RIO group

2018 Annual Research in Imagery and Observation Group Meeting

12-13 April 2018

CITEC, Bielefeld University, Germany

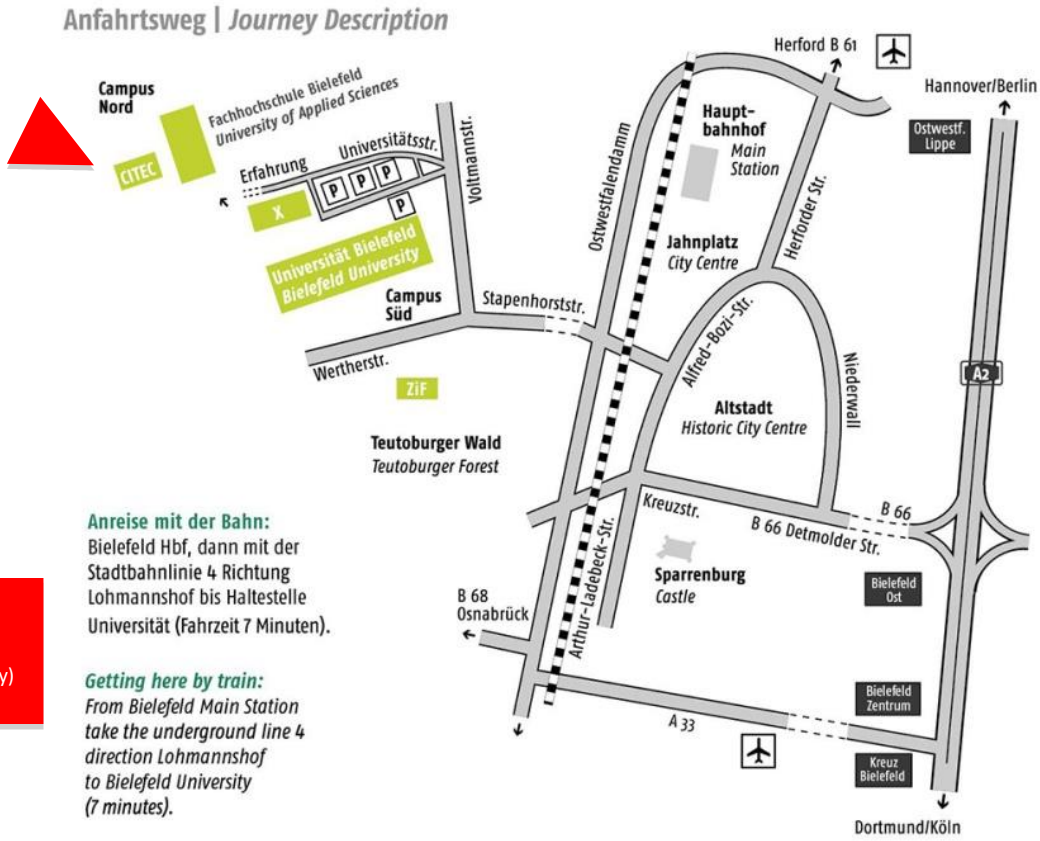
Welcome

Welcome to this year's RIO group meeting! The RIO group organisers Cornelia Frank, Daniel Eaves, David Wright, and Adam Bruton are looking forward to seeing all group members for the 2018 RIO group meeting in Germany. The meeting will take place 12-13 April at CITEC, Bielefeld University hosted by Cornelia Frank as local organiser. This year's programme looks excellent again, with contributions from various locations across Europe, and even worldwide. With this programme, we look forward to building on the success of recent meetings.

We would like to thank the Cluster of Excellence Cognitive Interaction Technology (CITEC) at Bielefeld University for providing us with financial support and a venue to host the 2018 Annual RIO Group Meeting. We would also like to thank BiSigma and the Institut für Wahrnehmungsforschung for their attendance and subsequent sponsorship of the meeting. Delegates are invited to visit the sponsors at their stand during coffee breaks.

Venue and Travel Information

The meeting will be held at
CITEC,
Bielefeld University,
Inspiration 1,
33619 Bielefeld,
Germany.
A campus map and travel information can be found online.

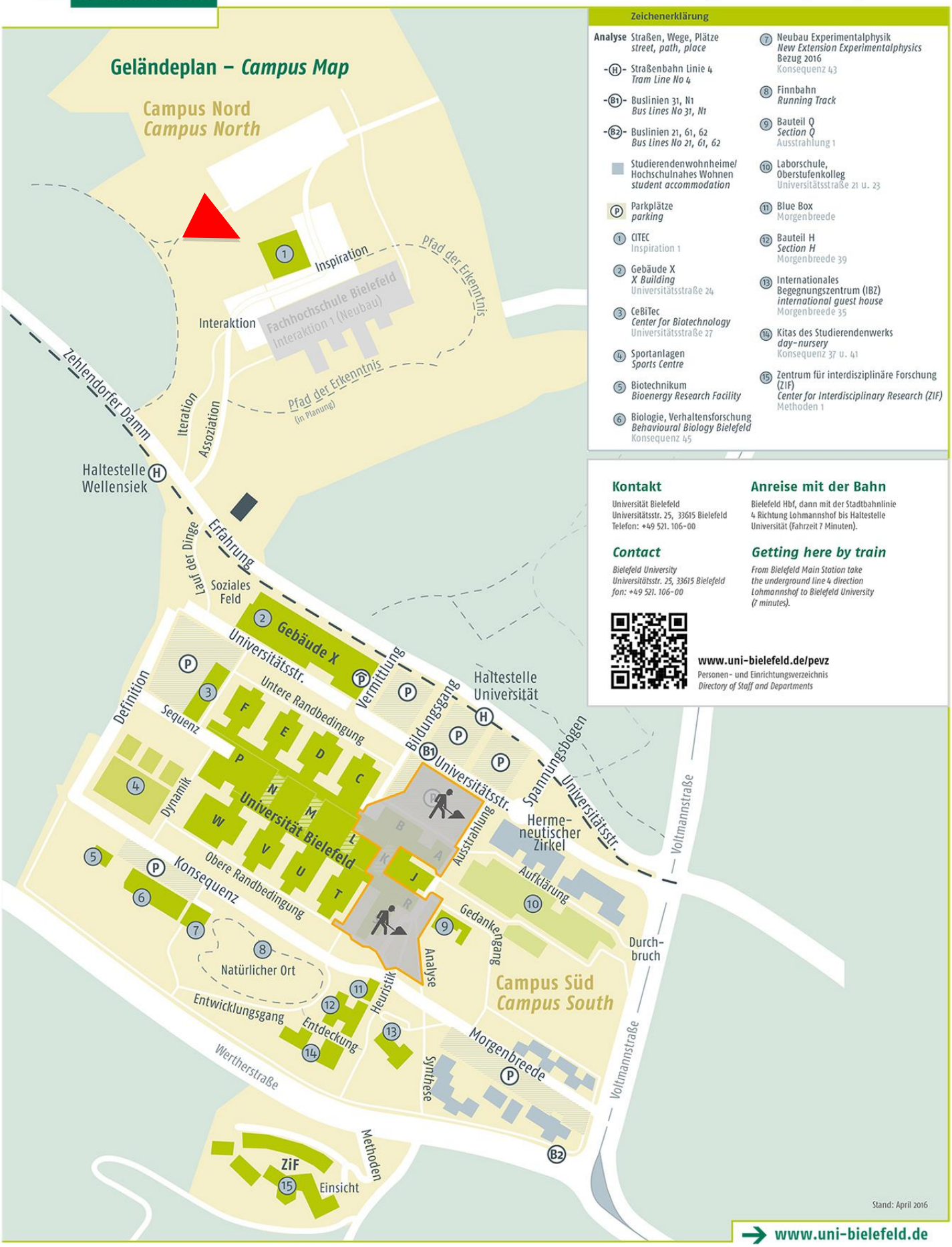


for CITEC, get off Wellensiek, please (1 stop after University)

Universität Bielefeld

Wegweiser | *Map Guide*

Geländeplan – *Campus Map*



Zeichenerklärung

Analyse Straßen, Wege, Plätze *street, path, place*

- (H) Straßenbahn Linie 4 *Tram Line No 4*
- (B1) Buslinien 31, N1 *Bus Lines No 31, N1*
- (B2) Buslinien 21, 61, 62 *Bus Lines No 21, 61, 62*
- Studierendenwohnheime/ Hochschulnahes Wohnen *student accommodation*
- (P) Parkplätze *parking*
- (1) CITEC Inspiration 1
- (2) Gebäude X *X Building* Universitätsstraße 24
- (3) CeBiTec *Center for Biotechnology* Universitätsstraße 27
- (4) Sportanlagen *Sports Centre*
- (5) Biotechnikum *Bioenergy Research Facility*
- (6) Biologie, Verhaltensforschung *Behavioural Biology Bielefeld* Konsequenz 45
- (7) Neubau Experimentalphysik *New Extension Experimentalphysics* Bezug 2016 Konsequenz 43
- (8) Finnbahn *Running Track*
- (9) Bauteil Q *Section Q* Ausstrahlung 1
- (10) Laborschule, Oberstufenkolleg Universitätsstraße 21 u. 23
- (11) Blue Box Morgenbreede
- (12) Bauteil H *Section H* Morgenbreede 39
- (13) Internationales Begegnungszentrum (IBZ) *international guest house* Morgenbreede 35
- (14) Kitas des Studierendenwerks *day-nursery* Konsequenz 37 u. 41
- (15) Zentrum für interdisziplinäre Forschung (ZIF) *Center for Interdisciplinary Research (ZIF)* Methoden 1

Kontakt

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Anreise mit der Bahn

Bielefeld Hbf, dann mit der Stadtbahnlinie 4 Richtung Lohmannshof bis Haltestelle Universität (Fahrzeit 7 Minuten).

