Results show that the translation with the larger eye-movement excursion was judged more often to be larger than chance, based on an oculomotor choice probability analysis. We conclude that eye-movement signals influence self-motion perception, even in the absence of visual stimulation.

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Project 3: (ongoing project, in collaboration with the Zurich group) The role of visual cues during 4-minutes static roll-tilt on the percept of the gravitational vertical

The sense of vertical depends on the integration of visual, proprioceptive and vestibular sensory cues. Because these cues are noisy, integration of them may yield a more reliable estimate of vertical than can be derived from a single cue in isolation. The integration must be capable to adapt when alterations occur in sensory fidelity (e.g. due to acute disorders or aging). Adaptation of the perceived vertical has been scarcely investigated. Recently, Tarnutzer et al. (2014) asked whether 5-minutes of static roll-tilt at 90° in total darkness induced an adaptation effect of vertical, measured at various other tilt angles. They found a local adaptation effect, which they explained in Bayesian terms as a shift of the prior about upright. Here, we asked whether the presence of panoramic visual information presented during sustained roll tilt further affects the adaptation of verticality percept. We hypothesized that a visual scene aligned to a world-fixed reference frame, so panoramically provides a veridical cue about vertical, should reduce the perceptual error, while a visual scene aligned to the 90 degrees tilted body would increase the adaptation effect of vertical. Results show that visual cues manipulate the roll-related adaptation effect of the vertical, in agreement with this hypothesis.

Tarnutzer, A. A., Bockisch, C. J., Straumann, D., Marti, S., & Bertolini, G. (2014). Static roll-tilt over 5 minutes locally distorts the internal estimate of direction of gravity. Journal of Neurophysiology, 112(11), 2672–2679. https://doi.org/10.1152/jn.00540.2014

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Project 4: Ongoing project: Contribution of head tilt to the perception of the dynamic visual vertical during sinusoidal body translation.

Information from the semicircular canals about head orientation in space is thought to be used in the disambiguation of the gravitoinertial force into linear acceleration and gravitational components. Following up on the results of Project 1, we asked whether the level of canal noise affects the verticality percepts during sinusoidal body translations. We asked subjects to judge the orientation of a briefly flashed line with respect to the gravitational vertical, at different phases during passively induced sinusoidal interaural whole-body motion, while their head was either upright or tilted relative to the body. Stimuli were presented based on a new algorithm, which presented stimuli adaptively under the assumption that the percept of vertical modulates sinusoidally with motion phase. The algorithm sped up the data acquisition significantly, replicated our previous results, and unveils an effect of head-tilt on vertical head perception during linear body acceleration.

Project 5: Ongoing project: Role of visual object reliability on the rod-and-frame effect.

The percept of vertical can be tested using the Subjective Visual Vertical (SVV) task, in which the subject is asked to judge the orientation of a visually presented line with respect to vertical. In order to represent how the line is oriented in space, information about body orientation in a world reference frame, head orientation with respect to the body, and head orientation in the world, have to be integrated. In the absence of visual cues, these signals come from body proprioceptors, neck proprioceptors and vestibular signals, respectively.

Also, since the SVV task involves the judgement of a visual object, the information will be transformed in retinal coordinates, so the orientation of the line on the retina, and of the retina in head have to be taken into account.

The role of visual panoramic cues on the percept of vertical can be investigated by adding a visual frame around the line. It has been shown that participants tends to perceive the rod to be tilted in the

same direction as the frame is oriented (e.g., if the frame is tilted in the counterclockwise direction, the rod will also be perceived as being tilted counterclockwise). This effect is known as rod and frame illusion.

This experiment aims at investigating how the reliability of the visual object influences performance in the rod and frame task.

In order to manipulate the reliability of the visual object, we varied the eccentricity of an ellipse. We tested whether the ellipse axes ratio affects subject's precision of an SVV task.

We hypothesize that if the visual object is less reliable (lower eccentricity), then the uncertainty in an SVV task should increase. As the ellipse becomes more elongated (more reliable stimulus), the uncertainty should decrease.

