7th Joint Action Meeting

July 22-26, 2017

London, United Kingdom

Organized by:
Arianna Curioni, Patrick Healey, Rosella Galindo-Esparza, Andrea Jenei, Günther Knoblich, Eszter Salamon, Natalie Sebanz, and Lida Theodorou
# Program

## Saturday, July 22\textsuperscript{nd}

<table>
<thead>
<tr>
<th>Time</th>
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<tr>
<td>9:00 - 10:00</td>
<td>Registration</td>
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<tr>
<td>10:00 - 10:15</td>
<td>Welcome</td>
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<tr>
<td>10:30 - 12:30</td>
<td>Talk session A: Music and improvisation</td>
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<td>12:30 - 14:00</td>
<td>Lunch break</td>
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<td>14:00 - 16:00</td>
<td>Talk session B: Coordination 1</td>
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<td>16:00 - 16:30</td>
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<td>16:30 - 18:30</td>
<td>Talk session C: Dialogue and conversation 1</td>
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<td>19:00 - 21:00</td>
<td>Reception</td>
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## Sunday, July 23\textsuperscript{rd}

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<th>Time</th>
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<tr>
<td>9:00 - 11:00</td>
<td>Talk session D: Shared attention 1</td>
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<td>11:00 - 11:30</td>
<td>Coffee break</td>
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<tr>
<td>11:30 - 13:00</td>
<td>Talk session E: Synchrony</td>
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<td>13:00 - 14:00</td>
<td>Lunch break</td>
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<td>14:00 - 16:00</td>
<td>Poster session 1 + coffee</td>
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<td>16:00 - 18:00</td>
<td>Talk session F: Joint planning</td>
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### Monday, July 24th

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<th>Time</th>
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<tr>
<td>9:00 - 10:30</td>
<td>Talk session G: Cooperation</td>
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<td>10:30 - 11:00</td>
<td>Coffee Break</td>
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<td>11:00 - 13:00</td>
<td>Talk session H: Goals and intentions</td>
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<td>13:00 - 14:00</td>
<td>Lunch break + impro workshop</td>
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<tr>
<td>14:00 - 16:00</td>
<td>Poster session 2 + coffee</td>
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<td>16:00 - 18:00</td>
<td>Talk session I: Coordination 2</td>
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### Tuesday, July 25th

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<th>Time</th>
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<tr>
<td>9:00 - 10:30</td>
<td>Talk session J: Joint action: development and disorders</td>
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<tr>
<td>10:30 - 11:00</td>
<td>Coffee break</td>
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<td>11:00 - 13:00</td>
<td>Talk session K: Shared attention 2</td>
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<td>13:00 - 14:00</td>
<td>Lunch Break</td>
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<tr>
<td>14:00 - 16:00</td>
<td>Poster session 3 + coffee</td>
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<td>16:00 - 18:00</td>
<td>Talk session L: Dialogue and conversation 2</td>
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<td>19:30 -</td>
<td>JAM dinner + party</td>
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### Wednesday, July 26th

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<th>Time</th>
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<tr>
<td>10:30 - 12:30</td>
<td>Robot JAM session 1</td>
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<tr>
<td>12:30 - 14:00</td>
<td>Lunch break</td>
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<tr>
<td>14:00 - 15:30</td>
<td>Robot JAM session 2</td>
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<td>15:30 - 16:00</td>
<td>Coffee break</td>
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<tr>
<td>16:00 - 17:30</td>
<td>Robot JAM session 3: Discussion and wrap-up</td>
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<td>17:30 - 18:00</td>
<td>Final remarks</td>
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Talk sessions

Talk session A: Music and improvisation  Sat, 10:30 - 12:30

Peter Keller, Giacomo Novembre, and Jennifer MacRitchie
Self-other integration and segregation is modulated by the congruency of shared goals in musical joint action

Ian D. Colley, Jennifer MacRitchie, Manuel Varlet1, and Peter Keller
Visual cues in musical synchronization: How can the conductor influence musicians?

Johann Issartel and Ludovic Marin
Joint-improvisation and Expertise

Saul Albert and Dirk vom Lehn
Beginning to dance: methods of mutual coordination between novice dancers

Tommi Himberg, Klaus Förger and Asaf Bachrach
Four-way mirror game: developing methods to study group coordination

Talk session B: Coordination 1  Sat, 14:00 - 16:00

Arianna Curioni, Cordula Vesper, Guenther Knoblich, and Natalie Sebanz
Kinematic signatures of joint action learning in reciprocal and non-reciprocal interactions

Gabriel Baud-Bovy and Fabio Tatti
Coordinated physical interaction and response strategies in a dyadic force detection task

Laura Schmitz, Cordula Vesper, Natalie Sebanz, and Günther Knoblich
How do we represent others’ action sequences?

Etienne Burdet
Physically interacting individuals estimate the partner’s goal to enhance their movements

Antonia Hamilton, Jamie A. Ward, and Jo Hale
Interpersonal coordination in natural conversations
Talk session C: Dialogue and conversation 1  Sat, 16:30 - 18:30

Anna K. Kuhlen and Rasha Abdel Rahman  
*Speaking together versus speaking alone: Cumulative semantic interference in joint task settings*

Sophie Skach, Patrick G. T. Healey, and Rebecca Stewart  
*On the Edge of Our Seat. Sensing Conversational Engagement from Pressure on Chair Seat Covers.*

Lucia Castillo, Holly Branigan, and Kenny Smith  
*It takes two to adapt: Interacting pairs’ language (but not individuals’) adapts to changing conditions in maze game*

Leonardo Lancia, Thierry Chaminade, Noël Nguyen, and Laurent Prévot  
*Prediction versus coupling: testing two different accounts of inter-speaker coordination*

Gregory Mills  
*The emergence of procedural coordination in joint activities: No evidence is better than negative evidence*

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Talk session D: Shared attention 1  Sun, 9:00 - 11:00

Margarita Blazevica, Igor Schindler, Geoff G. Cole, Kevin Riggs, Antonia D’Souza, and Paul A. Skarratt  
*Does the perceived reliability of co-actors influence joint action performance?*

Cathal O’Madagain and Michael Tomasello  
*Joint Attention to Mental Content and the Social Origin of Reasoning*

Xun He and Juan Camilo Avendaño Diaz  
*A dual-EEG study of shared attention effect in dyads: Sensory processing or top-down control?*

Francesca Capozzi and Jelena Ristic  
*Social attention depends on dynamic interactions between perceptions, mental states, and personal relevance*

Axel Seemann  
*Joint Action, Social Space, and Visual Perspective-Taking*
Talk session E: Synchrony  Sun, 11:30 - 13:00

R. C. Schmidt
Synchronization Dynamics Underlie Coordination in Natural Joint Actions

Lea Chauvigne, Ashley Walton, Michael J. Richardson, and Steven Brown
Group synchrony and multi-sensory integration in Greek folk dancing

Harjo J. de Poel
Natural asymmetry of between-agent interaction: anisotropic, repulsive and competitive coupling

Laurissa Tokarchuk
Walking in Sync and Sensing groups

Talk session F: Joint planning  Sun, 16:00 - 18:00

Timothy Welsh, Robrecht van der Wel, Anne Böckler
“I’ve got my eye on you”: Faces with sudden direct gaze are processed more efficiently than faces with averted gaze

Merryn D. Constable
How the concept of ownership influences human interaction with objects and other people

Dimitrios Kourtis, Günther Knoblich, and Natalie Sebanz
Action representations at the dyad level during joint action planning: Evidence from EEG

Basil Wahn, Alan Kingstone, and Peter König
Two trackers are better than one: Information about the co-actor’s actions and performance scores contribute to the collective benefit in a joint visuospatial task

Robrecht van der Wel
Experiencing joint action: Do “we” exist and when?
Talk session G: Cooperation

Mon, 9:00 - 10:30

Bert Hodges

*How humans became caring, cooperative, and conversing, but not conforming: Evolutionary and ecological perspectives*

Anika Fiebich

*Three Dimensions of Cooperation*

Corrado Sinigaglia and Steve Butterfill

*How Motor Representation Grounds Cooperation*

Talk session H: Goals and intentions

Mon, 11:00 - 13:00

Andrea Cavallo, Atesh Koul, Marco Soriano, and Cristina Becchio

*The kinematics you do not expect: How prior expectations and kinematics integrate for intention detection*

Atesh Koul, Andrea Cavallo, Franco Cauda, Tommaso Costa, and Cristina Becchio

*Mirror neuron regions encode intention-related information conveyed by movement kinematics*

Olle Blomberg

*Joint intentional action and acting as if part of one large agent*

Lise Hobeika, Marine Taffou, and Isabelle Viaud-Delmon

*Impact of a shared goal on the perception of the space around the body*
Talk session I: Coordination 2

Lucia Maria Sacheli, Elisa Arcangeli, and Eraldo Paulesu

Two agents, one melody: dual-person motor plans and interpersonal coordination in joint action

Vanessa Era, Marco Gandolfo, Lucia Maria Sacheli, and Matteo Candidi

Left anterior Intra-Parietal Sulcus causally scaffolds complementary joint-actions in freely interacting human-human pairs

Giacomo Novembre, Günther Knoblich, Laura Dunne, and Peter E. Keller

Interpersonal synchrony enhanced through 20 Hz phase-coupled dual brain stimulation

L.S. Cuijpers and H.J. de Poel

Mechanically coupled interpersonal coordination in crew rowing

Daniel C. Richardson and Jorina von Zimmermann

The dynamics of collective behaviour: opinions, judgements and jazz

Talk session J: Joint action: development and disorders

Xinyi Jin, Pengchao Li, Jie He, and Mowei Shen

Acting Interdependently Helps Young Children with Reasoning about Diverse Desires

Paula Fitzpatrick, Andrew Lampi, Shannon Campbell, Veronica Romero, Joseph Amaral, Michael J. Richardson, and R. C. Schmidt

The Influence of Social and Motor Context on Communication and Restricted and Repetitive Behaviors in Autism

Rose McCabe, Mary Lavelle, and Patrick G. T. Healey

Participation in first social encounters and social networks in schizophrenia

Christine Howes, Mary Lavelle, Patrick G. T. Healey, and Julian Hough

Do patients with schizophrenia do dialogue differently?
Talk session K: Shared attention 2  Tue, 11:00 - 13:00

Patrick G.T. Healey and Nicola J. Plant
   Embodiment as a Resource for Inter-subjectivity

Tobias Schlicht
   On individualism and interactionism in social cognition

Judith Martens
   Heuristics, bounded rationality, and joint action

Bill Wringe
   Joint Expressive Action: A Philosophical Analysis

Kristian Tylén, Riccardo Fusaroli, Pernille Smith, and Jakob Arnoldi
   Interaction, cognitive diversity and abstraction

Talk session L: Dialogue and conversation 2  Tue, 16:00 - 18:00

Chiara Gambi, Joris Van de Cavey, and Martin Pickering
   Joint Interference in picture description: Evidence for linguistically-detailed simulation of others’ utterances, but only when speaking concurrently

Simon Dobnik and Christine Howes
   Towards a computational model of frame of reference alignment in dialogue

Judith Holler and Stephen Levinson
   Coordination in face-to-face conversation
Transforming simple pursuit to rhythmic rocking: Recent developments in emergent coordination using the virtual shepherding task for the development of adaptive human-robot systems

Self-Referential Delays Facilitate Anticipatory Synchronization During Artificial Agent-Human Interaction

Can robots synchronize with humans in tempo changing environments?

Using unintentional entrainment effect for modelling synchronous interpersonal motor coordination in a context of Human Robot Interaction
ROBOT JAM session 2  
Wed, 14:00 - 15:30

Maurice Lamb, Riley Mayr, Tamara Lorenz, Rachel Kallen, Ali Minai, Michael Richardson

Joint Action with Non-Human Co-actors: Applying Human Joint Action Principles to Robotic and Virtual Co-actors in a Cooperative Pick-and-Place Task

Sandra Devin, Aurélie Clodic and Rachid Alami

Building and Managing Shared Plans for Human-Robot Joint Action

Tobias Fischer and Yiannis Demiris

Perspective mechanisms for facilitating joint actions in human-robot collaborations

Angelique Taylor and Laurel D. Riek

Robot Perception of Social Engagement Using Group Joint Action

ROBOT JAM session 3  
Wed, 16:00 - 17:30

Group discussion and wrap up

Moderators: Tamara Lorenz, Aurelie Clodic, Micheal J. Richardson, Laurel Riek
Poster sessions

Poster session 1

Jamie S. Allsop, Dannette Marie, and Lynden K. Miles
Exploring the effects of interdependence on group effectiveness

Ruth E. Corps, Chiara Gambi, & Martin J. Pickering
Do listeners use speech rate predictions to time responses during conversation?

Artur Czeszumski, Chiara Carrera, Basil Wahn, and Peter König
Compete or cooperate: Is feedback processing affected by the social situation?

Jill A. Dosso, Trish L. Varao-Sousa, and Alan Kingstone
Is there a Joint Simon Effect in word recall?

Vanessa Era, Carolina Mancusi, and Matteo Candidi
Distinct contribution of right TPJ and left aIPS to imitative and complementary human-avatar motor interactions

Vicente Estrada-González
Does it improve cognitive abilities exposure to complex visual art?

Felix J. