2015 Retreat, June 8-11

Kingbridge
Conference Centre & Institute

Contact: The Kingbridge Centre, 12750 Jane Street, King City, Toronto,Ontario, Canada L7B 1A3Tel: 905.833.3086, Fax: 905.833.3075, Web: http://www.kingbridgecentre.com/#home

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Queen's UNIVERSITY   JUSTUS-LIEBIG-UNIVERSITAT GIESSEN   YORK UNIVERSITÉ UNIVERSITY   Philipps Universität Marburg   Western
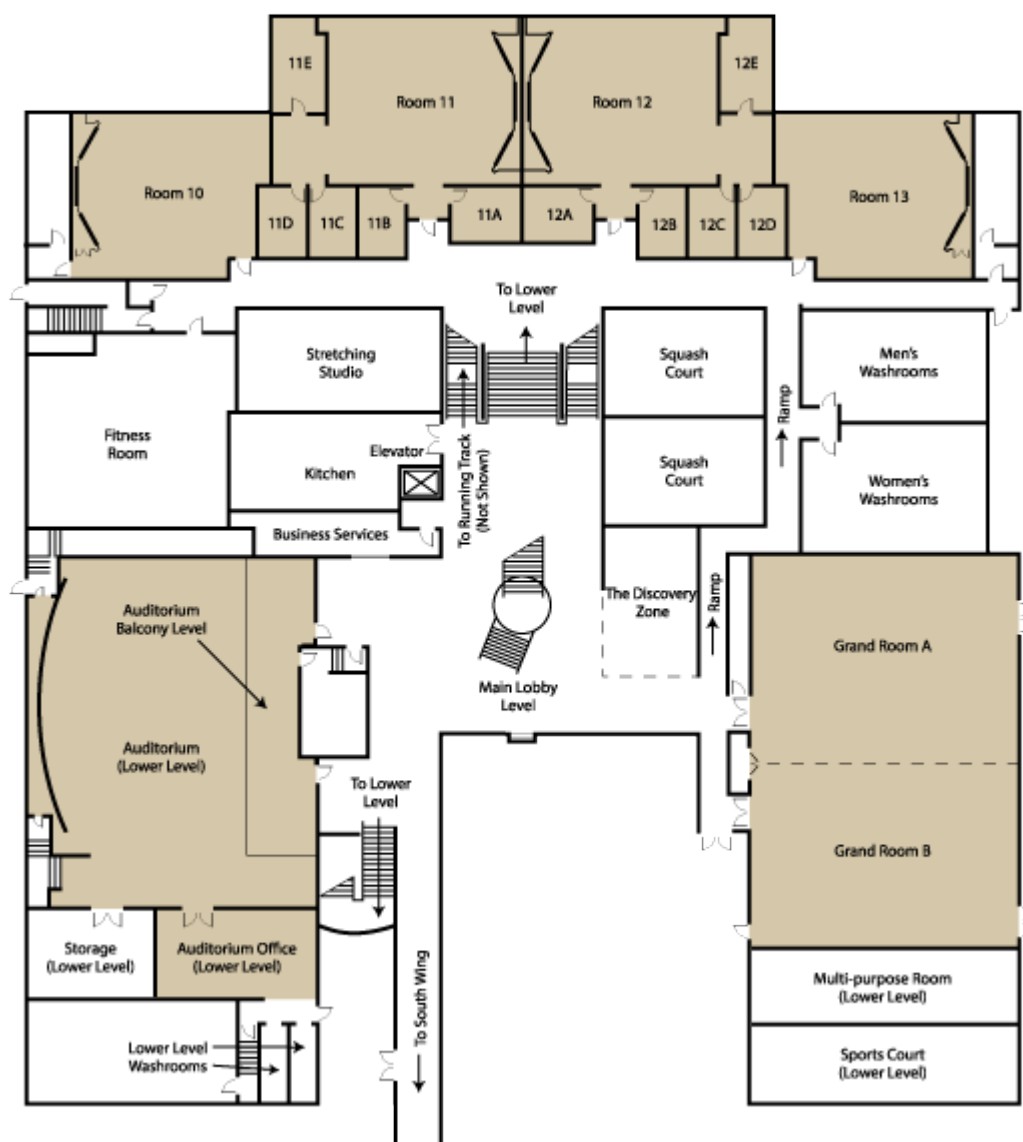
Main Kingbridge Event Locations (See Appendix for Site Location Maps):

All Meals: Connections Dining Room, South Wing

All Talks and Posters: Grand Room A&B, North Wing First Floor

Break Station Snacks and Beverages, North Wing Main Foyer

Map of North Wing, First Floor:

All Maps: http://www.kingbridgecentre.com/facilities/kingbridge-property-map/

Preliminary Retreat Program

Monday June 8

4PM onwards	Kingbridge check-in for Overnight Guests
5:30-9:30PM	Dinner for overnight guests

Tuesday June 9

7:00-9:00AM   Breakfast, Students Set-up Posters

9:00-9:30AM   Welcome and Opening Remarks

9:30-10:30AM   Opening Keynote Lecture: Prof. Frank Bremmer (Marburg) "Visual perception during eye movements" (JDC Introducing).

10:30-11:00AM   Coffee Break

11:00-12:00AM   Student Progress Talks(15 mins + 5 mins questions), Chair: G. Blohm

1) Adam, Ramina (Western): Resting-state functional connectivity changes following an ischemic frontal cortex stroke in a macaque
2) Arikan, Ezgi (Marburg): Predictive processing of multisensory action consequences
3) Mostafa, Ahmed (York): Different patterns of generalization for reach adaptation and proprioceptive recalibration following exposure to visual-proprioceptive discrepancies

12-12:30PM   Guest Speaker: Brent Nelson (Leo Burnett) Neuroscience in Advertising

12:30-2:00PM   Lunch

[Includes: Joint Steering Committee Lunch with Consul General Stechel (German Consulate General Toronto), Dr. Doll-Sellen (DFG), NSERC Representative, and VP Haché (York); CREATE students should meet with industry speaker]

2:00-2:15PM   Public Comments from Distinguished Guests

2:15-3:15PM   Student Progress Talks (15 mins + 5 mins questions), Chair: J. Culham

4) Heuer, Anna (Marburg): Action and visual working memory: what we do affects what we remember
5) Murdison, Scott (Queens): Evidence for an eye-centered perception of stimulus orientation during saccades

6) Paulun, Vivian(Giessen): Inverted Material-Weight illusion in objects made of two materials

3:15-3:40PM   Coffee Break

3:40-5:00PM   Student Progress Talks (15 mins + 5 mins questions), Chair: J. Culham

7) Merritt, Kate (Western): An alternative explanation for impaired iterative on-line motor control in Parkinson's disease
8) Helm, Fabian (Giessen): Analysis of human motion: Classification of deceptive and non-deceptive behavior in sport
9) Parr, Ashely (Queens): Comparing mixed-strategy decision-making in Parkinson's patients and healthy populations
10) Chen, Jing (Giessen): Anticipatory smooth pursuit of intentional finger movements

5:00-6:00PM   Student Advisory Committee Meetings (Ad Hoc Locations)

6:00-7:30PM   Dinner

7:30-9:00PM   Poster Session.

Wedesday June 10

7:00-9:00AM   Breakfast

9:00-10:30AM   Student Progress Talks (15 mins + 5 mins questions), Chair: K. Fiehler

11) Sultana, Arhum (York): Flexible hand simulation to measure the latency in virtual simulation of finger gestures
12) Klinghammer, Matthias (Giessen): The use of allocentric information for goal-directed reaching
13) Ayala, Maria (York): Concurrent reach and tracking adaptations of moving and static targets

10:30-11:00AM   Coffee Break

11:00-12:30AM   Student Talks (15 mins + 5 mins questions), Chair K. Fiehler

14) Oemisch, Mariann (York): Consequences of prediction errors in the fronto-striatal system
15) Schmitt, Constanze (Marburg): EEG-analysis of the processing of visual (self-) motion
16) Cardinali, Lucilla (Western): An electrophysiological investigation of object and body parts perception

12:30-2:00PM   Lunch

      (Includes: Joint Steering Committee / Program Advisory Committee Meeting)

2:00-3:30PM   Career Development & Industry Talks, Chair: D. Crawford

    2:00-2:30PM Karen Dubeau (Venture Lab): Entrepeneurship for Neuroscientists
    2:30-3:00PM Stephen Boyne (DRDC): Careers in Military Research
    3:00-3:00PM Yannick Rasmussin (NDI): Motion Tracking for Neuroscientists

3:30-4:00PM   Coffee Break (CREATE Students should talk to the non-academic guests)

4:00-5:00PM   Student Talks (15 mins + 5 mins questions) Chair: Anna Schubö

17) Fraser, Lindsey (York): Vestibular noise alters perceived location of the left hand, but not the right
18) Velychko, Dmytro (Marburg): Variational learning of coupled latent dynamics for a new kind of sensory-motor primitives
19) Weech, Séamas (Queens): Is optic flow used for online adjustments during perturbed locomotion?

5:00-6:00PM   Student Advisory Committee Meetings (Ad Hoc Locations)

6:00-7:30PM   Dinner (CREATE Students Meeting with Industry Speaker/s)

7:30PM Onwards   Free time*

*7:30PM   Gather at Cars for Karaoke Night Outing at the Schomberg Pub

Please let Janice know if you want to come, if you need transportation, or if you are willing to be a designated driver back to Kingsbridge, so we can plan this out.

http://www.theschombergpub.com/

Thursday June 11

7:00-9:00AM   Breakfast

9:00-10:40AM   Student Progress Talks (15 mins + 5 mins questions), Chair: D. Munoz

20) Baltaretu, Bianca-Ruxandra (York): Space-fixed, retina-fixed, and frame-independent mechanisms of trans-saccadic feature integration: An fMRIa paradigm
21) Veto, Peter (Marburg): Action and perceptual rivalry
22) Chang, Benedict (Western): The neural correlates of intercepting moving objects with the hand
23) Wilhelm Karén (Marburg): Pupillomotor patterns as an early direction prediction in prodromal and manifest neurodegenerative disorders (example: Parkinson's disease)
24) Theresa Gerhard (Giessen): Visual spatial processing in infancy: On mental rotation ability and habituation to two- and three-dimensional objects

10:40-11:00AM   Coffee Break (outer hall)

11:00-12:00AM   Closing Keynote Lecture: Karl Gegenfurtner (Giessen) 'Vision and eye movements' (DPM Introduces).

12:00-1:00PM   Check-Out and Departure

1:00PM   Bus to Doug's House for Afternoon Barbecue

4:00PM   Bus to Airport and York for TMS Workshop

4:00PM Onwards   Other Departures

Doug's Place, 25 Little Rebel Road, Schomberg ON

Affiliate Posters

(Tuesday -Thursday in Grand Room A/B)

Canadians

Name	Title of Poster
Le, Ada (York)	Investigating the neural mechanisms of reach-grasp integration
McManus, Meaghan (York)	How visual motion in different parts of the visual field updates our sense of spatial location
Khoozani, Parisa (Queens)	Effect of neck muscle sensory noise on reference frame transformation in reach planning
Maltseva, Margarita (Western)	Familiar size relationships decrease size contrast illusion
Chen, Juan (Western)	Pupil size is modulated by the size of flux-equated gratings
Kenny, Sophie (Queens)	Cues to gender perception in action performance
Khan, Janis (Queens)	Investigating the role of superior colliculus in the coding of visual saliency and behavioural priority
Yabe, Yoshiko (Western)	Temporal distortion in the perception of actions and events

Germans

Name	Title of Poster
Hitzel, Elena (Giessen)	Objects in the peripheral visual field influence gaze location in natural vision
Koch, Dennis (Marburg)	A combined approach to predictive processes in voluntary action: Sensory attenuation in N1 and SDT measures
Lezkan, Alexandra (Giessen)	Motivation modulates haptic softness exploration

Möhler, Tobias (Giessen)	Saccade curvature as a function of spatial congruency and movement preparation time in simultaneous and sequential dual-task paradigms
Schütz, Immo (Giessen)	Neural correlates of path direction detection using human echolocation
Vesker, Michael (Giessen)	Developmental aspects of the perceived arousal and valence of emotional facial expressions
Wolf, Christian (Giessen)	Maximum-likelihood integration of peripheral and foveal information across saccades
Zabicki, Adam (Giessen)	Action-specific motor maps of imagined and executed hand movements? An MVPA analysis

KEYNOTE ABSTRACTS:

Visual perception during eye movements

Frank Bremmer

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

Eye movements challenge visual processing. While the image of external objects moves across the retina during such movements, we perceive the outer world as being stable. Yet, it appears, that this perceptual stability is not complete. Recent studies have shown that spatial processing in the temporal vicinity of eye movements is not veridical. During saccades, perceived locations of briefly flashed stimuli are shifted in the direction of the eye movement or are compressed towards the landing point of the eyes, dependent on the exact experimental conditions. During smooth pursuit and the slow-phases of optokinetic nystagmus perceptual space is shifted in the direction of the eye movement. Yet, it is not only spatial perception that is modulated across eye movements; also the perception of more abstract quantities, i.e. time and number, are disturbed.

In our work, we aim at better understanding vision during eye movements. To this end we combine psychophysical studies in healthy humans as well as neurological and psychiatric patients with neurophysiological recordings in an animal model, i.e. the rhesus macaque. In my presentation I will review neurophysiological studies that we have performed over the years that aimed at identifying the neural correlate of changes of visual perception during eye movements.

Readings

Bremmer F. & Krekelberg B. Seeing and acting at the same time: challenges for brain (and) research. *Neuron* **38**, 367-370 (2003).

Krekelberg B., Kubischik M., Hoffmann K.P. & Bremmer F. Neural correlates of visual localization and perisaccadic mislocalization. *Neuron* **37**, 537-545 (2003).

Bremmer F., Kubischik M., Hoffmann K.P. & Krekelberg B. Neural dynamics of saccadic suppression. *J. Neurosci.* **29**, 12374-12383 (2009).

Morris A.P., Kubischik M., Hoffmann K.P., Krekelberg B. & Bremmer F. Dynamics of eye-position signals in the dorsal visual system. *Curr. Biol.* **22**, 173-179 (2012).

Vision and eye movements

Karl Gegenfurtner,

Giessen University, Department of Psychology, Otto-Behaghel-Str. 10, 35394 Giessen (Germany)

The existence of a central fovea, the small retinal region with high analytical performance, is arguably the most prominent design feature of the primate visual system. This centralization comes along with the corresponding capability to move the eyes to reposition the fovea continuously. Past research on perception was mainly concerned with foveal vision while the eyes were stationary. Research on the role of eye movements in visual perception emphasized their negative aspects, for example the active suppression of vision before and during the execution of saccades. But is the only benefit of our precise eye movement system to provide high acuity of small regions at the cost of retinal blur during their execution? In my talk I will compare human visual perception with and without eye movements to emphasize different aspects and functions of eye movements. I will argue that our visual system has evolved to optimize the interaction between perception and the active sampling of information.

For orientation and interaction in our environment we tend to make repeated fixations within a single object or, when the object moves, we track it for extended periods of time. When our eyes are fixating a stationary target, we can perceive and later memorize even complex natural images at presentation durations of only 100 ms. This is about a third of a typical fixation duration. Our motion system is able to obtain an excellent estimate of the speed and direction of moving objects within a similar time frame. What is then the added benefit of moving our eyes?

Recently we have shown that lightness judgments are significantly determined by where on an object we fixate. When we look at regions that are darker due to illumination effects, the whole uniformly colored object appears darker, and vice versa for brighter regions. Under free viewing conditions, fixations are not chosen randomly. Observers prefer those points that are maximally informative about the object's lightness.

For pursuit eye movements, we have shown that our sensitivity to visual stimuli is dynamically adjusted when pursuit is initiated. As a consequence of these adjustments, colored stimuli are actually seen better during pursuit than during fixation and small changes in the speed and direction of the object are more easily detected, enabling a better tracking of moving objects. Pursuit itself increases our ability to predict the future path of motion lending empirical support to the widespread belief that in sports it's a good idea to keep your eyes on the ball.

These results demonstrate that the movements of our eyes and visual information uptake are intricately intertwined. The two processes interact to enable an optimal vision of the world, one that we cannot fully grasp while fixating a small spot on a display.

Readings:

Schütz, A.C., Braun, D.I. & Gegenfurtner, K.R. (2011) Eye movements and perception: a selective review. Journal of Vision, 11(5):9.

Toscani, M., Valsecchi, M. & Gegenfurtner, K.R. (2013) Optimal sampling of visual information for lightness judgments. Proceedings of the National Academy of Sciences USA, 110(27), 11163-11168.

STUDENT PROGRESS REPORT TALK ABSTRACTS (in order of presentation)

1) Resting-state functional connectivity changes following an ischemic frontal cortex stroke in a macaque

Ramina Adam[1], Kevin Johnston[1], R Matthew Hutchison[2], Stefan Everling[1]

[1]*The University of Western Ontario, London, ON, Canada*
[2]*Harvard University, Cambridge, MA, United States*

Spatial neglect is a disorder of spatial attention commonly seen following right hemispheric stroke. It is characterized by an inability to attend to contralesional stimuli, resulting in a saccade choice bias to the ipsilesional hemifield. Here, we aim to correlate the behavioural recovery of the saccade choice bias as a marker of spatial attention with resting-state functional connectivity (FC) changes in the frontoparietal attention network. We created a macaque model of ischemic stroke using endothelin-1 injections in the right dorsolateral prefrontal cortex and frontal eye field as verified by anatomical magnetic resonance imaging (MRI). Following stroke, the animal exhibited both a profound ipsilesional saccade choice bias and increased contralesional saccadic reaction times. Resting-state functional MRI (rs-fMRI) scans obtained one week following stroke showed reduced frontoparietal FC in the ipsilesional hemisphere and some increased FC between the contralesional frontal cortex and contralesional and ipsilesional posterior parietal cortex. Data from daily behavioural eye tracking and biweekly rs-fMRI will be collected for another five months or until behavioural performance recovers to pre-stroke levels. Results will reveal how changes in whole-brain FC following stroke are related to the behavioural recovery of spatial attention.

2) Predictive processing of multisensory action consequences

B. Ezgi Arikan[1],Bianca M. van Kemenade[1], Jens Sommer[1], Benjamin Straube[1] and Tilo Kircher[1]

[1]*Philipps-University Marburg, Department of Psychiatry and Psychotherapy, Marburg, Germany*

Existing research on predicting perceptual consequences of one's own action so far mostly investigated mechanisms involved in the action-perception cycle with unimodal stimuli. However, in the real world our actions often have multisensory consequences. Therefore, more studies are needed to elucidate processes and neural correlates involved in predicting multisensory consequences of one's own actions. In two behavioral experiments, we investigated multisensory processing of action consequences. In the first study, we found facilitation of delay detection performance when consequences of the action were

multisensory compared to when there was unisensory feedback of the same action. In the second experiment, we assessed simultaneity judgments of audiovisual stimuli triggered by button presses. Introduction of temporal delays between action and audiovisual feedback resulted in enhanced sensitivity to audiovisual asynchronies. These findings are in line with the so-called forward model, which is believed to predict action consequences, compare this prediction to the actual sensory feedback, and update the system in case of mismatches. Furthermore, our findings suggest that the forward model includes predictions for all modalities and contributes to multisensory integration in the context of action. Currently, we are conducting an fMRI study to assess neural correlates involved in action prediction and perception of multisensory action consequences. Participants judge whether there is a delay between their button press and the occurrence of a visual dot or a tone. Although the second modality occuring in some trials should not affect performance, we expect facilitation of detection performance when the action consequences are multisensory. Specifically, we aim to assess whether areas that have previously been linked to comparing predicted and actual unisensory feedback are also involved in multisensory comparisons. We would expect parametric increase in BOLD response with increased delays between action and perceptual feedback in such areas.

3) Different Patterns of Generalization for Reach Adaptation and Proprioceptive Recalibration Following Exposure to Visual-Proprioceptive Discrepancies

Ahmed A. Mostafa[1,2], Erin K. Cressman[3], Denise Y. P. Henriques[1,2]

[1]Centre for Vision Research
[2]School of Kinesiology and Health Science, York University, Canada
[3]School of Human Kinetics, University of Ottawa, Canada

When participants train to reach to a target with rotated visual feedback of their hand, they adapt their reaches to reduce movement errors. Reach adaptation is found to generalize with greater extent when reaches are made in similar directions, regardless of changes in hand/targets spatial location. In addition to reach adaptation, felt hand position also changes following visuomotor rotation training, partially countering the discrepancy between seen and felt hand position introduced by the training. In our lab, we have recently shown that exposure to a visual-proprioceptive discrepancy, which does not allow participants to volitionally direct the movement (i.e. visuomotor remapping), is sufficient to produce smaller reach aftereffects (compared to usual visuomotor rotations paradigms) but similar changes in felt hand position. We sought to investigate the generalization patterns for reach adaptation and proprioceptive recalibration following training with this cross-sensory error signal paradigm. To investigate this, we had our participants train by reaching from a start position (S1) along a robot generated linear path that was aligned or gradually rotated 45° clockwise relative to a cursor which represented their hand and was always viewed to be headed directly towards the target. That is, there are no movement errors, but there is a discrepancy between seen and

felt hand position. After training, participants reached to the training target and novel targets without visual feedback of their hand, including reaches from a different start position (S2) to assess generalization of reach adaptation. Then they performed a proprioceptive estimation task, in which they indicated the felt position of their hand relative to reference markers at locations similar to the trained and novel reach targets. We found changes in proprioceptive estimates and changes in open-loop reaches (i.e. aftereffect) at the trained direction. Additionally, relative to peripheral reference markers locations, participants tended to estimate their hand position to be closer to their body than it actually was, in the direction of the visual feedback during the exposure training. Moreover, they adapted their reaches to the same locations but to a smaller extent than the proprioceptive recalibration. These findings suggest that the cross-sensory error signal results in changes to felt hand position which generalize across the workspace when proprioceptive estimations are made relative to peripheral locations and these proprioceptive changes also drive partial reach aftereffects which hence follow a similar generalization pattern.

4) Action and visual working memory: what we do affects what we remember

Anna Heuer[1], J. Douglas Crawford[2,3,4] & Anna Schubö[1]

[1] Experimental and Biological Psychology, Philipps-Universität Marburg, Marburg, Germany
[2] Centre for Vision Research, York University, Toronto, Ontario, Canada
[3] Department of Psychology, Biology, and Kinesiology and Health Sciences, and Neuroscience Graduate Diploma Program, York University, Toronto, Ontario, Canada
[4] Canadian Action and Perception Network (CAPnet)

Although it seems highly intuitive that what we are doing modulates which visual information from our environment is relevant and should be maintained in visual working memory (VWM), action-induced effects on VWM maintenance have not yet been systematically investigated. It has been shown that attention is automatically drawn towards the goal of a movement, and that the deployment of attention towards representations held in VWM improves memory performance for the respective items. We combined these two insights and tested whether memory items previously presented at an action-relevant location benefit from the action-related stronger attentional engagement at that location in a similar manner as when attention is explicitly cued to be deployed to certain representations. During the retention interval of a VWM task, participants performed a pointing movement to one of the locations at which the memory items had previously been presented. Indeed, memory performance for items presented at the location of the pointing goal was better than for items presented at action-irrelevant locations. Importantly, this was only observed when participants actually pointed towards the location at which the memory item had been presented, but not when the movement was performed towards fixation. These findings indicate that our actions contribute to the flexible updating of VWM: Information which is potentially action-relevant, simply due to

the spatial correspondence between the respective memory representation and our action goal, is preferentially maintained.

5) Evidence for an eye-centered perception of stimulus orientation during saccades

T. Scott Murdison[1,2,3], Gunnar Blohm[1,2,3] and Frank Bremmer[4]

[1] Centre for Neuroscience Studies, Queen's University, Kingston, Ontario, Canada
[2] Canadian Action and Perception Network (CAPnet)
[3] Association for Canadian Neuroinformatics and Computational Neuroscience (CNCN)
[4] Dept. Neurophysics. Philipps-Universität Marburg, Marburg, Germany

Despite the nearly constant motion of information on our retina due to eye movements, we perceive the world around us as stable. Many have investigated how the brain accomplishes this spatial reconstruction during horizontal and vertical retinal displacements, but, surprisingly, little focus has been placed on the effects of torsional rotations. Due to the spherical shape of the eyes, retinal input is rotated during oblique eye orientations. Importantly, Listing's law provides that there is no actual torsion of the eyeballs at these orientations, so, to reconstruct a stable perception of space during eye movements, the brain must utilize an eye orientation-based internal model of this oblique gaze-induced effect.

To investigate if this is the case, we induced rotations of retinal input using oblique eye orientations, and presented oriented bar stimuli for one frame (8 ms) pre-, peri- and post- saccadically during horizontal saccades (presentation window from 800 ms before saccade onset to 800 ms after saccade offset). Participants performed 40 deg saccades either along the screen's horizontal meridian (control condition) or along the same line from a vertically eccentric orientation (+20 deg; test condition), producing approximately 2 deg of retinal rotation at maximum eccentricity. Participants were then asked to judge the direction of stimulus rotation relative to vertical in a two-alternative, forced choice task.

On average, psychometric PSEs revealed that participants systematically perceived vertically eccentric stimuli on the left third of the screen as rotated by -1.7 deg (average predicted retinal rotation of -2.2 deg), in the middle of the screen as rotated by 0.5 deg (average predicted retinal rotation 0 deg), and on the right side of the screen as rotated by +1.6 deg (average predicted retinal rotation +2.2 deg). In comparison, control trials along the horizontal meridian yielded much smaller shifts in PSEs (left: +0.7 deg, middle: +1.1 deg, right: +1.2 deg), suggesting an eye-centered coding of orientation during saccades. Furthermore, for both control and test conditions a shift in the psychometric function began approximately 100 ms prior to saccade onset until about 100 ms after saccade onset, possibly indicating a pre-saccadic remapping effect consistent with previous work on spatial localization. Together, these findings suggest that during saccades in the absence of surrounding visual cues, perceptual processes rely more heavily on

retinal inputs than on extraretinal inputs that are ultimately required for a stable perception of the world.

6) Inverted Material-Weight illusion in objects made of two materials

Vivian C. Paulun[1, 2], Gavin Buckingham[3], Karl R. Gegenfurtner[1], Roland W. Fleming[1], Melvyn A. Goodale[2]

[1]*Department of Psychology, Justus-Liebig-University, Giessen, Germany*
[2]*The Brain and Mind Institute, The University of Western Ontario, London, Canada*
[3]*Department of Psychology, School of Life Sciences, Heriot-Watt University, Edinburgh, UK*

Knowledge about the material properties of objects is essential for successful manual interactions. Vision can provide useful information about features such as weight or friction even before interaction, allowing us to prepare the action appropriately, e.g. adjusting initial forces applied to an object when lifting it. But visual information can also alter multisensory perception of object properties during interaction. When violated, visually-inferred expectations can result in perceptual illusions such as the material-weight illusion (MWI). In this illusion, an object that appears to be made of a low-weight material (e.g., polystyrene) feels heavier than an equally-weighted object of a heavier-looking material (e.g., wood). However, objects are often made of more than one material. Thus, in the present study, we investigated the perceived heaviness of symmetrical objects consisting of two halves, which appeared to be made of different materials: polystyrene, wood, or stone. The true mass of these bipartite objects was identical (400g) and evenly distributed around their geometric centre. Thus, the objects and their halves were visually distinct, but identical in terms of their weight and mass distribution. Participants were asked to lift the objects by a small handle attached centrally, while forces and torques were recorded. Additionally, they were asked to report the perceived weight of both halves of the objects. The visual appearance did indeed alter perceived heaviness. Although estimates of heavier and lighter portions of the objects converged after lifting the objects, the heavier-looking materials in our bipartite objects were still perceived as heavier than the lighter-looking materials. Again, prior expectations appear to affect the perception, but in a direction opposite to that of the MWI. Despite the effects of the visual appearance on perceived heaviness, no corresponding effects were observed on forces or torques.

7) An alternative explanation for impaired iterative on-line motor control in Parkinson's disease

Kate E. Merritt[1], Penny A. MacDonald[1], & Melvyn A. Goodale[1]

[1] *The Brain and Mind Institute, The University of Western Ontario, London, ON, Canada*

Rather than our actions being under the strict control of a predefined motor plan, fast and precise modifications can be processed and implemented as those actions are occurring (i.e. on-line). In healthy controls, such an ability to rapidly correct movements on-line can occur both with and without conscious cognitive control. As of late, contradictory findings have surfaced as to whether patients with Parkinson's disease (PD) have a general impairment in the on-line control of action. The current interpretation for such inconsistencies lies in the notion that while patients with PD are impaired in performing on-line motor corrections requiring conscious cognitive control, they retain the ability to perform on-line motor adjustments that bypass conscious awareness. However, a critical re-appraisal of this work has rendered the conscious-subconscious dissociation interpretation problematic. Specifically, the prior work has failed to take into account how their experimental demands may have interacted with the already well-established motor symptoms of PD, such as akinesia and hypometria. In this current study, we aim to systematically consider how PD-related akinesia and hypometria may be confounded by the traditional approaches used to investigate conscious on-line motor control. Here, we will employ a modified double step-paradigm that accounts for and compensates for confounding PD-related motor deficits. During this task, healthy controls and patients with PD will be instructed to point to a peripheral visual target, which depending on the trial, will either remain stationary or will unexpectedly change locations. We will manipulate both the timing and magnitude of target displacement such that the experimental demands become identical between both groups. We propose that the alleged deficits in on-line motor control may not be due to the consciousness of the correction, but rather may be attributable to the akinesia and hypometria associated with PD. In line with this alternative explanation, we predict that when the experimental demands are adjusted in order to account for PD-related akinesia and hypometria, any previously observed impairment in on-line motor control will be attenuated. In conclusion, the results of this study will allow us to objectively evaluate the true extent in which deficits in the on-line control of action exist in PD.

8) <u>Analysis of human motion: Classification of deceptive and non-deceptive behavior in sport</u>

Fabian Helm[1,2], Nikolaus Troje[2], Jörn Munzert[1]

[1] *Nemolab – Justus-Liebig-University Giessen*
[2] *Biomotion Lab – Queen's University*

In various situations in sport, athletes are asked to adapt their behavior to the constantly changing conditions. Action prediction can help to achieve these behavioral goals easily. In recent years, several studies emphasized possible perceptual-cognitive strategies used for the prediction of an opponent's action (Williams et al., 2011, for review). However, we assume that strategies mostly benefit the prediction of actions if they rely on the perception of

movement differences in the opponent's behavior. With this background, the present study investigated if and across which movement parameters deceptive and non-deceptive 7m throws could be classified in team handball. According to the methods used by Troje (2002), we analysed the motion data of 1600 (800 deceptive) 7m throws of skilled handball field players (n=5) and novices (n=5) by means of linear discriminant analysis (LDA) to distinguish kinematic features for the type of 7m throw. Data collection was carried out by means of a motion capture system (VICON, Oxford, UK). The results of the LDA show the possibility to discriminate deceptive from non-deceptive behavior supported by the movement characteristics elicited from the precision and dynamics of the actions. The number of misclassifications seems to be higher for the skilled athletes in comparison to the novices. Their deceptive throws are much more similar to a „real" (non-deceptive) throw.

9) <u>Comparing mixed-strategy decision-making in Parkinson's patients and healthy populations</u>

Parr, A.C.[1], Coe, B.C.[1], Pari, G.[2,3], Munoz, D.P[1,4]

[1] Centre for Neuroscience Studies, Queen's University, Kingston, Ontario, K7L 3N6
[2] Department of Medicine, division of Neurology, Queen's University, Kingston, Ontario, K7L 3N6
[3] Kingston General Hospital, Kingston, Ontario K7L 2V7
[4] Department of Biomedical and Molecular Sciences, Queen's University, Kingston, Ontario, K7L 3N6

Decision makers face a fundamental problem when deciding on the appropriate course of action in uncertain environments. Often arising during competitive social interactions, such as a penalty shootout in soccer, or predator---prey relations, each player's actions and their associated outcomes change dynamically based on the actions of their opponents. To avoid exploitation by one's opponent, each competitor can adopt a mixed---strategy wherein available actions are chosen unpredictably. Mixed---strategy decisions are ubiquitous throughout our daily lives, and are used to gain advantage within various arenas, including sporting (e.g., penalty shootouts) and financial (e.g., stock market) competitions.

Neuroeconomic approaches, combining the predictions of game theory and neuroscientific methodologies, have begun to characterize choice patterns and their neural underpinnings during mixed---strategy games, such as Rock---Paper---Scissors.

An important realization from these investigations is that strategic action selection requires coordination across multiple subsystems of the brain, each thought to perform distinct, but complementary, computations. Given that maladaptive decision---making behaviours can be observed across various neuropsychiatric conditions, characterization of strategic choice patterns, and their underlying neural correlates, can provide rich insight into the diagnosis and

treatment of various clinical disorders. I will discuss ongoing research projects designed to quantify and compare choice strategies during mixed---strategy games among Parkinson's patients and healthy individuals, with the aim of developing biomarkers at the early stages of Parkinson's disease. Finally, I will discuss exciting future research ventures wherein I aim to investigate decision---making traits in a preclinical Parkinson's population, ultimately developing a tool to help identify Parkinson's disease at the preclinical stages.

10) Anticipatory smooth pursuit of intentional finger movements

Jing Chen[1], Matteo Valsecchi[1], Karl Gegenfurtner[1]

[1] *Department of Psychology, Justus-Liebig-University Giessen*

The smooth pursuit system is known to have prediction mechanisms. In the present study we investigate whether the motor command for hand movements can be integrated in the prediction and be used to anticipate pursuit.

In Experiment 1, observers were asked to place their index finger on a screen and to fixate it. As soon as a tone was presented, they could freely decide to move their finger to the left or to the right, and pursued it with their gaze. In three control conditions, observers tracked a finger-sized dot. The trajectories replayed each observer's own finger movements. Observers could predict the trace and direction (predictable-trace), only the direction (predictable direction), or neither trace nor direction (unpredictable).

When tracking the finger, the eye started to move on average 36 ms before finger motion. In 80% of all trials the eye started before the finger. In the predictable-direction and predictable-trace conditions, pursuit latencies were comparable, with -25 ms and -37 ms, respectively. However, the predictable controls showed less percentage of trials with anticipatory pursuit (53% and 56%, respectively). The latency increased to 143 ms when the direction was unpredictable. In addition, the finger tracking condition differed from the control conditions in that, first, we observed significantly fewer catch-up saccades in finger tracking. Second, the eye preceded the finger, while it lagged behind the dot in the initiation period of pursuit.

In Experiment 2, we recorded the EEG in order to find a direct link between the finger motor preparation (indexed by the lateralized readiness potential, LRP) and the anticipatory eye movement. Observers were asked to place their left and right index fingers at the center of a board in front of them and to fixate a dot between the fingers. They were free to decide whether to move the left finger to the left, or the right finger to the right. Based on the frequency of a tone, they were instructed to either pursue the finger with their gaze or keep fixating the dot while moving the finger. Generally, observed executed a saccade to the finger 43 ms before it started to move. We found a stronger LRP in the trials when the eye moved earlier compared to those where pursuit started later. In addition, by applying a mixed linear

model, we were able to show that the LRP amplitude significantly predicted the eye latency in single trials. Furthermore, across subjects, the LRP onset correlated with the averaged eye latency. In summary, the LRP for finger motor preparation was strictly coupled with the anticipatory eye movement.

Overall, the present results show that the arm motor system and the oculomotor system are closely tied to each other. The shared information in the two systems results in a better performance in the eye tracking of intentional finger movements.

11) Flexible Hand System to measure the latency in Virtual simulation of Finger gestures

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People with degenerative diseases affecting the brain, brainstem, or spinal cord can suffer from clumsiness, inaccuracy, delay or difficulty in synchronizing actions with intent while performing routine tasks. I present a hand gesture recognition and movement detection system that can experimentally introduce delays between actions and their consequences. The purpose of the system is to measure the ability to detect sensorimotor delay for movements of the human upper limb as such judgments have been shown to be affected by a variety of neurophysiological disorders. The system supports recognition of several gestures including wrist flick, curling and bending of fingers, and opening and closing of a fist. In the proposed experiments, participants are asked to tap with their middle finger (or make other finger movements) while observing an avatar in a virtual environment that represents their own hand in real time. Following the exposure, participants judge whether the movement of their avatar's hand was synchronous or asynchronous with respect to their actual finger taps. The ability to make such judgements will be compared to the ability to judge the synchronization of the finger taps with external stimuli such as audible sounds. To quantify the baseline real-time performance of the system (1) the intrinsic latency was measured in terms of internal measurements of computational delay and (2) the extrinsic end-to-end latency was measured using a high-speed camera. The system developed can contribute to the study of predictive mechanism of human behavior for multi-sensory consequences of *proprioception*.

12) The use of allocentric information for goal-directed reaching

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When interacting with objects in daily life situations, our brain relies on information represented in two main classes of reference frames: an egocentric (relative to the observer) and an allocentric (relative to objects or the environment) reference frame. In recent studies (Fiehler, Wolf, Klinghammer, & Blohm, 2014; Klinghammer, Blohm, & Fiehler, in preparation) we demonstrated that allocentric information is integrated into the movement plan when subjects performed memory-guided reaching movements to targets surrounded by allocentric cues in a complex environment (i.e. images of a breakfast scene). We further showed that this integration depended on the task-relevance of the allocentric cues. In our current study, we aimed to investigate how task relevance and/or the coherence of the scene influence the integration of the allocentric information into the movement plan.

To this end, we presented participants 3D-rendered images of a breakfast scene on a computer screen with some objects on and some objects behind a table. Six of these objects were used as possible reach targets and were learned before the experiment. Thus, the scene contained task-relevant and task-irrelevant objects. After a free exploration phase and a 1s delay, the same scene reappeared for 1.3s but with one of the six possible targets missing. Moreover, task-relevant and task-irrelevant objects were shifted either to the left or to the right in different conditions, e.g. relevant or irrelevant solely, together, or in the same or in opposite directions. After this image vanished, subjects had to reach towards the target on a grey screen. We predicted higher systematic deviations of reaching endpoints into the direction of the object shifts if task-relevant objects were shifted and the scene remained coherent compared to conditions with shifts of task-irrelevant objects or with incoherent object shifts.

Our results confirm that task-relevance is an important factor for the integration of allocentric cues for goal-directed reaching in a complex scene. Moreover, we show that coherence of object shifts supports this integration which is represented by a higher weighting of the allocentric information and less variability of reaching endpoints in conditions with coherent object shifts.

13) Concurrent reach and tracking adaptations of moving and static targets

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How does visuomotor adaptation to tracking movements differ from that of reaching movements? In the following experiments, we explored whether training by tracking a moving target with a perturbed hand-cursor produces motor aftereffects and if these aftereffects differ from those produced in a typical perturbed ballistic reaching task with a static target. We found that adaptation to perturbed tracking movements produce significant reach aftereffects although to a smaller extent; tracking aftereffects were about half the size (on average 9°) of those produced after ballistic reach training (on average 19°). Additionally, we looked at whether neural processing of adaptation to tracking and reaching paradigms are independent of one another and would thus allow for concurrent adaptation to opposing perturbations (i.e. dual adaptation). During dual adaptation training, tracking trials were associated with a 30° CCW rotation while reach trials were associated with a 30° CW rotation. We found significant reach aftereffects following dual training of about 7°; which was substantially smaller than that produced when reach training was not concurrently with track training. The size of reduction is consistent with the extent of the interference from track training as measured by the reach aftereffects produced when only that condition was performed. Additionally, tracking performance in response to a visuomotor rotation significantly improved for both single and dual tracking groups, both saturating at the same level but with different learning curves, with only the single group fully returning to baseline levels. Finally, reach errors for static targets in the dual-training group significantly decrease across training although to a lesser extent when compared to that of the single-training group. These findings suggest that adaptation of tracking movements which tend to produce small errors that can be adjusted on-line, are processed somewhat although not completely independently of reaching movements which tend to produce larger errors that are adjusted on a trial-by-trial basis.

14) Consequences of prediction errors in the fronto-striatal system

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Theories suggest that the formation of new associations between stimuli, actions, and their consequences primarily depends on learning from prediction errors. Prediction errors signal the difference of actually experienced and expected outcome and are essential to update expectations in order to make future predictions more accurate. A large array of brain regions have previously been implicated to play a role in encoding prediction errors, including the anterior cingulate cortex (ACC) (Hayden et al., 2011, Nat Neurosci 14:933), the medial prefrontal cortex (Matsumoto et al., 2007, Nat Neurosci 10:647),

subareas of the striatum (Daw et al., 2011, Neuron 69:1204; O'Doherty et al., 2003, Neuron 28:329), and dopamine neurons of the midbrain (Hollerman and Schultz, 1998, Nature 1) among many others. Prediction error signals in these separate brain regions differ markedly. Prefrontal regions, including the ACC, seem to represent mainly unsigned prediction errors that depend on the surprisingness of an outcome independent of its sign, sometimes also called state prediction errors. The striatum and midbrain dopamine neurons in turn encode a reward prediction error that encodes the difference between an actual and expected reward outcome at a particular state (Gläscher et al., 2010, Neuron 66:585). It is largely unknown how and where these different prediction error signals are integrated and how they lead to behavioural adjustment in future trials.

We aim to elucidate these two questions by having monkeys perform a feature-based reversal learning task that is unique in requiring feature learning independent of action plans. Monkeys have to match the action plan of one of two simultaneously presented visual stimuli in order to receive a liquid reward. Colour is the reward-determining feature and this feature changes in a block-design fashion, whereby uncued block changes are initiated by performance surpassing learning criterion. We quantified trial predictability by isolating error (ECnE) and correct (CEnC) trials with increasing number n of preceding correct and error trials, respectively; as well as by using an expectation maximization (EM) algorithm that identifies the time course of learning. Prediction error signals (negative and positive) should increase with increasing n. An average of 9 learning reversals were achieved per experimental session in the first animal. Identified by the EM algorithm, 77.4% of all blocks were learned and in those blocks a median of 12 trials were needed to learn the currently rewarded feature. Learning did not occur after a single correct trial, instead 7.4 correct trials were needed on average prior to learning.

In order to unravel the neural consequences and uses of prediction error signals, we, concurrently with task performance, recorded over 1200 units across the striatum, prefrontal and anterior cingulate cortex. In future analyses we will identify neurons that encode prediction error signals in the striatum and prefrontal regions and then determine whether an increased feedback-aligned prediction error signal is a) followed by an increased neural representation of the rewarded feature at the time of feature onset, and b) followed by a behavioural adjustment whereby the likelihood of performing a correct trial is enhanced.

15) EEG-analysis of the processing of visual (self-)motion

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Everyday life requires monitoring changes in the environment even without paying attention to it. Numerous EEG-studies have revealed that we are able to detect visual changes pre-attentively. Here we asked, whether also changes of the trajectory of moving objects and visually simulated self-motion are processed automatically, i.e. without paying attention to it.

We studied event-related potentials (ERPs) in two visual oddball paradigms. The potentials calculated in response to standard (80% occurrence) and deviant (20% occurrence) stimuli were compared to test if visual mismatch negativity (MMN) can be observed. The MMN is a component of an event-related brain potential that reflects a pre-attentive mechanism for change detection. In both studies the subject's attention was drawn off the movement by an unrelated secondary task they had to perform.

In the first study subjects were presented a visual object moving horizontally across a computer monitor 71cm in front of them. Object motion was hidden for a 7,1 to 10,6 degree wide central region of the monitor. The full (but not always visible) movement trajectory was either a straight line across the whole screen (standard) or it changed its vertical position at the center of the screen (i.e. jumped up or down) while continuing its horizontal motion (deviant). The ERPs evoked by standard and deviant stimuli differed significantly from 120 ms to 190 ms after motion onset. Topographic analysis of this difference showed a typical N2-component topography across occipital and parietal areas.

In the second study subjects viewed a random dot pattern that simulated self-motion across a ground plane. Standard and deviant trials differed in simulated heading direction (forward-left vs. forward-right). Analysis of the evoked ERPs revealed a MMN over occipital and parietal areas between 120 ms and 220 ms after movement onset.

The generation of MMNs in both studies indicates that both the processing of visual object motion and the processing of visually simulated self-motion are pre-attentive mechanisms.

16) An electrophysiological investigation of body parts and object visual perception

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We recently discovered a new illusion where participants feel a grabber as their own hand when it is brushed synchronously (but not asynchronously) with their hand. We called it Toolish Hand Illusion (THI).

Here we wanted to test whether such illusion implies a change in the way the body and tool images are processed in the brain. We used 128-channels EEG to record brain activity in naïve participants attending to pictures of their own hand, the grabber, a fake hand and a different tool. Participants seated at a table with their right arm and hand underneath a wooden board. A video projector was used to show the pictures on the top of the board in 18 separated blocks of 48 trials each. Crucially, in-between the last nine blocks we induced the THI by synchronously brushing the participants' right index finger and the tool for 45s at a time.

I will present preliminary results suggesting that the patterns of response to the four types of images changes before and after the illusion induction.

17) Vestibular noise alters perceived location of the left hand, but not the right

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Disruption of vestibular function can induce reach errors (Bresciani et al. 2002) and mislocalization of touch on the hands (Lopez et al. 2010). The vestibular signal seems to aid in perception of the hands in space. Does disruption of vestibular input degrade our sense of our hand position, or does it interfere with a higher-level representation of the hand? Twelve right-handed participants sat with their left or right index finger attached to a motor obscured by an optically superimposed screen. Their finger was passively moved around to several orientations in the frontoparallel plane, before stopping at a final test orientation (vertical, 5° or 10° ulnar/radial deviation). A line appeared on screen, and participants were instructed to orient the line via keypress so that it overlapped with their unseen finger. A bipolar sum-of-sines signal was applied via Galvanic Vestibular Stimulation (GVS), thus disrupting vestibular input, either 1) during movement of the hand, 2) during the response phase, or 3) prior to hand movement. A control no-GVS condition was also run. If GVS were to interfere with the sense of hand position over time, localization errors should be greatest when GVS is applied while position estimates of the hand are updated (during movement). If GVS were to disrupt an online representation of the self, we would expect larger errors if it were applied during the response phase, when this representation is accessed.

Results showed participants perceived their hands as more rotated radially than their actual orientation; these errors were larger for the left hand than the right in controls. The presence of GVS shifted perceived orientation of the left hand further radially, but did not affect the perceived orientation of the right hand. Perceived left hand orientation did not depend on GVS timing, suggesting the perceptual effects of GVS may linger at least 10s after stimulation. An analysis of the precision of responses suggests the left hand's vulnerability to GVS does not stem from a lack of precision compared to the right hand. Our data are consistent with the notion that a vestibular signal is important for tracking the position of the left hand in space over time. The asymmetry of the effect of GVS may be due to specialization of the right vestibular/multisensory hemisphere in maintaining a congruent representation of the body.

Bresciani JP, Blouin J, Popov K, et al (2002) Galvanic vestibular stimulation in humans produces online arm movement deviations when reaching towards memorized visual targets. Neurosci Lett 318:34–38.

Lopez C, Lenggenhager B, Blanke O (2010) How vestibular stimulation interacts with illusory hand ownership. Conscious Cogn 19:33–47.

18) Variational learning of coupled latent dynamics for a new kind of sensory-motor primitives

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Continuous optimal control and rigid motion primitives are two extremes of the space of action generation models. We want to investigate where human performance is located in this space. For this we need a flexible model with adjustable memory capacity which is also able to learn a control policy. This would allow us to sample models form the action generation models space and compare them with human performance.

Motion primitives based on dynamical systems have been suggested by many researchers as building blocks for action generation. Adapting to a changing environment or new problem constraints, however, requires readjustment of the learned dynamics due to the lack of flexibility of the dynamical motor primitives. Such online adaptation also computationally expensive, as it requires recomputing of the desired trajectory and a subsequent adjustment of the dynamical system.

We suggest combining sensory and motor parts into one interacting dynamical system. Coupling different dynamical systems for sensory prediction and motor activations yields a new model for sensory-motor primitive generation, which accounts for immediate sensory changes.

In previous work on Coupled Gaussian Process Dynamical Models (GPDM) we used the maximum likelihood criteria for learning, which is known to be prone to overfitting. Here we address this problem and present a variational treatment for learning of coupled dynamics in latent space, which is both Bayesian and allows to avoid overfitting issues. Factorising property of the coupling kernel makes such systems learnable with little overhead. Inducing variables, which are variational parameters, also serve as a limited memory resource, providing a control over the model complexity.

Variational inference in Coupled GPDM provides an attractive model for basic sensory-motor primitives research.

19) Is optic flow used for online adjustments during perturbed locomotion?

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Vision is a key source of information about self-motion and has been shown to drive human locomotion control. For example, optic flow (retinal slip due to observer motion; Gibson, 1950) is used to estimate heading direction and velocity, and to guide steering of locomotion (Warren, 1995). Artificial manipulations of visual information have important consequences on locomotion: changing the speed of optic flow induces systematic changes in walking speed (Pailhous et al., 1988). Often during locomotion perturbations to the postural control system must be counteracted. Vision provides a rich and reliable source of information about perturbations. Visual information is used in both feed-forward and feed-back loops: Feed-forward anticipation of oncoming perturbations seems to be a primary function of visual information in walking (see Patla, 1997, 2003); feed-back optomotor responses correspond to online adjustments to the locomotor control system. Generally, findings have supported a dominant view that human locomotion is driven by feed-forward visual information, and that feed-back control of locomotion is minimally supported by simple visual cues from the peripheral field. However, compared to feed-forward control, few studies on feed-back locomotion control have been carried out. One study showed that occlusion of the lower visual field leads to increased movement variability when stepping over an obstacle (Graci, Elliott, & Buckley, 2010). Another study has indicated that when objects in the lower visual field suddenly change in size, limb swing trajectory is amended with sub-100ms latency (Perry & Patla, 2001). These studies emphasize that visual cues regarding obstacle size or limb swing trajectory are used in feed-back control loops. Given the dominant role that optic flow plays in human locomotion, it seems likely that information derived from the optic flow field could also drive responses to perturbations. However, this idea has not been studied in detail. Our research tests the idea that walking humans take advantage of optic flow in the active phase during a perturbation in order to remain stable. Our current experiment employs a VR system to simulate stepping over obstacles. The task reveals the degree to which optic flow is integrated online into the stepping response. We manipulate visual information at the step-over time (thus assessing feed-back rather than feed-forward integration). Manipulations during the step-over are: continuous optic flow, a left-right shift of the scene, or no optic flow. If these conditions produce predictable changes in stepping kinematics, we can conclude that optic flow is used online for locomotion control.

20) Space-fixed, retina-fixed, and frame-independent mechanisms of trans-saccadic feature integration: An fMRIa paradigm

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To date, the neural mechanisms of feature information integration across saccades, also known as trans-saccadic integration (TSI), of low-level object features are relatively unknown. Using fMRI adaptation (fMRIa), we found that the right inferior parietal lobule (IPL; specifically, SMG) and extrastriate cortex (putative V4) are sensitive to stimulus orientation in a space-fixed reference frame (Dunkley & Crawford, Society for Neuroscience Abstracts, 2012). To identify the neural mechanisms of underlying TSI in multiple reference frames, we employed fMRIa to probe three spatial conditions: 1) Space-fixed, 2) Retina-fixed and 3) Frame-independent (neither Space-fixed, nor Retina-fixed). Functional data were collected across 12 participants while they observed an obliquely oriented grating (45° or 135°), followed by a grating at the same ('Repeat' condition) or different angle ('Novel' condition). Participants were instructed to decide via 2AFC if the subsequent grating was repeated or novel. Repeat vs. Novel contrasts showed repetition suppression (RS) and enhancement (RE). RS showed condition-specific patterns within a parieto-frontal network. Distinct areas of activation were identified for the three conditions (i.e., SMG for Condition 1; inferior frontal gyrus (IFG) for Condition 2; and FEF and Brodmann area 7 for Condition 3) as well as common clusters (i.e., posterior middle intraparietal sulcus, M1and pre-supplementary area). RE was observed in occipitotemporal areas. Specifically, RE in Condition 1 was observed in lateral occipitotemporal gyrus (LOtG) in the left hemisphere. RE in Condition 2 was not observed. In Condition 3, RE was found in LOtG in the right hemisphere. Overall, TSI of orientation activated different cortical patterns (with some parietal overlap) in the three frames. Specifically, suppression occurred in a 'cognitive-sensorimotor,' parieto-frontal network, whereas enhancement occurred in occipitotemporal regions.

21) Action and perceptual rivalry

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Hand actions that are relevant to the perceptual task can bias the perception of a bistable stimulus: if one interpretation of the stimulus is congruent with the action while the other is incongruent, the congruent percept becomes more dominant. In our experiment we apply this idea to a binocular rivalry situation, where the task of the participant is to perceive a moving

grating stimulus presented to one eye, while a flash suppressor is presented to the other eye. Tracking the eye movements allows us to measure when the eyes are following the grating stimulus (optokinetic nystagmus), while participants also give a subjective report of when they are able to perceive the grating. The relative dominance of the grating stimulus is greater, when the speed of the grating is directly coupled to the hand movement of the participant, as opposed to when the grating is coupled with the hand movements of a previous block and the participant makes no concurrent hand movements. In the second phase of the experiment we manipulate the degree of coupling between action and grating velocity to see if the effect is due to merely the concurrent action or if direct coupling is necessary.

Perceiving biological motion can also bias perceptual rivalry. In my other experiment I examine how cueing spatial locations with biological versus non-biological stimuli causes incidental attentional orienting that alters perception of time (prior entry) and space (change in perceived size).

22) The neural correlates of intercepting moving objects with the hand

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In everyday life, we are subjected to dynamic object interaction. Manual interception of a moving object is a complex process which involves the perception of object motion and creating a motor plan to intercept the object while considering inherent delays of sensorimotor processing. Currently, research has primarily focused on either the perception of motion or the control of arm movements rather than the role of motion in guiding actions (such as catching a baseball or falling glass). The intention of this study is to examine the cognitive processes in humans that are involved in the interception of moving targets with a reaching movement using functional magnetic resonance imaging (fMRI). Using a touch screen, participants perform a dynamic interception task in the MRI scanner to explore the neural correlates involved in the perception and interception of dynamic objects. In the interception conditions, participants are instructed to covertly attend and intercept one of four 2-D targets on cue with a reach-to-point movement. In perception conditions, participants attend a target where they intercept a non-target location on cue. We independently manipulate the behaviour to isolate brain areas preferentially involved in either interception, perception, or both. The covertly attended target may either be dynamic or static to isolate areas involved in planning versus execution of the reach-to-point movement. We hypothesize that area MT+/V5 is involved in the perception of the moving targets, whereas areas of the dorsal stream, involved in visually guided reaching, such as the superior parietal occipital cortex (SPOC) and interparietal sulcus (IPS) are involved in the motor planning of

interception. With this research, we aim to merge the literature between arm movements and motion perception.

23) Pupillomotor patterns as an early direction prediction in prodromal and manifest neurodegenerative diseases (e.g. Parkinson's disease)

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Rapid eye movement sleep behavior disorder (RBD) is a parasomnia which is defined by a loss of muscle atonia during REM sleep. Thereby, patients with RBD display often complex motion sequences during sleep by enacting violent dreams in which they are being chased or attacked by strangers or animals harming themselves or their bed partners many times. The prevalence of RBD is estimated 0.5% of the general population. Importantly to note, approximately 10 to 20 years afterward more than 82% of the patients with idiopathic RBD show a conversion to α-synucleinopathies, making this disease the most specific prodromal marker of Parkinson's disease (PD) and, in rare cases of multiple system atrophy (MSA) and dementia with Lewy bodies (DLB).

Previous studies in animals and in humans have shown that the etiology of RBD and hence, the prodromal stage of the stated neurodegenerative diseases, might be related to an impairment of the coeruleus/subcoeruleus complex due to intraneuronal inclusion of α-synuclein. This anatomic structure in the brain stem modulates the autonomic nervous system by norepinephrine and seems especially involved in the control of muscle atonia during REM sleep. Further, the noradrenergic locus coeruleus (LC) regulates attention and the orienting response thus inter alia the psychophysiological parameter of pupil dilation.

A non-invasive method to investigate the function of the noradrenergic LC is to detect pupil dilation by an eye-tracking-system EyeSeeCam under a perceptual rivalry task. The later provokes different internal percepts of the same visual stimulus. By presenting the so called Necker's cube, pupil dilation during visual perception changes can be registered by keypress and could be used as an indirect measurement of LC activation.

Therefore, we currently examine differences in the pupil reaction of N = 40 patients with RBD, N = 120 patients with PD (de novo, with/without dopaminergic medication), N = 40 patients with MSA, N = 40 patients with progressive supranuclear palsy (PSP), N = 40 patients with DLB and N = 50 healthy controls to determine different pupillomotor patterns between the groups. Thus, in future it might be possible to establish a non-invasive and economic

diagnostic procedure in and for the pre-motor stage of alpha-synucleionpathies, i.e. PD, MSA and DLB.

24) Visual spatial processing in infancy: On mental rotation ability and habituation to two- and three-dimensional objects

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Successful actions upon the visual world around us require continuous processing of visual spatial object information; such as discriminating two- and three dimensional objects or rotating their mental representations. Concerning this, studies with adults and children provide evidence for a distinct processing of real objects versus object images (Carver, Meltzoff, & Dawson, 2006; Snow et al., 2011), as well as for processes of analog mental rotation (Shepard & Metzler, 1971). However, the questions of when these phenomena emerge and which developmental factors may contribute to their progression is still subject to current research. In order to shed some light onto the questions raised above, we conducted two experiments on 7- to 9-month-old infants' visual habituation to two- and three-dimensional objects and their mental rotation ability.

Experiment 1 aimed at investigating if and to which extent 7- and 9-month-old infants' visual habituation patterns differ with respect to real 3D objects versus matched image displays. By using the habituation-dishabituation paradigm, we first habituated 7- and 9-month-old infants to a real 3D object or the corresponding 2D photograph of that object. During testing, we presented the 3D and corresponding 2D stimuli as pairs. We expected that infants' habituation to 2D objects differs from the habituation to the corresponding 3D objects and that infants prefer to look at 3D objects.

In experiment 2 we wanted to test whether 9-month-old infants with varying levels of motor skills show signs of analog mental rotation. Infants were habituated to a video of a simplified Shepard-Metzler object rotating forward through a 180° angle. During testing, infants were allocated to different conditions varying in the angular difference between habituation and test objects. Infants' fine and gross motor development was also assessed. We assumed that larger angles of rotation would impede infants' task performance. At the same time we expected infants to benefit from higher fine and gross motor skills.

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POSTER ABSTRACTS

1) Investigating the neural mechanisms of reach-grasp integration

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Grasping is a fundamental skill that we need to interact with our environment. To successfully grasp an object, the transport of the arm and hand must be closely coordinated with the grip. However, most research to date employ experimental paradigms that emphasize the independence of the reach (transport) and grasp (grip) components. Indeed, it is still largely unknown how the two components are integrated by the human brain to produce reach-grasp coordination. To investigate this, we used slow event-related fMRI to examine the neural circuits involved in the integration of reach direction and grasp orientation. Participants performed a cue-separation task in which they received visual information about the object location and auditory information about the grasp orientation in two successive phases. In one condition, participants were first cued about the location of the object (left or right), and then after an 8 second delay, they were cued about the grasp orientation (horizontal or vertical), followed by another 8 second delay, after which the participants grasped the object. In another condition, the cues were given in the reverse order. We predicted that brain areas associated with reach-grasp integration would respond more strongly during the second delay compared to the first delay, because of the added integrative processes of visual information about the object location into action planning. We performed voxelwise analyses (n = 10) and found increased activations in the anterior intraparietal sulcus (aIPS), ventral premotor cortex (PMv), and primary motor area (M1) in the left hemisphere. The results suggest that brain areas within the dorsolateral grasp-network is involved in integrating reach location with grasp orientation. These results are significant for the medical field because of its ability to help develop rehabilitation programs that can test multiple aspects of visuomotor performance in patients.

2) How visual motion in different parts of the visual field updates our sense of spatial location

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Visual motion can induce an illusionary sensation of self-motion, called vection, which can be used to update our sense of location through an estimate of a change in position.

Previous research has found that when using visually induced self-motion participants either over- or under-estimate their change in position depending on if they are moving toward a target or away from a starting point, respectively. The full range of performance can be modeled as a leaky spatial integrator (Lappe et al. 2007). Early studies suggested that peripheral vision was more effective than central vision in evoking self-motion (Brandt et al. 1973). This may be due to stimuli in the periphery being perceived as farther away than stimuli in the central field. By controlling for depth, all retinal zones within the central 90 degrees appear equally effective at evoking vection (Nakamura, 2008). Neither study was able to investigate the far periphery.

Using a large-field, Edgeless Graphics display (Christie, Canada, field of view ±112°) and blocking central (±20 and ±40°) or peripheral (viewing through holes of the same sizes) parts of the field, we compared participants' ability to update their perceived location during vection. Ten participants indicated when they had reached the position of a previously presented target. Three speeds (2, 6, 10m/s) and five target distances (5-45m) were interleaved to prevent using time estimates. Data were modelled with Lappe's leaky spatial integrator model to estimate gains (perceived/actual distance) and a spatial decay factor.

In all cases participants had a gain less than 1.0 indicating that they needed to visually travel further than the target distance to believe they had reached the target. When visual motion was only available in the periphery (beyond ±40°) gains were significantly higher compared to motion presented full-field or centrally. A second study using similar methods but slower speeds (05, 1, 1.5m/s) and closer distances (3-12m) blocked up to ±90° of the central visual field. Data are in the preliminary stages of analysis but the trend indicates that the further in the periphery visual motion is presented, the higher the gain. When visual motion was only available in the far periphery (beyond ±90°) gains were greater than one, indicating that participants believed they had arrived at the target destination before actually having arrived there.

It appears that any kind of central-field motion, including full-field motion, causes participants to require more visual motion in order to believe they have travelled through a given distance compared to when visual motion is only presented in the periphery.

3) **Effect of neck muscle sensory noise on reference frame transformation in reach planning**

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Human beings combine different sensory modalities in a statistically optimal manner for reach planning. For example, in a reaching task, both visual and proprioceptive information will be combined for estimating hand position and planning the movement. Based on weak fusion model, these signals should be transformed to a common reference frame, known as Reference Frame Transformation (RFT). This RFT introduces noise to the transformed signal and ultimately affects the reaching behavior. The goal of this experiment is to investigate the effect of noise in RFT and reach planning. The motivation comes from two different interpretation of an observation made by Burns and Blohm. They observed that rolling the head increased the variability in reach errors and speculated that the noise in Head Roll (HR) estimation is a Signal-Dependent Noise (SDN) which induces noise in RFTs and ultimately reaching. However, another interpretation could be that since the straight head is the more common posture, the central nervous system assigned more resources for RFT in this posture and therefore is less noisy, independent of SDN. As a result, we are interested in manipulating HR estimation by stimulating neck muscles' signal to examine the rule of SDN in RFT and reaching.

Subjects were asked to stand in front of a virtual reality robotic setup (KINARM, BKIN Technologies) and perform center-out reaches toward one of eight visual targets that were uniformly distributed on a 10cm radius circle, while keeping their gaze at the center. A conflict between visual and proprioceptive information occurred by shifting the hand 2.5cm either vertically or laterally while providing visual feedback that indicated the IHP was always at the center. Subjects performed the task with three different HR rotations;-30, 0, and +30 degrees. Each HR condition was performed under three head load (1.8kg) conditions, simulating neck muscle tension required for 30deg head roll; leftward load, no load and rightward load. We hypothesized that altering neck muscles' force will create a bias in HR estimation and varying the HR estimation.

Looking at the effect of neck load on reach errors without rolling the head, we found that psychometric curves shifted upward/downward, indicating that the neck load creates a bias in HR estimation. This increase in bias implies that even though actual HR was 0, the HR estimation was higher than when no load was applied to the neck; however, this HR estimation was less than when the actual HR was 30 degrees. Comparing these three cases, we observed that the noise increases with increasing HR estimation. This demonstrates that noise in extra-retinal signals (here neck muscles) affects RFT and consequently reach planning.

4) Familiar size relationships decrease size contrast illusion

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The image of a large dog beside a small cat is familiar to us because it is congruent with our knowledge of the real world sizes of these animals. The familiar size effect, which is characterized by slower reaction times when judging the size of objects that are incongruent with their familiar sizes, suggests that previous knowledge of an object's real world size can influence visual perception. But does familiar size also affect the perceived size? Here we examined the effect of familiar size on the classic Ebbinghaus illusion in which a central image surrounded by larger images is perceived as smaller than it actually is (and one surrounded by smaller images is perceived as larger). Participants used a keyboard to adjust the size of the target image on a computer screen so that it matched the perceived size of the central image in an Ebbinghaus illusion. The central image was identical throughout all trials (a 25-mm-wide dog), but the surrounding images (i.e., annuli) could differ according to physical size (12 mm vs. 37 mm), semantic category (animate vs. inanimate), and familiar size (cat vs. horse for the animate category; shoe vs. car for the inanimate category). Importantly, the physical size relationship between the central and surrounding images was either congruent (e.g., dog surrounded by *small* shoes or large cars) or incongruent (e.g., dog surrounded by *large* shoes or small cars) with their familiar size relationship. Illusion strength was defined by the difference in the perceived size of the central image between the conditions with physically small and physically large annuli. The strength of the illusion was significantly weaker in the congruent conditions than the incongruent conditions. For example, a dog of constant size was perceived as much smaller when surrounded by large shoes compared to small cars but the difference in perceived size was much attenuated for a dog surrounded by small shoes compared to large cars. These results show that perceived size is affected not just by retinal size but also by familiar size relationships.

5) Pupil size is modulated by the size of flux-equated gratings

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Pupil size changes with light. For this reason, researchers studying the effect of attention, contextual processing and arousal on pupillary response have matched the mean luminance of their stimuli across conditions to eliminate the contribution of differences in light levels. Here we argue that the match of mean luminance is not enough. We presented a circular sinewave grating on a gray background for 2 s. The diameter of the grating could be 2 °, 4 ° or 8 °. The mean luminance of each grating was equal to the luminance of the gray background, such that regardless of the size of the grating, there was never a change in flux between presentations of the gratings. Participants were asked to fixate the center of the grating and passively view it. We found that in all size conditions, there was a pupil constriction starting at about 300 ms after stimulus onset, and the pupil constriction increased with the size of the grating. To explore to what extent this effect was due to attention, we

replicated this experiment but had the subjects perform an attention-demanding fixation task in one session, and passively view the stimuli in the other. The main effect of size was significant but the main effect of attention was not. This suggests that the effect of stimulus size on pupil size cannot be attributed to attention. In sum, our results show that stimulus size can modulate pupil size even when the luminance is matched across the different stimuli.

6) <u>Cues to gender perception in action performance</u>

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Gender discrimination denotes the process through which observers categorize others as male or female. The last 50 years have seen a growing movement arguing for the necessity of studying the information available in impoverished point-light displays instead of relying on socio-cognitive theories (Baron, 1980; Cutting, Proffit, & Kozlowski, 1978). So far, walking has been the preferred action to investigate. Researchers have exploited computerized point-light stimuli to examine and manipulate the gender-related information in walking, and have concluded that kinematic cues are more important than structural information in gender discrimination. For example, when the effect of kinematic cues (e.g., magnitude of hip and shoulder sway) is contrasted experimentally with the effects of structural cues (e.g., magnitude of the shoulder-to-waist ratio), perceived gender is mostly dictated by the kinematic cues (e.g., Mather & Murdoch, 1994; Troje, 2002, 2008).

An underexplored issue has been the extent to which this preference for kinematic information holds true over a variety of observed actions —e.g., walking, jumping, kicking a ball, lifting objects—and whether there are action-invariant kinematic cues to gender. Few experiments have tackled this issue directly. Instead, most experiments have simply focused on correct gender discrimination rates across actions (e.g., Pollick, Lestou, Ryu, & Cho, 2002; Runeson & Frykholm, 1983) while others have tried to identify action-specific cues to gender and their correlation to individual characteristics (e.g., Hufschmidt et al., 2015; Wöllner & Deconinck, 2013).

We propose that correct gender discrimination rates across actions are directly related to the kinematic cue characteristics available in the stimuli. To answer this question, we are analysing data from an experiment where observers viewed a variety of actions and reported whether the performer was male or female. This psychophysical data is used as a class indicator in a linear discriminant analysis (Troje, 2008). The class indicator is regressed on a low-dimensional representation of the non-periodic actions where the corresponding features have been aligned. Kinematic cue differences of action performance are expressed in terms of gender variations in temporal and postural differences in execution, as well as velocity and acceleration profiles (Ramsey, Hookers, & Graves, 2009). This research will bring light to possible invariants in action-based gender discrimination that modulate perceived gender.

7) <u>Investigating the role of superior colliculus in the coding of visual saliency and behavioural priority</u>

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The primate superior colliculus (SC; optic tectum in non-mammals) is a multilayered midbrain structure with visual representations in the superficial-layers (SCs), and sensorimotor representations linked to the control of eye movements/attention in the intermediate-layers (SCi). Our laboratory has been exploring the hypothesis that the SCs embodies the role of a visual saliency map (the pure visual properties that make a stimulus stand out from its neighbors), and the SCi embodies the role of a behavioural priority map (the combined representation of visual saliency and behavioural relevancy or value associated with a stimulus). Previous work in our laboratory revealed that SCs neurons showed a behavioural-agnostic representation of visual saliency in (i) structured tasks in which the salient stimulus was goal irrelevant, and (ii) during free viewing of natural dynamic scenes using a computational model to extract saliency across time and space of a series of high definition video clips. SCi neurons only showed an enhanced response for greater saliency when the stimulus that evoked it was the goal of the next saccade (suggesting these stimuli/locations elicited greater top-down interest or value). These results implicate the SCs in the role of a bottom-up saliency map, whereas the SCi regulates which salient signals are prioritized for the locus of gaze. To better examine the effect of relevancy on SCi, we will expand on the current tasks to include controlled manipulations of top-down goals. First, we propose to make the salient stimulus in the structured task goal relevant (ie. by making it the target of a second saccade) in a subset of trials, and compare SC neurons' response to the stimulus when it is goal relevant and when it is goal irrelevant. We hypothesize that SCi activity will only reflect the saliency of the stimulus when the stimulus is made goal relevant. Second, we propose to add a search target in the natural scenes to see how similarity to goal-directed stimuli affect activity in the SC, with the ultimate goal of introducing similarity to search target as a new component in the saliency model. Finally, we will explore in greater detail the roles of the different layers of the SC in saliency and priority encoding by using linear electrode arrays to simultaneously record activity in different layers of the SC during our tasks. This will allow us to directly compare activity in the SCs and SCi to the same stimulus, which will be particularly valuable in the natural scene experiments, where stimuli are always changing.

8) <u>Temporal distortion in the perception of actions and events</u>

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We recently showed that when a sensory event triggers an action, we perceive the event to occur later than it really does (Yabe & Goodale, Journal of Neuroscience, in press). Previous studies have shown that when we make our action results in a sensory event, we perceive the event to have occurred earlier than it really did (intentional binding). Events and actions are temporally bound to each other. It is not known, however, whether or not binding occurs when multiple events and actions occur alternately. In this study, we compared the temporal binding in an event-action-event (EAE) sequence to binding in an event-action (EA) sequence. Participants viewed a black dot displayed on a computer screen. A hand rotated around the dot like a conventional clock. In both conditions, participants were required to respond to a tone by making a hand-movement. In the EAE condition, another tone followed the elicited hand-movement. In the baseline condition, the participants heard the same tone, but were not required to respond. At the end of each trial, participants were required to report the location of the clock hand at the moment the tone occurred. We found that the perceived timing of the event in EA sequence was later than when the event was passively observed in the baseline condition, consistent with our previous study. In contrast, the perceived timing of the first event in EAE sequence was not significantly different from that observed in the baseline. The results suggest that the perceived timing of events triggering actions is sensitive to sensory events following the actions.

9) <u>Objects in the peripheral visual field influence gaze location in natural vision</u>

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In everyday behavior there are multiple competing demands for gaze; for instance, walking along a sidewalk requires paying attention to the path while avoiding other pedestrians. Therefore, humans make numerous fixations to satisfy their behavioral goals. One attempt to explore suitable strategies of gaze allocation for natural situations was made by Sprague, Ballard and Robinson (2007), whose computational model predicts human visuo-motor behavior based on intrinsic reward and uncertainty. Their model presupposes that specific visual information is acquired from the currently fixated object only. However, evidence that peripheral objects affect gaze position by drawing it towards the center of gravity of target ensembles (Findlay, 1982; Vishwanath & Kowler, 2003) challenges this premise. Since the influence of peripheral information for natural vision remains largely unexplored, we investigated whether gaze targeting is biased towards peripheral objects in naturalistic tasks. Using a Virtual Reality environment, the fixations of 12 participants were examined while they walked through a virtual room with objects of two different colors that were designated targets or obstacles. The subjects were instructed to either collect

targets, to avoid obstacles or to do both tasks simultaneously. For situations in which one of two visible objects was fixated, subjects' gaze positions were biased more often *towards* the non-fixated object (72.6%) than away from it (27.4%). Moreover, the gaze position tended to be drawn more frequently towards the neighboring object when this neighbor was relevant to the current task than when it was task-irrelevant. These results indicate that information from peripheral objects affect human gaze targeting in natural vision. Furthermore, the effect of the neighbor's task-relevance - and therefore of intrinsic reward - suggests that in a given fixation subjects might gather information from the peripheral visual field to accomplish a current set of goals at once.

10) A combined approach to predictive processes in voluntary action: Sensory attenuation in N1 and SDT measures

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Outcomes of voluntary actions are predicted by the actor if they match the intended action goal. Ideomotor theories claim that representations of actions and their effects form bidirectional links. Thinking about or actually performing an action thus can trigger a corresponding effect representation and vice versa, resulting in action-effect anticipation. It has been shown, that anticipated sensory stimuli following voluntary actions are attenuated both in their neural response and subjective measures. This effect of sensory attenuation can be used as a marker for action-effect anticipation. Most studies however claim that this effect is a result of motor prediction processes in line with ideomotor theories but fail to account for other predictive processes such as temporal prediction. Additionally no study so far used neurophysiological and behavioral measures of sensory attenuation within one common paradigm. The relation between those two aspects thus remains unclear. We adapted a paradigm which is able to isolate the specific motor prediction process in action-effect prediction, introduced a naturalistic task to better represent ideomotor actions and measured both the N1 component of the event-related potential (ERP) and the sensitivity statistic (d') from signal detection theory for sensory attenuation.

Participants freely rotated one of two switches to cause a ball to roll either to the left or to the right side of a computer screen. A gabor patch, whose orientation participants had to report, was then presented shortly on top of the target ball. We manipulated the predictability of the target ball depending on participants' actions. Expecting sensory attenuation in both measures for predictable trials we then compared fully predictable versus unpredictable and prediction-congruent (i.e. when the ball appeared on the right side after a right hand action) versus prediction-incongruent trials.

We found sensory attenuation in d' measures for fully predictable but not for prediction-congruent trials. N1 amplitudes on the other hand were evidently attenuated for prediction-

congruent but not for fully predictable trials. In addition we found that the N1 effect vanished if participants were instructed to attend to a red ball as contrasted to an isoluminant blue ball.

These findings contribute to a better understanding of how action and perception work together and may even lead to new insights into disorders like schizophrenia, which are related to disturbances in sensorimotor processing.

11) Motivation modulates haptic softness exploration

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Haptic softness perception requires active movement control. Stereotypically, softness is judged by repeatedly indenting an objects surface. In an exploration without any constrains, participants freely control the number of indentations and the executed forces. We investigated the influence of motivation and task difficulty on these two parameters. Participants performed a 2AFC discrimination task for stimulus pairs, taken from two softness categories and with one of two difficulties. Half of the participants explored all stimulus pairs from one softness in one block, allowing expectations on softness category, while the second half of participants explored all stimulus pairs in a random order. We manipulated the participants' motivation by associating a monetary value to each correct response for half of the experiment. In the other half, performance was unrelated to the payment. We found higher exploratory forces in the high-motivation condition. The number of indentations was influenced by task difficulty and not by motivation. Furthermore, motivational effects were modulated by the existence of softness expectations. Taken together, these results indicate the existence of motivational effects on movement control in haptic softness exploration. Consequently, as executed movements influence the sensory intake, top-down signals affect how we gather bottom-up sensory information.

12) Saccade curvature as a function of spatial congruency and movement preparation time in simultaneous and sequential dual-task paradigms

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Saccade curvature is a sensitive measure of spatial attention with saccades curving away from covertly attended locations. The current study investigated whether curvature away remains unaffected by movement preparation time when a perceptual task is performed concurrently, and declines with increasing movement preparation time when the perceptual task is performed before the saccade task. Participants underwent a dual-task including a

visual discrimination task at a cued location and a saccade task to the same (congruent) or a different (incongruent) location. We varied saccade preparation time (time between saccade cue and Go-signal) and the occurrence of the discrimination task (immediately after the Go-signal = simultaneous vs. before saccade preparation = sequential). Results show that saccades curved away in incongruent relative to congruent trials. This effect remained stable in the simultaneous condition while it decreased with increasing movement preparation time in the sequential condition. Our finding indicates that a competing saccade plan is inhibited after the Go-signal during simultaneous task performance while inhibition is applied earlier and decays gradually with movement preparation time in the sequential condition. This can be explained by different time courses of attentional deployment at the discrimination target location for simultaneous and sequential dual-tasks.

13) Neural correlates of path direction detection using human echolocation

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It is well established that blind and sighted humans can learn to sense and interact with their environment using echolocation. In skilled blind echolocators, recent brain imaging studies have shown that judging shape, identity or location of surfaces using echolocation activates primary visual areas. In the present study, we investigated fMRI BOLD activity elicited by the processing of path direction through echolocation during walking. We measured brain activations using fMRI in 3 blind echolocation experts, as well as 3 blind and 3 sighted novices. During scanning, participants listened to binaural audio stimuli recorded while blind experts had walked along a corridor in a naturalistic indoor and outdoor setting and echolocated. Corridors could continue to the left, right or straight ahead. Our subjects also listened to control stimuli containing ambient sounds and clicks, but no echoes. They were instructed to indicate via button press whether the corridor in the recording continued left, right or straight ahead, or if they were listening to a control sound. Participants were very good at discriminating echo from control sounds, but the echolocation experts performed better at path direction detection. We found that processing of path direction (contrasting echo vs. control) activated the superior parietal lobule (SPL) and inferior frontal cortex (IFC). SPL activation was stronger in blind participants. The sighted novices additionally activated the inferior parietal lobule (IPL) and middle and superior frontal areas. Our results suggest that blind people are able to directly assign spatial meaning to echo sounds, while sighted participants rely on more conscious, high-level cognitive processes.

14) Developmental aspects of the perceived arousal and valence of facial expressions

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Arousal and valence have long been studied as the two primary dimensions for the perception of emotional stimuli such as facial expressions (Russell, 1980; Schubert, 1999). There have been a number of studies in adults showing the influence of these two emotional dimensions using various techniques such as fMRI, EEG and behavioral tasks (Güntekin & Basar, 2007; Ku et al., 2005; Nelson et al., 2003). However, there have been few studies examining the developmental differences in the perception of emotional facial expressions between children and adults along these dimensions. One such study (Russell & Bullock, 1985) examined the correlation between two-dimensional solutions of an emotional-similarity grouping task (for faces), and the valence/arousal two-dimension space, and found high correlations in children and adults. Another study (McManis, Bradley, Berg, Cuthbert, & Lang, 2001) using the Self-Assessment Manikin (SAM) also found high correlations in ratings of general affective images in children, adolescents, and adults. These results validated the valence-arousal emotional space, and show that both children and adults follow similar perception patterns along these two dimensions. However, that still leaves open to question the degree of similarity in absolute terms between children and adults in the perception of facial expressions. In the present experiments, we tested 9-year-old children and adults. They were asked to rate facial stimuli on emotional arousal and valence using the SAM rating scale. Facial stimuli consisted of 24 positive (happy, happy-surprised) and 24 negative (sad, fearful, angry) facial expressions. Next, we analyzed the effects of age, sex, and emotional categories on the perceived valence and arousal ratings. Despite high correlations between children's and adults' ratings of valence and arousal, our findings show significant differences between children and adults in absolute terms: Children rate emotional expressions significantly higher than adults in both arousal and valence ($p < 0.001$, $p < 0.01$, respectively). We also found significant interactions between age and the sex of our subjects in both arousal and valence ($p < 0.01$, $p < 0.05$, respectively), with girls giving higher ratings than boys, and men giving higher ratings than women. In sum, our results demonstrate that emotional expression perception as measured by arousal and valence follows similar patterns in both children and adults. However, despite this broad similarity a number of sex-related factors significantly impacted valence and arousal ratings, and require further examination in future developmental studies of emotional expression perception.

15) Maximum-likelihood integration of peripheral and foveal information across saccades

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Humans identify interesting objects with peripheral vision and use eye movements to project them onto the fovea to receive high-acuity information. Although there is evidence that pre-saccadic peripheral and post-saccadic foveal information is integrated (Demeyer, De Graef, Wagemans & Verfaillie, 2010), this has not been assessed with respect to formal models of signal integration (Ernst & Banks, 2002).

Observers foveated peripherally appearing plaid stimuli and judged the orientation of the vertical component in a 2AFC task. To measure peripheral and foveal perception separately, plaids were visible either before or after the saccade for the same duration. To measure the integrated percept, plaids were visible throughout the trial but were exchanged during the saccade. We manipulated relative reliability of peripheral and foveal information by varying the foveal contrast in three steps. To manipulate relative biases, pre-saccadic orientation could either be identical to foveal orientation or shifted to either side by 2.5°.

As predicted, the weighting of peripheral information increased with decreasing foveal reliability. Moreover, reliabilities of the combined percept were higher than for peripheral or foveal perception alone. These results suggest that pre-saccadic peripheral and post-saccadic foveal information is integrated into a combined percept according to their relative reliability.

16) Action-specific motor maps of imagined and executed hand movements? An MVPA analysis

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Jeannerod (2001) hypothesized that action execution, imagery and observation are functionally equivalent, what led to the prediction that these motor states are based on the same motor representations. Furthermore, the organization of motor maps within the human motor areas during the execution and imagination of actions is an intensely debated issue. In particular, it is unclear whether motor imagery and execution relies on action- specific somatotopic or effector-specific representations in motor, premotor and posterior parietal cortices, respectivley (see, for a review, Fernandino and Iacoboni, 2010). The present study sought to test an action- specific driven hypothesis by attempting to decode the content of motor imagery and execution from spatial patterns of Blood Oxygen Level Dependent (BOLD) signals in motor and motor-related cortices. During fMRI-scanning 20 right-

handed volunteers underwent seven conditions: three imagery condition, three execution conditions and one baseline condition. In the six experimental conditions participants had to imagine and execute three different right-hand movements: a precision movement, an extension-flexion movement, and a squeezing movement. We then used multivoxel pattern analysis to decode the identity of imagined and executed movements based on spatial patterns of BOLD signals they evoked in premotor and posterior parietal cortices. We found that the content of motor imagination and execution, respectively, could be decoded significantly above chance level from spatial patterns of BOLD signals in both, frontal and parietal motor areas. Our data provide evidence that patterns of activity within premotor and posterior parietal cortex systematically vary with the contents of action imagination and execution, respectively.

Literature

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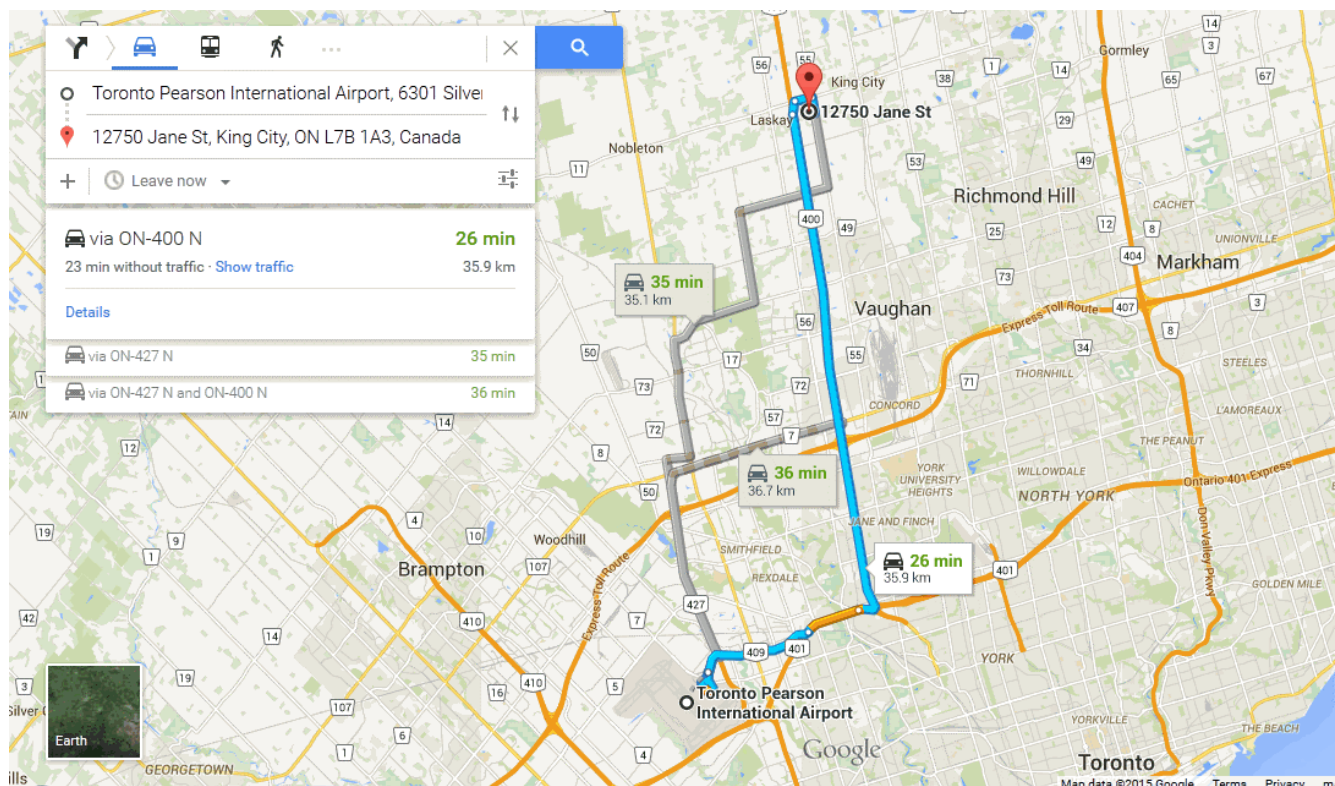
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Appendix Direction Maps:

Airport to Kingsbridge

From the Airport:

- Hwy 409 East
- Hwy 401 East
- Hwy 400 North
- Exit King Road East
- Turn right on to Jane Street
- Enter gates on the right

Kingsbridge to Pub