Getting here by train

From Bielefeld Main Station take the underground line 4 direction Lohmannshof to Bielefeld University (7 minutes).

www.uni-bielefeld.de/pevz
Personen- und Einrichtungsverzeichnis
Directory of Staff and Departments

Stand: April 2016

www.uni-bielefeld.de

Research in Imagery and Observation
2018 Conference Schedule
Thursday 12th April

08.30 – 09.00 Registration (Entrance Hall, CITEC)

09.00 – 09.20 Welcome and Introduction (Lecture Hall, CITEC)

09.20 – 11.00 Oral Session 1: ***Imagery, Observation and Neuroscience*** (Lecture Hall, CITEC)

09.20 **Martin Riach**, Paul Holmes, Zoe Franklin, David Wright
Manchester Metropolitan University
Action observation with a congruent contextual background facilitates corticospinal excitability: A transcranial magnetic stimulation and eye-tracking experiment

09.40 **Giorgia D'Innocenzo[1]**, Dan Bishop[1], Alex Nowicky[1], Claudia Gonzalez[2], Andrew Williams[3], Francesco di Gruttola[4]
[1]Brunel University London, [2]Thompson Rivers University, [3]University of Utah, [4]University of Pisa
The relationship between gaze and information pickup during action observation

10.00 **David Wright[1]**, Greg Wood[1], Daniel Eaves[2], Adam Bruton[3], Cornelia Frank[4], Zoe Franklin[1]
[1]Manchester Metropolitan University, [2]Teesside University, [3]University of Roehampton, [4]Bielefeld University
Corticospinal excitability is facilitated by combined action observation and motor imagery of a basketball free throw

10.20 **Stefan Vogt**, Rosie Meers, Helen Nuttall
Lancaster University
Probing incongruent motor imagery during action observation states with motor evoked potentials: And the winner is…?

10.40 **Vasiliki Meletaki**, Beatriz Calvo-Merino, Irena Arslanova, Martina Fanghella, Bettina Forster
City, University of London
Investigating neural correlates of embodiment through facial emotion perception, its relation to heartbeat evoked potential and personality traits

11.00 – 11.30 Coffee Break (Foyer in front of lecture hall, CITEC)
Complementary tea/coffee available, provided by BiSigma and the Institut für Wahrnehmungsforschung

11.30 – 13.10 Oral Session 2: ***Imagery and Observation in Clinical Settings*** (Lecture Hall, CITEC)

11.30 **Andrius Vabalas**, Alex Casson, Emma Gowen, Ellen Poliakoff
University of Manchester
Characterizing motor impairments In autism using imitation and computational techniques

11.50 **Martina Fanghella[1,2]**, Beatriz Calvo Merino[1], Sebastian Gaigg[1], Matteo Candidi[2], Salvatore Maria Aglioti[2]
[1]City University of London, [2]Sapienza University of Rome
Investigating sensorimotor simulation of emotional expressions in autistic spectrum disorder: A study with somatosensory evoked potentials

12.10 **Matthew Scott**, Jonathan Emerson, Martin Tayler, John Dixon, Daniel Eaves
Teesside University
Motor imagery during action observation enhances automatic imitation in children with developmental coordination disorder

12.30 **Ben Marshall,** David Wright, Paul Holmes, Greg Wood
Manchester Metropolitan University
Combined action observation and motor imagery improves eye-hand coordination in children with developmental coordination disorder

12.50 **Judith Bek[1]**, Paul Holmes[2], Jordan Webb[1], Chesney Craig[2], Zoe Franklin[2], Matthew Sullivan[2], Emma Gowen[1], Ellen Poliakoff[1]
[1]University of Manchester, [2]Manchester Metropolitan University
Feasibility of home-based combined action observation and motor imagery training to facilitate everyday actions in Parkinson's disease

13.10 – 14.00 Lunch Break (FH Cafeteria)
Hot food and sandwiches available for purchase

14.00 – 15.00 Invited Talk 1 (Lecture Hall, CITEC)
Cathy Craig
Queen's University Belfast
How immersive, interactive virtual reality can help us understand decision-making in sport

15.00 – 16.00 Poster Session 1 – ***Imagery and Observation Across Domains*** (Foyer in front of lecture hall, CITEC)
Complementary tea/coffee available, provided by BiSigma and the Institut für Wahrnehmungsforschung

Amy Allington, Rae Hawkins, Matyas Varga, Nicholas Smeeton
University of Brighton
Action observation: Gait training in healthy people

Judith Bek[1], Matthew Sullivan[2], Gayathri Ganapathy[3], Ellen Poliakoff[1]
[1]University of Manchester, [2]Manchester Metropolitan University, [3]Equilibrium Dance and Arts
Observation of dance by people with Parkinson's disease

Adam Bruton[1], Stephen Mellalieu[2], David Shearer[3]
[1]University of Roehampton, [2]Cardiff Metropolitan University, [3]University of South Wales
A two-study investigation of observation level upon collective efficacy in team sports athletes

Stephan Dahm, Martina Rieger
Hall University for Health Sciences, Medical Informatics and Technology
Deviations from optimal performance in motor imagery

Cornelia Frank, Iwan de Kok, Felix Hülsmann, Mario Botsch, Stefan Kopp, Thomas Schack
Bielefeld University
Virtual coaching: On the influence of memory-based and execution-based verbal feedback in a virtual training environment

Taeho Kim, Cornelia Frank, Thomas Schack
Bielefeld University
The effect of different training schedules of action observation and motor imagery on the changes in mental representation structure, cognitive and skill performance

Alexis Deighton MacIntyre
University College London
The rhythmic coordination of breathing during joint speech and imagined joint speech

Eoghan McNeill, Adam Toth, Drew Harrison, Mark Campbell
University of Limerick
The impact of mental imagery on golf performance: Current understanding, unresolved issues and future research opportunities

Duru Gün Özkan[1,2], Rachele Pezzetta[1,2]
[1]Sapienza University of Rome, [2] Institute for Research and Health Care
Predicting the fate of basketball throws: A psychophysics and electroencephalography study in healthy and paraplegics athletes

Rachele Pezzetta[1,2], Valentina Nicolardi[1,2], Emmanuele Tidoni[2,3]
[1]Sapienza University of Rome, [2]Fondazione Santa Lucia, IRCCS, [3]University of Bologna
Electroencephalography indices of performance monitoring activity and error predictability: Embodying the actions of an avatar in immersive virtual reality

Ellen Poliakoff[1], Judith Bek[1], Chesney Craig[2], Zoe Franklin[2], Matthew Sullivan[2], Emma Gowen[1], Stefan Vogt[3], Trevor Crawford[3], Paul Holmes[2]
[1]University of Manchester, [2]Manchester Metropolitan University. [3]Lancaster University
Action imagery and observation in neurorehabilitation for Parkinson's disease: A pilot randomized controlled trial

Stephanie Romano-Smith[1], Dave Smith[2], David Wright[2], Ben Deller-Rust[2], Caroline Wakefield[1]
[1]Liverpool Hope University, [2]Manchester Metropolitan University
The effects of combining physical, environment, task, timing, learning, emotion, and perspective imagery and action observation on strength performance: A single-case design

Jack Solomon, Sarah Kraeutner, Tim Bardouille, Shaun Boe
Dalhousie University
Motor execution and imagery are unique processes

16.00 – 17.20 Oral Session 3 – ***Imagery and Observation in Sport and Exercise*** (Lecture Hall, CITEC)

16.00 **Waltraud Stadler[1]**, Veit Kraft[1], Masami Ishihara[2]
[1]Technical University of Munich, [2]Tokyo Metropolitan University
Cutting action into pieces: Segmentation of observed Taekwondo sequences by experts and novices

16.20 **Bettina Bläsing[1]**, Elizabeth Waterhouse[2,3]
[1]Bielefeld University, [2]University of Bern, [3]Freie Universität Berlin
How dance spectators watch dancers moving together: Effects of expertise, experience, intention and preference

16.40 **Melanie Stemper**, Matyas Varga, James Wrightson, Nicolas Smeeton
University of Brighton
The impact of action observation on a 15-min cycling time trial performance

17.00 **Tadhg MacIntyre[1]**, Christopher Madan[2]
[1]University of Limerick; [2]University of Nottingham
Green exercise effects: The role of mental imagery and mental time travel

17.20 – 17.30 Annual Group Meeting Photo (CITEC Entrance)

17.30 – 17.50 Virtual Reality Laboratory Tour, optional

18.30 Meet for Drinks (Bernstein; address see below)

19.30 Conference Dinner (Bernstein; address: Niederwall 2, entrance via Renteistraße; get off Jahnplatz)

Research in Imagery and Observation
2018 Conference Schedule
Friday 13th April

09.00 – 10.20 Oral Session 4 – ***Imagery, Observation, and Learning*** (Lecture Hall, CITEC)

09.00 **Franziska Klein**, Ling-Chia Chen, Cornelia Kranczioch
University of Oldenburg
Functional near-infrared spectroscopy-based motor imagery neurofeedback and motor learning: A pilot study

09.20 **Mareike Daeglau[1]**, Catharina Zich[1,2], Reiner Emkes[1], Julius Welzel[1], Stefan Debener[1], Cornelia Kranczioch[1]
[1]University of Oldenburg, [2]University of Oxford
Peripheral and neurophysiological correlates of motor imagery training with prior physical practice of a reach-to-grasp movement: Methodological challenges and first results

09.40 **Stephanie Romano-Smith[1]**, Greg Wood[2], Ginny Coyles[1], James Roberts[1], Caroline Wakefield[1]
[1]Liverpool Hope University, [2]Manchester Metropolitan University
The effect of combining motor imagery and action observation on aiming performance, upper-limb kinematics and muscle activation

10.00 **Jack Binks**, Christopher Wilson, Paul Van Schaik, Daniel Eaves
Teesside University
Motor imagery during action observation enhances learning of a complex movement sequencing task in the absence of physical practice

10.20 – 11.20 Poster Session 2 – ***Imagery and Observation Across Domains*** (Foyer in front of lecture hall, CITEC)
Complementary tea/coffee available, provided by BiSigma and the Institut für Wahrnehmungsforschung

For posters, see Poster Session 1 on day 1 of the RIO Group Meeting

11.20 – 12.20 Invited Talk 2 (Lecture Hall, CITEC)
Shaun Boe
Dalhousie University
The nature of motor imagery: A behavioural and neuroimaging perspective

12.20 – 13.00 Lunch Break (FH Cafeteria)
Hot food and sandwiches available for purchase

13.00 – 14.40 Oral Session 5 – ***Imagery, Observation, and Representation*** (Lecture Hall, CITEC)

13.00 **Sarah Kraeutner**, Sarah Eppler, Alexandra Stratas, Shaun Boe
Dalhousie University
Generate, maintain, manipulate? Linking assessments to dimensions of motor imagery

13.20 **Shiau-Chuen Chiou**, Thomas Schack
Bielefeld University
From observation to imitation: Working memory for whole-body movement sequences

13.40 **Francesco Di Gruttola[1]**, Diego Manzoni[1], Danilo Menicucci[1], Giorgia D'Innocenzo[2], Ursula Debarnot[3], Daniel Bishop[2], Angelo Gemignani[1], Giuseppe Cristodaro[1], Alexander Nowicky[2], Aymeric Guillot[3], Laura Sebastiani[1]
[1]University of Pisa; [2]Brunel University London; [3]Université Claude Bernard Lyon
The relation between motor imagery abilities, memory and plasticity in healthy adults

14.00 **Alessio D´Aquino**, Cornelia Frank, Thomas Schack
Bielefeld University
Exploring gaze behavior in motor execution and motor imagery during manual interception

14.20 **Tim Naumann**, Adam Zabicki, Johannes Kurz, Jörn Munzert
Justus-Liebig-University Gießen
Effects of variations in imagined movement characteristics on postural control

14.40 – 15.30 Group Discussion and Closing Remarks (Lecture Hall, CITEC)

16.00 Social Activity, optional

Abstracts for Invited Speakers

Invited Talk 1

Cathy Craig, Queen's University Belfast, Northern Ireland

How immersive, interactive virtual reality can help us understand decision-making in sport

Through the preservation of the perception/action loop, immersive, interactive virtual reality technology can offer an exciting new way of studying decision making in sport. The versatility of this technology in terms of generating digital content means that it can be easily applied to a wide variety of sports (e.g., rugby, soccer, cricket). In this talk I will present examples that show how the dynamics of the unfolding events (e.g., side-step in rugby, curved free kicks in soccer) presented in a virtual environment impact on the decisions players make. I will show how an in-depth analysis of the player's action (what they do and when and how they do it) can offer a new way of studying decision-making in sport. I will finish by exploring how this technology can be used to profile, train and improve decision making in sport and how it can offer new insight into player performance. I will suggest that this ability to act in the right place, at the right time and in the right way can be considered as a new form of intelligence, namely action intelligence.

Invited Talk 2

Shaun Boe, Dalhousie University, Canada

The nature of motor imagery: A behavioural and neuroimaging perspective

Much of the rationale for the use of motor imagery in learning and rehabilitation is the prevailing belief that it is very similar to physical performance. Indeed, motor imagery is often referred to as 'motor planning without the execution'. Evidence in support of this assumption comes from neuroimaging studies showing similar patterns of brain activity during actual and imagined performance of the same task. Motor imagery is hypothesized to drive brain plasticity because it engages similar neural substrates to physical practice – the gold standard for learning and rehabilitation. Despite this evidence, learning and recovery that occurs via imagery is inferior to that of physical performance, leading us to question the fundamental assumption that motor imagery is simply motor planning without execution. Our recent work has explored the nature of imagery-based learning, leading to the contention that motor imagery involves unique mechanisms that are not associated with physical performance, and that the resulting learning is fundamentally different. This talk will summarize our past work on the nature of MI-based learning, including behavioural and neuroimaging studies. The overarching goal of this work is to address gaps in our understanding of the mechanisms underlying motor imagery-based learning, with the long-term goal of leveraging this knowledge to improve the prescription of imagery-based therapies.

Abstracts for Oral Presentations

Martin Riach, Paul Holmes, Zoe Franklin, David Wright
Manchester Metropolitan University

Action observation with a congruent contextual background facilitates corticospinal excitability: A transcranial magnetic stimulation and eye-tracking experiment

Action observation produces activity in similar regions of the brain to those involved in action execution and can offer an effective motor (re)learning intervention. However, optimal viewing conditions for such interventions remain to be established. In this experiment, single-pulse transcranial magnetic stimulation (TMS) and eye-tracking were used simultaneously to investigate the effect of manipulating background context on both corticospinal excitability and visual attention during action observation. Twenty-four participants observed four conditions: (i) a control condition of a static hand holding a sponge, or an index finger-thumb pinch of a sponge with a background that contained either (ii) no objects, (iii) objects that were incongruent to the observed action, or (iv) objects that were congruent to the observed action. TMS was delivered to the hand representation of the left primary motor cortex, and motor evoked potentials were recorded from the first dorsal interosseous and abductor digiti minimi muscles of the right hand. Eye movements were recorded simultaneously throughout each condition. Results indicated significantly greater corticospinal excitability during the congruent context condition compared to the static hand and no object conditions. Additionally, the number of fixations and percentage fixation duration on the background scene was significantly greater during the incongruent and congruent conditions compared to the static hand and no object conditions. These results indicate that the provision of additional visual information that is congruent to the observed movement contributes to a facilitation of corticospinal excitability. Providing congruent contextual information may, therefore, enhance the efficacy of action observation interventions for motor (re)learning.

Giorgia D'Innocenzo[1], Dan Bishop[1], Alex Nowicky[1], Claudia Gonzalez[2], Andrew Williams[3], Francesco di Gruttola[4]
[1]Brunel University London, [2]Thompson Rivers University, [3]University of Utah, [4]University of Pisa

The relationship between gaze and information pickup during action observation

The present programme of research aimed to investigate the relationship between eye movements and information pickup during action observation. In the first study we examined the effects of visual guidance on observational learning of the golf swing. The results showed that the visual guides effectively accelerated novices' learning of the action. In the remaining studies, transcranial magnetic stimulation and eye tracking data were acquired concurrently to measure the interaction between gaze and motor resonance, a neurophysiological index of the motor system's engagement with a viewed action. In the second study, we directed observers' gaze to distinct locations of the display while they viewed thumb adduction/ abduction. The results showed that, by directing gaze to a location that maximised the amount of thumb motion across the fovea, motor resonance was maximised relative to a free viewing condition. In the third study we examined the link between gaze and motor resonance during the observation of reach-to-grasp actions. Participants viewed the actions naturally, or while looking at a target- or an effector-based visual guide. The results showed that the effector-based guide disrupted natural gaze behaviour, and this was associated with a reversal of the motor resonance response. In the fourth study we showed novice and skilled golfers videos of the golf swing and of a reach-grasp-lift action. The results revealed that, for both actions, motor resonance was related to the location of participants' fixations. The present work provides the first evidence of a relationship between gaze and motor resonance and highlights the importance of appropriate gaze for observational learning.

David Wright[1], Greg Wood[1], Daniel Eaves[2], Adam Bruton[3], Cornelia Frank[4], Zoe Franklin[1]
[1]Manchester Metropolitan University, [2]Teesside University, [3]University of Roehampton, [4]Bielefeld University

Corticospinal excitability is facilitated by combined action observation and motor imagery of a basketball free throw

Action observation and motor imagery can elicit activity in brain regions involved in motor execution and improvements in motor performance and learning. This study investigated the extent to which independent action observation, independent motor imagery and combined action observation and motor imagery of a sport-related motor skill would elicit activity within the motor system. Eighteen, right-handed, male participants engaged in four conditions following a repeated measures design. A control condition involved observing a static image, whilst experimental conditions involved action observation, motor imagery, or combined action observation and motor imagery of a basketball free throw. Single pulse transcranial magnetic stimulation was delivered to the forearm representation of the left motor cortex. The amplitude of the resulting motor evoked potentials was recorded from the flexor carpi ulnaris and extensor carpi ulnaris muscles of the right forearm and used as a marker of corticospinal excitability. Corticospinal excitability was significantly greater during combined action observation and motor imagery of the basketball free throw, compared to both the action observation and control conditions. In contrast, the independent use of either action observation or motor imagery did not facilitate corticospinal excitability compared to the control condition. The findings have implications for the design and delivery of action observation and motor imagery interventions in sport. As corticospinal excitability was facilitated by the use of combined action observation and motor imagery, researchers should seek to establish the efficacy of implementing combined action observation and motor imagery interventions for improving motor skill performance and learning in sporting settings.