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OUTREACH ACTIVITIES

OUTREACH ACTIVITIES FROM 01/01/2014 UNTIL 31/12/2017

Mention your public presentations on open days, participation in general public events, press, etc. etc.: when, what and where.
Your publications: those that have been submitted/published (provide all bibliographic details), and those that you are currently finishing: give title, and foreseen journal, if possible)
Are there any patents? New foreground? Applications for the general public/society?

Public presentations

2015 *Preview of the European Researchers Night,* International Lounge, Radboud University Nijmegen, The Netherlands
2015 *Science is wonder-ful; 10th Anniversary of the European Researchers Night,* Autoworld Museum, Brussels, Belgium
2015 *Radboud Researchers Night (European Researchers Night),* LUX cinema, Nijmegen, The Netherlands
2017 *BrainBox (Vierdaagse festivities),* Kelfkensbos, Nijmegen, The Netherlands

Publications

Perception of the dynamic visual vertical during sinusoidal linear motion.

Pomante A, Selen LPJ, Medendorp WP.

J Neurophysiol. 2017 Oct 1;118(4):2499-2506. doi: 10.1152/jn.00439.2017. Epub 2017 Aug 16.

PMID: 28814635
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2.
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Clemens IA, Selen LP, Pomante A, MacNeilage PR, Medendorp WP.

eNeuro. 2017 Jan 25;4(1). pii: ENEURO.0211-16.2016. doi: 10.1523/ENEURO.0211-16.2016. eCollection 2017 Jan-Feb.

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in prep. Pomante A, Romano F, Medendorp WP, Selen LPJ, Bertolini G The role of visual cues during 4-minutes static roll-tilt on the percept of the gravitational vertical *Currently in preparation*.

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TRAINING ACTIVITIES

TRAINING ACTIVITIES FROM 01/01/2014 UNTIL 31/12/2017

Describe your courses (received and given), (summer)schools, and your Secondments: when, what, and where
Summer schools

Coursework

2015 *Bayesian neurocognitive modeling,* Radboud University Nijmegen
2015 *Machine learning*, Coursera.org
2015 *Motor Control*, Radboud University Nijmegen
2015 *Designing a PhD research project*, Radboud University Nijmegen
2016 *Neuro-science: Optimising Cognitive Functioning? Sleep, Mood and Attention Management,* Radboud University Nijmegen
2016 *Biological Learning and Control,* Radboud University Nijmegen

Summer schools

2017 *HealthPAC PhD Business School*, Nijmegen and Eindhoven, The Netherlands (participant and organizer)
2015 *Summer School in Computational Sensory-Motor Neuroscience (CoSMo)*, Nijmegen, The Netherlands

Teaching, at Radboud University Nijmegen

2017 Teaching assistant, *Linear algebra*
2017 Teaching assistant, *Brain for Artificial Intelligence*
2016 Teaching assistant, *Signal analysis and Matlab*
2015 Teaching assistant, *Signal analysis and Matlab*

CONFERENCES

CONFERENCES, WORKSHOPS FROM 01/01/2014 UNTIL 31/12/2017

Mention which conferences and workshops you have attended: when and where.

Conferences

2016 *Day of Perception*, Nijmegen, The Netherlands
2016 *46th annual meeting of the Society for Neuroscience*, San Diego, Ca, USA
2016 *The Brain Forum*, Lausanne, Switzerland
2015 *IMRF,* Pisa, Italy
2014 *Donders Discussions*, Nijmegen, The Netherlands
2014 *Day of Perception*, Eindhoven, The Netherlands
2014 *Neurovation*, Utrecht, The Netherlands

FUTURE CAREER PLANS

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Describe your future career plan(s), after the end of the project. Note: the PhD is obtained after HP (31/12/2017!), so it's part of the future career plan.
What are your career plans after obtaining your PhD?

In the immediate future, I will work towards obtaining a PhD degree at the Radboud University Nijmegen. In the midterm, I plan to work in commercial, application-driven research, for example for prosthesis development. I would also consider working as a data analyst. Work in a clinical environment is also a possibility, with the goal to develop and apply medical technology