Stefan Vogt, Rosie Meers, Helen Nuttall
Lancaster University

Probing incongruent motor imagery during action observation states with motor evoked potentials: And the winner is…?

Combining action observation and motor imagery (AOMI) makes sense for many applications of such non-motor forms of practice in sports and neurorehabilitation. However, perhaps we shouldn't expect wonders over the more established 'pure' applications of action observation (AO) or motor imagery (MI). Whilst in applied contexts congruent AOMI is possibly the most typical usage, from a neuroscience perspective incongruent AOMI states are particularly interesting, since they provide a testing ground for the wider hypothesis of parallel neural representations (PNR). We tested the PNR hypothesis, namely that observed and imagined action are represented concurrently, using transcranial magnetic stimulation (TMS), measuring motor evoked potentials (MEPs) from the right hand whilst participants watched and/or synchronously imagined rhythmical finger movements. For the pure AO condition, results indicated only slightly enhanced MEPs compared to baseline. As expected, for congruent AOMI we found robustly enhanced MEPs. Somewhat unexpected, the results for incongruent AOMI were vastly dominated by the MI component, whilst the AO component produced significantly smaller MEPs. This result does not quite support the PNR hypothesis. One possible explanation is that at the level of primary motor cortex, over which our MEPs were recorded, parallel action representation is suppressed: After all, M1 sits at a relatively late stage of neuromotor processing, and parallel representation might be restricted to earlier, planning-related regions. Alternatively, it is possible that our AO task was less 'engaging' compared to the MI task, despite our usage of an oddball observation task where participants were asked to detect deviant finger movements. Directions for future research will be outlined.

Vasiliki Meletaki, Beatriz Calvo-Merino, Irena Arslanova, Martina Fanghella, Bettina Forster
City, University of London

Investigating neural correlates of embodiment through facial emotion perception, its relation to heartbeat evoked potential and personality traits

Embodiment theories and studies have suggested that there is an activation in somatosensory cortices at an early stage of facial expression processing that might work independently from visual processing. Our study further investigates how different emotions modulate this early somatosensory activity and if this measurement of embodiment is related to other physiological measures (i.e., heartbeat evoked potential) or personality traits (i.e., depression). In the present study participants were shown photos of faces of four emotions: happiness, anger, sadness and neutral, while measuring their electrophysiological activity (visual and somatosensory evoked potentials- VEPs, SEPs). We also measured their heartbeat evoked potentials and their levels of depression and alexithymia (by means of Beck Depression Inventory and the Toronto Alexithymia Scale respectively). The data analysis is still ongoing. Preliminary analysis of variance on the SEPs showed a strong main effect of emotion starting at 60ms (after the somatosensory stimulation (105ms after visual onset). Interestingly, levels of depression interacted with emotion perception at the 60-80ms time window. Regarding VEPs, we found significant emotion effects at P120 (happy) and P200 (angry). We found the N170 to be face processing specific with asymmetric brain activity. Further analysis integrating the heart beat potential is planned. The present study is of interest due to its innovative and interdisciplinary methodology; we combine the neural index of embodiment with depression questionnaires and the heartbeat evoked potential.

Andrius Vabalas, Alex Casson, Emma Gowen, Ellen Poliakoff
University of Manchester

Characterizing motor impairments in autism using imitation and computational techniques

Autism is a developmental condition primarily identified by social and communication deficits. Additionally, over 70% of autistic individuals show motor function deficits on standardized assessments. Imitation of observed actions is also impaired in autism. While autistic individuals imitate goal-directed actions well, they imitate the style of the movement to a lesser extent. Currently, it is unclear whether imitation deficits are due to problems with visuomotor integration or reduced attention to the observed movement. This study focuses on movement imitation, attention and motor function to further understanding of the above. In the study, 15 high functioning autistic adults and 15 intelligence quotient (IQ) matched non-autistic adults observed and then immediately imitated videos of human hand movement sequences, while movement kinematics and eye movements were recorded. In the videos, movement style (i.e., vertical amplitude and speed) was manipulated. Two blocks of trials were completed. In a first block, participants were instructed to simply copy movements while in a second block they were instructed to pay close attention to movement kinematics. Motor function was also assessed with coin rotation, grooved pegboard and speeded pointing tasks. Preliminary results indicate that control participants imitated changes in movement vertical amplitude and this was further enhanced by an attention instruction. Autistic participants modulated movement vertical amplitude to a lesser extent, but it was substantially enhanced by attention instruction. This study has the potential to advance knowledge about imitation difficulties in autism. Preliminary findings show that attention can enhance imitation and potentially has implications for motor learning and rehabilitation.

Martina Fanghella[1,2], Beatriz Calvo Merino[1], Sebastian Gaigg[1], Matteo Candidi[2], Salvatore Maria Aglioti[2]
[1]City University of London, [2]Sapienza University of Rome

Investigating sensorimotor simulation of emotional expressions in autistic spectrum disorder: A study with somatosensory evoked potentials

Autistic Spectrum Disorder (ASD) is a group of neurodevelopmental disorders characterised by social interaction and communication impairments, as well as repetitive and restricted patterns of behaviour. Recent research has highlighted that impaired embodied representations of emotions might play a role in ASD. In fact, empirical studies show that emotional expression recognition, interoception and physiological responses are atypical in ASD individuals. However, a selective impairment of sensorimotor representations of emotional expression in ASD has not been systematically investigated yet. Our methodology combines visual and somatosensory evoked potentials (VEPs and SEPs), to isolate embodiment effects driven by somatosensory or visual processing. This methodology has already provided evidences of the involvement of the somatosensory cortex in processing emotional expressions in typical populations, and we are now interested in investigating whether ASD population show different patterns of response compared to typical developing (TD) population. We are comparing visual and somatosensory response in a group of ASD and TD while they perform visual emotion recognition task and a control gender recognition task. Preliminary data will be presented, we expect to find a differential modulation of facial expression in the visual somatosensory evoked potentials.

Matthew Scott, Jonathan Emerson, Martin Tayler, John Dixon, Daniel Eaves
Teesside University

Motor imagery during action observation enhances automatic imitation in children with developmental coordination disorder

Developmental Coordination Disorder (DCD) is a neurodevelopmental condition causing impairments in motor planning, manual dexterity, balance and locomotion. Recent neuroimaging studies have also shown reduced mirror neuron function in children with DCD. We investigated the possible implications of mirror neuron dysfunction in children with DCD under different instruction conditions, using an automatic imitation paradigm. On each trial participants (n = 11; age range = 7-12 years) pantomimed rhythmical face-washing or paint-brushing in either the horizontal or vertical plane, cued by a picture. Immediately before execution participants saw a short rhythmical distractor action, where the movement cycle times were subtly manipulated across trials (i.e., fast vs. slow). The instructed and distractor actions either matched or differed both in action type and plane of motion. The primary measure was the 'imitation bias'. This reflected the distractor speed effects on participant movement cycle times, under four instruction conditions: passive distractor action observation (AO), motor imagery during action observation (AOMI) and intentional distractor speed imitation. For the motor imagery condition (MI) participants observed a short video before imagining and then executing this action. While rhythmical action execution was significantly slower for slow compared to fast distractor trials overall, this imitation bias was significantly stronger for compatible AOMI compared to both MI and incompatible AO trials, presumably due to increased mirror neuron involvement during AOMI. Although MI is recommended for motor planning in DCD children, AOMI instructions may be a more effective alternative. Data collection for a control group of typically developing children is ongoing.

Ben Marshall, David Wright, Paul Holmes, Greg Wood
Manchester Metropolitan University

Combined action observation and motor imagery improves eye-hand coordination in children with developmental coordination disorder

Developmental coordination disorder (DCD) is associated with motor learning impairments that may be the result of an inability to update internal models of movement. It has been suggested that combined action observation and motor imagery (AOMI) interventions might offer a potentially effective method for aiding skill acquisition in children with DCD, although this assertion had yet to be tested empirically. This study examined the ability of 20 children (13 male, 7 female) with confirmed or suspected DCD, aged 7-11 years, to adapt to a visuomotor rotation task in which a cursor had to be guided to targets. Participants completed a pre-test consisting of three trials of the task with no rotation effects and one trial with a 90° rotation. Participants were then randomly assigned to either an AOMI group (n = 10) who performed motor imagery of executing the 90° rotation task whilst simultaneously watching videos of a novice learning the same task; or a control group (n = 10) who watched an equal dose of educational video clips containing no human motor content. Both groups completed 20 blocks of one video observation followed by one physical practice trial. Following completion of the training, participants repeated the pre-test procedure. Completion time, mean square error of the cursor path and eye-movement data was recorded during both test phases. Preliminary analyses indicate that participants in the AOMI group completed the task significantly quicker at post-test than the control group. Once analysed, the eye-movement data recorded during testing will also be presented.

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Feasibility of home-based combined action observation and motor imagery training to facilitate everyday actions in Parkinson's disease

Combining action observation (AO) and motor imagery (MI) increases behavioural and neural effects. AO and MI have been shown separately to facilitate movement in Parkinson's disease (PD), and we have recently found that combined AOMI increases imitation of simple hand movements in PD. The present study investigated the feasibility of a flexible home-based AOMI intervention to improve performance of everyday actions by people with PD. The intervention, 'ACTION-PD', was informed by focus groups, and a tablet-based app was developed through modification of a therapy designed for stroke rehabilitation. Preliminary testing was conducted with four individuals with mild/ moderate PD: the six-week intervention involved simultaneous AOMI using videos of everyday bimanual actions, followed immediately by physical practice. Participants practiced core and personally-selected actions with a target of 150 minutes/ week. Usability and feasibility were assessed through adherence data, training diaries and interviews. Preliminary data on motor, cognitive and quality of life outcomes were obtained. All participants completed the intervention with an average adherence of 78%. Interviews indicated that the training was acceptable and easy to use. Three participants perceived improvements in trained actions with some transfer to other actions, and unexpected psychosocial benefits such as increased confidence were reported. The importance of personalisation and need for variety of actions were also highlighted. Quantitative data indicated numerical improvements in dexterity (Dexterity Questionnaire 24) and MI (Kinaesthetic and Visual Imagery Questionnaire). Home-based AOMI training is feasible in mild to moderate PD and may increase independence in daily activities while also offering psychosocial benefits. This flexible, individualised, low-cost solution could augment traditional rehabilitation approaches.

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Cutting action into pieces: Segmentation of observed Taekwondo sequences by experts and novices

Event boundaries are moments in action sequences, at which individuals subjectively perceive a coherent episode or segment to end and a new one to begin. Boundaries are characterised by increases in the amount of information and are moments from which several continuations are possible. Here we assessed how expertise and familiarity with the observed action influence the subjective segmentation of action sequences into coherent units. On the basis of video sequences showing Taekwondo forms, that are following a predefined sequential structure, participants marked boundaries between segments in action sequences, the so-called segmentation task. A group of 24 highly skilled Taekwondo athletes and 28 controls, performed the segmentation task on 12 video-sequences. In two sessions separated by a short break, each sequence was segmented twice. In order to analyse the consensus within each experimental group, their placement of segmentations was overlaid in each video, and the number of responses at each frame was summed-up to obtain a measure of objective event boundaries. The central finding of this study was that the group of Taekwondo experts showed a higher consensus on where to segment the sequences and agreed upon a higher number of event boundaries as compared to the control group. Experts were highly coherent in the timing of their judgements, suggesting a predictive strategy. This points to experts not only relying on change in motion to identify boundaries between action segments but also on their prior knowledge.

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How dance spectators watch dancers moving together: Effects of expertise, experience, intention and preference

Eye movements provide detailed quantitative information about processes of visual attention. Little is known so far about how spectators of contemporary dance watch dancers moving together, and how this relates to their own expertise, experience and preference. In an ongoing project, we use eye-tracking and questionnaires to investigate how spectators watch video footage of William Forsythe's choreography Duo that is special in view of the fact that the two dancers are dancing without music, relying on breath and body sounds as basis for entrainment. We study in particular how experts and novices visually monitor the dancers' interactions, specifically their moving in synchrony or unison, and how this interacts with the spectators' perception and evaluation of the performance. Preliminary results reveal that patterns of visual attention differ between tasks (i.e., just watching vs. marking synchronicity) and that that participants apply different strategies to identify dancers' modes of togetherness, such as focusing mainly between the dancers or switching frequently between the dancers. We are currently analysing data recorded with dancers from the Forsythe Company (including "Duo" dancers), dancers from Tanztheater Bielefeld and non-dancers. Furthermore, we are working on a detailed annotation of the performance videos to be used as a reference for the eye-tracking data. The situation of two dancers engaging in a danced conversation without external cues or pulse is not only relevant in the context of dance, it also has the potential to shed a new light on entrainment, joint action, joint attention, nonverbal communication, and social interaction.

Melanie Stemper, Matyas Varga, James Wrightson, Nicolas Smeeton
University of Brighton

The impact of action observation on a 15-min cycling time trial performance

The aim of this study was to examine the effect of observing a cyclist with modified cadences during a 15-min cycling time trial performance and to survey competitiveness as a reason for any changes in performance. Nine participants completed four different 15-min cycling time trials (TT), while observing a cycling action on a large immersive screen. On the screen a cyclist, performed a trial at either, the same cadence, 7.5% faster or 15% faster as the participants' previous maximal performance, in randomized order. Participants completed the Sport and Orientation Questionnaire to measure competitiveness. Action observation did not change performance. However, rate of perceived exertion (RPE) was significantly higher in TT_{15} compared to $TT_{7.5}$. A significant negative correlation was found between goal orientation and the RPE in TT_{15}. And a significantly positive correlation for win orientation and power output in TT_{15} and win orientation and distance in $TT_{15.}$ Observation of a same, 7.5% faster, as well as 15% faster speed has no significant effect on performance measures during a 15-min cycling time trial, although this effect may be underpowered. There was no evidence that motivation and arousal caused changes in performance during action observation. The significant difference in RPE, without an increase in any other performance measure, during the observation of a 15% faster speed trial supports the theory that action observation is affected by visual cues and effected by a mirroring system in a greater way than previously thought. Future research is needed to understand and verify the effect of action observation on performance.

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Green exercise effects: The role of mental imagery and mental time travel

We review evidence that the memorability and distinctiveness of our experiences with activity in natural spaces, termed green exercise, is a fundamental factor in illuminating the underlying mechanisms that may enhance mood, increase attention and enduring implications for well-being. Episodic memory, enabling conscious recollection of past episodes, reflects the influence of prior experiences on our later behaviour. Episodic memory shares a core brain network with the simulation of future episodes, enabling 'mental time travel' both retrospectively and prospectively. The capacity to simulate possible future events enables the simulation of different possible scenarios that can increase our propensity to engage in activity more frequently. As such, our ability to recall, manipulate and consolidate these memories is mediated by cognitive abilities including metacognition and imagery abilities. Here we outline how measurement of these abilities can shed light on the variables influencing engagement in green exercise.

Franziska Klein, Ling-Chia Chen, Cornelia Kranczioch
University of Oldenburg

Functional near-infrared spectroscopy-based motor imagery neurofeedback and motor learning: A pilot study

In motor imagery neurofeedback (MI NFB), brain activity associated with imagining a motor task is fed back to the person performing the MI. By means of the NFB, it is possible to learn to self-regulate one's own brain activity and by that, NFB can aid plastic changes in the brain. Functional near infrared spectroscopy (fNIRS) is a relatively new brain imaging method and not yet widely used as MI NFB modality. The aim of the present study was to test whether fNIRS-based MI NFB on a finger tapping task is associated with behavioural improvement and activity changes in motor-related brain areas relative to a no-feedback condition. Two groups (each n = 17) practiced a finger tapping task through kinaesthetic MI, before and after MI practice the task was performed physically (motor execution, ME). One group received delayed visual feedback on their oxygenated haemoglobin concentration changes during the MI task (oxyFB group) and was instructed to increase the feedback value by means of MI. The second group performed MI practice without any additional NFB (noFB group). Both groups improved significantly in the finger tapping task from pre- to post-test, but unexpectedly, improvement was not larger in the oxyFB group. Similarly, no group differences were observed for MI- and ME-related fNIRS signals. However, across groups a trend for a reduction of fNIRS signals from pre- to post-ME and in the course of MI practice became evident. These main results will be discussed in light of additional exploratory analyses and methodological challenges of fNIRS.

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Peripheral and neurophysiological correlates of motor imagery training with prior physical practice of a reach-to-grasp movement: Methodological challenges and first results

Motor Imagery practice (MI) in combination with neurofeedback is a promising supplement to physical rehabilitation interventions for motor impairments following stroke. Basic research in healthy participants aimed at developing and improving MI-based neurofeedback interventions, is hampered by the simplicity of tasks tailored to paretic stroke patients, as they allow for little or no measurable motor improvement through training. In contrast, more complex motor tasks have the disadvantage of not being transferable to a rehabilitation setup and having little everyday relevance. This study investigates oscillatory brain activity and motor learning in healthy participants in a complex visuomotor task consisting of a variant of an everyday reach-to-grasp movement that allows adjustment of task difficulty along various dimensions. Participants were assigned to either of two groups and each of them performed a total of 256 trials. The first and the last eight trials were motor execution trials (ME). For the remaining trials participants of one group (n = 20) performed 240 MI trials, while the other group (n = 20) performed 80 ME trials followed by 160 MI trials. Sixty-four channel electroencephalogram (EEG), electromyogram (EMG) and electrodermal activity (EDA) were recorded, and an inertial measurement unit (IMU) tracked the movement in space. We expect to see improvements in performing the reach-to-grasp movement and associated changes in oscillatory brain activity, both should be more pronounced in the group with ME training prior to MI training. The experimental setup and preliminary results will be presented together with a discussion of challenges in the ongoing data analysis.

Stephanie Romano-Smith[1], Greg Wood[2], Ginny Coyles[1], James Roberts[1], Caroline Wakefield[1]
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The effect of combining motor imagery and action observation on aiming performance, upper-limb kinematics and muscle activation

Motor imagery (MI) and action observation (AO) enhance motor skill learning. While both techniques have typically been used in isolation, research has begun to employ combined interventions. However, the most effective way to combine these techniques and mechanisms behind their facilitative effect remain unclear. Participants (n = 50) were randomly allocated to one of five training groups: action observation (AO), motor imagery (MI), simultaneous action observation and motor imagery (S-AOMI), alternate action observation and motor imagery (A-AOMI) and a no task-specific instruction (control). Pre- and post-tests involved dart-throwing toward a concentric circle dartboard. Interventions were conducted three times per week for six weeks. Data were collected from the performance outcomes, mean muscle activation of the upper arm (anterior deltoid, bicep brachii, and tricep brachii) and forearm muscles (flexor carpi radialis and extensor carpi radialis). Critical elbow flexion and extension joint angles, angular velocity and peak angular velocity of the elbow were also collected. Performance significantly improved from pre to post test ($ps < .05$) in all experimental groups. A-AOMI, S-AOMI and MI groups improved significantly more than the than AO group ($ps < .05$). Mean muscle activation, critical elbow flexion and extension joint angles, angular velocity and peak angular velocity did not differ significantly from pre- to post-test in any group ($ps > .05$). These findings have important implications for understanding the mechanisms of motor imagery and action observation used both independently and in combination. Furthermore, this paves the way for examination of the potential neural mechanisms that underpin the learning and performance of motor skills.

Jack Binks, Christopher Wilson, Paul Van Schaik, Daniel Eaves
Teesside University

Motor imagery during action observation enhances learning of a complex movement sequencing task in the absence of physical practice

Recent neuroimaging studies show the involvement of motor and motor-related cortical areas in the brain is significantly greater for motor imagery during action observation (AOMI), compared to the more traditional use of either independent action observation (AO) or motor imagery (MI). Here we report AOMI training effects in a complex cup-stacking task, without physical practice. Using a Graeco-Latin square design we randomly assigned twenty-six participants into four groups. This counterbalanced the within-subjects factor of instruction (AOMI, AO, MI, Control) across four cup-stacking sequences. On three consecutive days participants performed 20 trials under the three experimental instructions. Each trial displayed a first-person perspective video of a bilateral cup-stacking action performed at pace by an experienced model. During AO, participants observed these videos while responding to an occasional colour cue. For AOMI participants imagined the effort and sensation of performing this action and synchronized this with the video. For MI the imagery instructions were repeated, while only pictures cued each sequence. In both a 'surprise' post-test (day three), and a one-week retention test, participants executed the three practiced sequences, plus the fourth unpracticed sequence (i.e., Control) as fast as possible. The main effect of instruction showed execution times were significantly shorter for AOMI than for both MI and Control, both in post- and retention testing. While the main effect of task identified an increasing difficulty gradient across the four sequences, preliminary analyses indicate AOMI effects were more pronounced in the more challenging sequences, thus evidencing specific AOMI advantages in complex sequence learning.

Sarah Kraeutner, Sarah Eppler, Alexandra Stratas, Shaun Boe
Dalhousie University

Generate, maintain, manipulate? Linking assessments to dimensions of motor imagery

Motor imagery (MI), the mental rehearsal of a motor task, is a thought to arise via cognitive processes that allow for the generation, maintenance, and manipulation of motor images. While our understanding of the multidimensional nature of MI stems from research examining various tools used to assess MI ability, limited research has been conducted employing multiple assessments across participants to probe the underlying dimensions of MI. Accordingly, the current study seeks to explore the multidimensional nature of MI by administering a battery of assessments thought to measure different dimensions of motor imagery. Participants (N = 50) underwent a battery of MI-assessments including questionnaires, mental chronometry, a mental rotation task, and a MI-based learning task, and data was analysed via principal component analysis (PCA). Four components were extracted from the initial component solution, accounting for 81.1% of the total variance in the data. Based on the outcome measures that loaded on to each component, the components were named: generation, manipulation, maintenance, and temporal sequencing of the motor images. Concordant with previous research, we highlight the importance of employing multiple measures when assessing imagery ability. Our findings also suggest that 'generation', as the primary component extracted from the PCA (37.7% of the total variance), may be the most critical dimension to MI. Ultimately, by linking assessments of MI to underlying dimensions, this work extends knowledge related to the multidimensional nature of MI.

Shiau-Chuen Chiou, Thomas Schack
Bielefeld University

From observation to imitation: Working memory for whole-body movement sequences

Working memory (WM) plays an important role in the cognitive-perceptual control of human action, especially in the observation-imitation process of motor skill learning due to an unavoidable time delay between visual perception and motor output. However, how the spatial and temporal information of a whole-body movement sequence are encoded, retained and retrieved from the WM, and more specifically, how different factors such as memory load and maintenance delay influence memory performance remain unclear. To address these questions, we used a delayed discrimination task, in which participants watched two sequentially displayed movement sequences composed of 1, 2, 3, or 4 linked movement units (each unit lasts one to two seconds) with a retention interval (RI) of 0.5, 2, 4, or 6 seconds. Movement sequences, all without action semantics, were different in either spatial (trajectory) or temporal (rhythm) domain. The results showed a non-decaying, near-perfect recognition performance of movement trajectory in all conditions, while the recognition of rhythm (i.e. pattern of movement durations) was jointly influenced by memory load and maintenance delay. When the memory load was low, recognition performance remained high if RI was short, but performance deteriorated if RI was lengthened to four seconds or longer, illustrating a time-based forgetting. On the contrary, when the memory load was high, performance remained low across all RIs, indicating that the memory load might have surpassed the limited capacity of WM. The results also suggest that the processing of spatial and temporal information of human actions may rely on different mechanisms or strategies.

Francesco Di Gruttola[1], Diego Manzoni[1], Danilo Menicucci[1], Giorgia D'Innocenzo[2], Ursula Debarnot[3], Daniel Bishop[2], Angelo Gemignani[1], Giuseppe Cristodaro[1], Alexander Nowicky[2], Aymeric Guillot[3], Laura Sebastiani[1]
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The relation between motor imagery abilities, memory and plasticity in healthy adults

I will present three studies that investigate the relation between the ability to generate and maintain/manipulate a motor image (measured by the Movement Imagery Questionnaire-3 and the mental chronometry score, respectively), memory processes and plasticity phenomena on healthy young adults. In the first study, I will highlight how a high Movement Imagery Questionnaire-3 score of kinaesthetic imagery is associated with a widespread increase in the electroencephalographical alpha power underling participants' ability of maintaining a mental representation in mind and blocking the retrieval of irrelevant information. Contrariwise, the mental chronometry score is correlated with the working memory's central executive system performance. Specifically, good imagers decrease Theta power in temporal regions, where this rhythm is implicated in the temporal sequencing of the information retrieved from memory. In the second study, I will evidence how a brief immobilization (~30 min) of the dominant arm is sufficient to affect its performance in a reaction-time task. A mental motor imagery training is both ineffective in preventing these negative outcomes and detrimental for the not-immobilized arm: the higher participants' ability in generating a visual internal motor image, the lower the improvement of the left-hand after the training. In the third study, I will underline how action observation exerts a perceptual priming effect on motor regions that induces a spontaneous form of motor imagery. Posing an attentional constraint that guides participants' gaze during action observation attenuates the negative effects of spontaneous motor imagery on corticospinal excitability. The implications of these evidences both in research and applied fields will be discussed.

Alessio D´Aquino, Cornelia Frank, Thomas Schack
Bielefeld University

Exploring gaze behavior in motor execution and motor imagery during manual interception

Prior work has investigated the degree of shared motor representations between motor imagery and motor execution by examining eye movements. While spatio-temporal eye movements' dynamics seem to be preserved for cyclical tasks, perceptual congruency seem to be disrupted for point-and-reach tasks. The present study extends previous work by examining eye movements' congruency between motor imagery and motor execution for a manual interceptive task. More specifically, we classified gaze behaviour as the combination of smooth pursuit and saccades during the interception of a target moving horizontally on the fronto-parallel plane. Twenty-four right-handed students (26.9 ± 2.8 years old) were requested to visually track and perform the manual interception as accurately as possible by clicking with the mouse cursor. Both target speed (i.e., fast and slow) and performance conditions (i.e., motor execution, guided motor imagery, and control) were manipulated. Participants completed six blocks of 20 trials in each experimental condition for both the slow and fast target speed. We statistically analysed several smooth pursuit and saccadic gaze parameters using generalized linear multi-level modelling. We found that 1) saccadic and smooth pursuit parameters during guided motor imagery seem to be affected by similar visuomotor processes underlying motor execution (i.e., similar number of saccades and smooth pursuit gain); 2) additional eye movements linked to the actual movement execution seem to be absent during guided motor imagery (i.e., different total smooth pursuit duration, and probability of saccades to anticipate the target); 3) increases in target speed seem to negatively affect saccadic and smooth pursuit quality for guided motor imagery in comparison to motor execution (i.e., lower saccadic accuracy and smooth pursuit gain).

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Justus-Liebig-University Gießen

Effects of variations in imagined movement characteristics on postural control

It has been shown that kinaesthetic motor imagery of bilateral plantar flexions in upright position leads to increased body sway. Furthermore, it has been shown that imagining oneself executing a fast reaction task with different loads lead to specific modulation of postural control. A possible explanation for these findings is that kinaesthetic imagery evokes motor representations involved in balance control. In addition, balance control seems to be affected by variations of imagined movement characteristics like load. The aim of this study was to examine whether for an imagined continuous movement, the effect of imagined load on postural control could be verified. Moreover, whether variations in imagined velocity and amplitude also lead to specific adaptations in body sway. Sixteen participants (12 female, age: 25.0 ± 4.1 years) imagined or executed repetitive shoulder abduction movements while standing in tandem position. The movements varied in load that had to be lifted (0, 1.5, or 3 kg), in velocity (1.5, 2.25, or 3 s/ movement cycle) and in amplitude (30°, 60°, or 90°). Body sway as a measure for postural control was recorded with a force plate. Results showed for the execution conditions, that body sway increased significantly according to higher load, velocity and amplitude. In contrast, in imagery conditions, no significant increase of body sway was found for any of the examined movement characteristics. One possible explanation could be that, in repetitive shoulder abduction movements, demands on postural control are lower compared to the tasks that were used in previous studies.

Abstracts for Poster Presentations

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Action observation: Gait training in healthy people

The aim of the present study was to investigate the effect of gait observation and changes in walking cadence on markers of gait variability in healthy adults. Ten healthy adults (mean ± standard deviation: age 22 ± 1 year, 166.7 ± 9.8 cm, 65.7 ± 12 kg) completed two treadmill walking trials at preferred walking speed (PWS) and then at 80% of PWS whilst observing another person at a matched cadence on a 180º immersive projection system (Igloo, Vision 360). Gait variability was measured (Stride Frequency (SF), Stride Time (ST), Stride Velocity (SV) and Stride Time Variability (STV)) using wearable multi-gait accelerometers. Also, transcranial magnetic stimulation (TMS) was used under passive observation of gait (*n* = 4). Significant mains effect of walking speed (80% vs PWS) were found on STV, SF, SV and ST where walking at 80% of PWS significantly reduced SF and SV and significantly increased STV and ST when compared with PWS. There were no significant main effects of video. Additionally, there was a significant interaction effect of speed and video on SV only. There was an increase in SV from no video to video in the PWS condition, but this effect was reversed in the 80% PWS condition. During TMS, motor evoked potential amplitude was higher in the action observation (AO) conditions compared to the no observation condition. The current findings suggest that AO has limited effects on gait variability at or near PWS in healthy adults. This may be due to participants' already controlling gait at or near PWS in an optimal way.

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Observation of dance by people with Parkinson's disease

Dance is a complex activity involving action observation (AO), imitation and motor imagery (MI), and the AO network is activated when simply watching dance. Dance is becoming popular as a therapeutic activity for people with Parkinson's disease (PD), and current evidence indicates a range of positive motor and non-motor outcomes. Internal representation of action, through AO, imitation and MI, may contribute to the effects of dance on movement and emotion in PD. Moreover, action simulation may be enhanced by certain elements of dance, or by contextual factors. This project investigated how people with PD observe dance, and the influence of meaning and emotion within dance on motor, physiological and subjective responses. Identifying which aspects of dance people with PD engage with, and respond to, may inform the design of effective dance programmes. We measured eye movements while people with PD (*N* = 13) and age-matched controls (*N* = 10) viewed videos of classical Indian and contemporary dance. The effect of meaning was examined by comparing trials with and without descriptive titles, and emotional content was manipulated by the use of facial expressions accompanying dance sequences. Heart rate and spontaneous bodily movements were also recorded as potential markers of action simulation during AO, and subjective ratings of emotional response and embodiment were obtained. Initial analysis indicated no difference between groups or stimulus types in basic eye movement metrics, and subjective ratings indicated a preference for videos containing facial expressions in both groups. Analysis of eye movements for specific interest areas, as well as physiological and motor responses, is ongoing.

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A two-study investigation of observation level upon collective efficacy in team sports athletes

Observation-based interventions can improve collective efficacy in sport. This investigation examined the effects of observation level (individual vs team) upon collective efficacy (CE) in team sports athletes. In the first study, 182 participants (team sports: *n* = 99; individual sports: *n* = 83) completed the functions of observational learning questionnaire (FOLQ) and the collective efficacy questionnaire for sports (CEQS). Total observational learning use predicted CE at both individual- and team-level. Individual-level scores for specific functions of observational learning use did not predict CE. Team-level scores for strategy function of observational learning predicted CE. The second study examined the effects of individual- and team-level observation interventions on CE in two United Kingdom soccer teams (*N* = 22), with competitive video footage collected over four weeks. The interventions comprised 70s videos displaying positive actions. Participants completed both interventions in a counterbalanced order. Individual CE perceptions were recorded pre-/ post-intervention for both conditions using the CEQS. CE increased for both individual- and team-level interventions. Social validation interviews revealed participants perceived the video footage to increase CE beliefs by demonstrating mastery at both levels. Our findings outline the importance of individual- and team-levels when using observation interventions to develop collective efficacy within team sports athletes for learning or performance purposes.

Stephan Dahm, Martina Rieger
Hall University for Health Sciences, Medical Informatics and Technology

Deviations from optimal performance in motor imagery

In motor execution, movements often deviate from optimal behaviour. We investigated whether deviations from optimal performance are predicted in motor imagery. In the first experiment, aiming for the bullseye experts and novices imagined and executed 50 dart throws. In imagination, they imagined themselves performing a dart throw and indicated the landing position of the dart on the dartboard. Two-dimensional error scores (in cm: distance to the bullseye, consistency across throws, and bias) were analysed. It was expected that internal predictions in experts are more precise than in novices and therefore experts' predictions in motor imagery may resemble their actual throws more closely than in novices. Experts performed better than novices in both, imagination and execution. Irrespective of expertise, distance to the target and bias were smaller in imagination than in execution. In the second experiment, three randomized groups reported the predicted landing position of 50 dart throws after execution with delayed visual feedback of the dart's landing position, execution without visual feedback, or imagination. The predicted positions of the dart did not differ significantly between groups. However, position estimates resulted in smaller distance and less bias than actual positions. Imagined movement consequences are more accurate than actual movement consequences. However, predicted movement consequences in execution are also more accurate than actual movement consequences. Thus, predictive mechanisms (e.g., based on forward models) might be similar in motor imagery and motor execution. The present study further demonstrates, to our surprise, that predictions in motor imagery are similar in dart experts and novices.

Cornelia Frank, Iwan de Kok, Felix Hülsmann, Mario Botsch, Stefan Kopp, Thomas Schack
Bielefeld University

Virtual coaching: On the influence of memory-based and execution-based verbal feedback in a virtual training environment

Adequate, multimodal feedback is crucial for skill acquisition. As opposed to real world environments, virtual environments allow for generating and evaluating innovative types of augmented feedback during the coaching process. Using an immersive, closed-loop virtual coaching environment, in which the user enters a virtual fitness room with a virtual mirror and a virtual coach, we examined the influence of different types of verbal, individualized feedback as provided by a virtual coach during acquisition of a motor skill. Novices were assigned to one of three coaching conditions whilst practicing and observing the squat for three blocks of ten squats during acquisition phase: memory-based feedback, execution-based feedback, and no feedback. Feedback for participants was derived based on errors in either their memory representation or in their motor execution. The two most severe errors were chosen, and participants were instructed accordingly during acquisition phase (first block: instruction one, second block: instruction two, third block: instruction one and two). With these instructions in mind, participants practiced their squats whilst observing their own performance in the virtual mirror. Participants were tested for their cognitive representation and their motor performance prior to and after acquisition phase as well as after a retention interval of one day. Preliminary results of this experiment indicate that new types of individualized, verbal feedback provided by a virtual coach in addition to observing one's own performance positively influence the learning process. Addressing particular error patterns by way of automatically generated feedback in virtual reality seems to promote motor learning.

Taeho Kim, Cornelia Frank, Thomas Schack
Bielefeld University

The effect of different training schedules of action observation and motor imagery on the changes in mental representation structure, cognitive and skill performance

As different types of action simulation, action observation refers to observing motor action, and motor imagery refers to imagining mentally motor action, without actual movements. Action observation (AO) training and motor imagery (MI) training have long been used independently as effective training methods to facilitate skill acquisition and learning. Recently, neurophysiological and behavioural studies on AO + MI training have shown that AO + MI training may be more effective than AO or MI training alone. To date, however, research on the effect of different AO and MI training schedule is lacking. The purpose of this study was to examine an optimal AO + MI training schedule by investigating the effect of different AO + MI training schedules of Taekwondo Poomsae on the changes in mental representation structure, cognitive and skill performance. Forty novices in Taekwondo were randomly assigned to one of four groups: concurrent training group (AOMI, AOMI,…), alternate training group (AO, MI, AO, MI,…), intensive training group (AO, AO,…, MI, MI,…), and non-training group. Participants practiced the Taekwondo Poomsae thirty trials a day during a three-day training period. Mental representational structure, cognitive performance, and skill performance were measured before and after three days of training as well as after a retention interval of one day. Mental representation structure was measured by Structural Dimensional Analysis of Mental Representation, and cognitive performance was measured by Cognition Movement Chronometry. Skill performance was video-recorded and rated by two Taekwondo experts. Currently, data analysis is in progress.

Alexis Deighton MacIntyre
University College London

The rhythmic coordination of breathing during joint speech and imagined joint speech

Despite the inherent complexity of language production, joint speech is a commonplace activity that requires no special effort for most individuals. Joint speech is the act of speaking aloud or signing together, as in saying a prayer, reciting a pledge, or performing a text. Notwithstanding this banality, the very tight synchrony that characterizes joint speech remains scientifically enigmatic. Humans also harmonize their movements during dance, music, sports, and marching, but this is typically to a beat or pulse. Whether such a pulse exists in language is controversial. The current project investigates respiratory cycles as a possible source of periodicity by which individuals time joint speech. In this behavioural experiment, participant dyads read passages, engage in natural conversation, and recite memorised texts whilst wearing piezo-electric transducer breath belts and undergoing concomitant acoustic recording. To disentangle the coordinative role of breath from the constraints on breathing during vocal production, participants also observe and imagine reading or speaking aloud in some conditions, together and individually. The breath belts produce a linear signal in response to lengthening due to diaphragmatic movement. The resultant data is analysed using frequency coherence and windowed cross correlational analysis, and respiratory and acoustic profiles and time series are compared. It is hypothesized that the mutual respiratory cycle will be most stable during joint reading and recitation with complex verbal rhythmic structure, both executed and imagined, and that this stability will be relatively reduced in spontaneous dialogue and when verbal structure is simple and overtly rhythmic, such as in nursery rhymes.

Eoghan McNeill, Adam Toth, Drew Harrison, Mark Campbell
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The impact of mental imagery on golf performance: Current understanding, unresolved issues and future research opportunities

Mental imagery is defined as 'the ability to simulate information that is not currently being perceived by the sense organs' and is an area of research interest in both experimental and applied psychology. Golf, as a self-paced skill, is an exemplar motor skill to showcase the benefit to performance gained from the structured use of mental imagery. The current review critically evaluates previous research attempting to demonstrate imagery's efficacy at enhancing golf performance. Results indicate a large positive effect size of 1.07 for mental imagery's efficacy for enhancing performance in golf. We also highlight several unresolved issues that are commonplace within the existing research. Central amongst these problematic issues are opportunities missed regarding the homogeneity of sampling, particularly related to the underrepresentation of expert/ skilled performers and a clear dependence on convenience sampling. Additionally, the over-reliance of putting as a performance measure results in an idiosyncratic understanding of how imagery interventions are influencing golf performance. Finally, we argue more rigorous methods for controlling imagery ability are required to better account for the potential influence of imagery ability on imagery's efficacy in golf, and beyond. We strongly believe that imagery research should seek to augment the field by exhibiting greater care and rigour when designing and delivering research in simulation training and golf performance. We offer potential future research opportunities to address these existing challenges and propose a model to explain the continuum of performance benefits to be had from mental imagery to action-observation to physical practice.

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Predicting the fate of basketball throws: A psychophysics and electroencephalography study in healthy and paraplegics athletes

Elite athletes can predict successful free shots more rapidly and accurately, with cues of body kinematics, also reflected in their motor activation for successful and unsuccessful shots. Here, we explored the behavioural and electrocortical underpinnings of wheelchair athletes who predict the fate of throws to basket performed by paraplegic athletes. Using electroencephalography (EEG), we searched for the possible electrocortical correlates of observing domain specific actions and predicting their outcome. Expert wheelchair basketball players with two levels of physical movement capability were chosen (Points one and four; former with most severe disability, least trunk movement and latter with least severe disability, most trunk movement). Thus far no study has focused on the action observation network modulation contingent upon expertise and severity injury in people with body-brain somatosensory and motor disconnection. Ten athletes and 19 healthy participants observed free throw videos (IN – correct movement execution; OUT – incorrect movement execution). They were asked to predict the outcome of the shot which was occluded by a black screen. Preliminary results highlight that the players had significantly stronger P300 response compared to naïve healthy subjects over parietal electrodes, both for IN and for OUT videos. Moreover, the P300 response was greater for Point four players, which are not only experts, but also have a wider range of motor representations due to less injury, compared to Point one players. This suggests that the P300 modulation might be a correlate of motor expertise during action observation.

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Electroencephalography indices of performance monitoring activity and error predictability: Embodying the actions of an avatar in immersive virtual reality

Detecting errors in one's own actions, and in the actions of others, is a crucial ability for an adaptable and flexible behaviour. Studies show that specific electroencephalography (EEG) signatures underpin the monitoring of observed erroneous actions (error-related negativity, error-positivity, mid-frontal theta oscillations). By combining EEG and immersive virtual reality cave automated virtual environment (IVR-CAVE system), we previously reported that observing errors in reach-to-grasp actions of an avatar seen from a first-person perspective elicited error-related signature. However, former studies on observed actions used sequences of trials were erroneous actions were less frequent than correct actions. Therefore, it was not possible to disentangle whether the activation of the performance system was due to error per se or to surprise/ novelty effect associated with rare and less predictable events. To address this issue, we recorded the EEG signal of 25 participants observing actions performed by an avatar in first-person perspective, in which the proportion of erroneous actions was higher than correct ones. Results show that observation of erroneous actions elicit typical electro-cortical signatures of error monitoring. Additionally, correct trials showed stronger alpha suppression than erroneous trials, in line with previous works. Taken together, our data suggest that an action error, and not its percentage of occurrence, triggered the activity of the performance monitoring system, likely with the aim of flexibly adapting actions to the challenges of the external environment. Future work will be addressed in understanding the integrity of the monitoring system in clinical populations, during the observation of virtual actions.

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Action imagery and observation in neurorehabilitation for Parkinson's disease: A pilot randomized controlled trial

Parkinson's disease (PD) affects movement profoundly. Difficulties include initiation of movement and a reduction in movement size. We have developed Action Imagery and Observation in Neurorehabilitation for Parkinson's Disease (ACTION-PD), drawing on patient and clinician input, which allows people with PD to train everyday hand actions at home, using a tablet-based app, adapted from an app for stroke patients. The training combines action observation and motor imagery, which improve movement amplitude in people with PD in the lab. The current project is a pilot randomized control trial, building on the findings of a small-scale feasibility study (N = 4) of a prototype app. We are investigating participants with mild to moderate PD, who will be randomized to the intervention (n = 10) or control (n = 10) group. Training consists of video-based observation, imagery and physical practice of five functional manual actions (e.g., fastening buttons), including three selected by the individual from a video library. The intervention will be delivered in a seated position, via tablet computers in participants' homes. Participants will be asked to train for approximately 20 minutes a day (100 minutes/ week) for six weeks, with support from the researchers via weekly telephone calls. Control participants will receive no intervention but will be contacted weekly to maintain engagement. Feasibility and acceptability will be assessed via usage data, as well as subjective difficulty ratings during training and thematic analysis of semi-structured post-training interviews. We will also collect preliminary outcome data. The primary measure is self-reported dexterity (Dexterity Questionnaire 24). Exploratory secondary outcomes include quality of life (Parkinson's Disease Questionnaire 39), perceived control and laboratory measures of movement speed and quality.

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The effects of combining physical, environment, task, timing, learning, emotion, and perspective imagery and action observation on strength performance: A single-case design

The physical, environment, task, timing, learning, emotion, and perspective (PETTLEP) model of imagery has been shown to be effective in enhancing strength performance. With recent literature discussing the shared neural substrates between imagery and action observation, this study investigated whether PETTLEP imagery would improve strength performance both with and without an additional observational aid. Using a single-case design, four participants completed a baseline phase followed by PETTLEP imagery with and without an observation aid in a counterbalanced manner. Weekly bicep curl 1 repetition maximum was used as the performance measure. Results indicated that using an observational aid in conjunction with PETTLEP imagery can aid performance, but not to a greater degree than PETTLEP imagery alone. This indicates that observational aids are not an essential addition to imagery interventions. However, the study further highlights the benefit of using PETTLEP imagery for strength performance.

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Motor execution and imagery are unique processes

Motor imagery (MI), the mental rehearsal of movement, is a method of motor learning that has been thought to parallel motor execution (ME). The neural mechanisms underlying the primary difference between MI and ME, the lack of movement in MI, are not well understood. This difference is thought to result from inhibition of the motor command in MI. Here we generated evidence from neuroimaging data to test two theories that exist to explain motor inhibition in MI: 1) that motor inhibition is innate to the generation of a movement representation in MI; and 2) motor inhibition occurs as a result of suppressive influences of cortical regions on the motor command after it was formed. We hypothesized that motor inhibition was an innate part of MI, and that MI and ME would diverge at the early stages of performance. Eighteen participants performed a grasping task using both MI and MI while we recorded their brain activity. Using common measures of brain activity that relate to movement planning and execution (i.e., change in field strength and power change in the 15-30 Hz beta frequency band). Our results show that in the frequency domain, MI and ME differ early in the preparation phase for movement but the field strength only differed between both modalities post-movement. This refutes our hypothesis and supports the second theory of motor inhibition in MI. Despite the lack of difference in the preparation phase, the frequency domain results challenge the assertion that MI and ME are parallel processes.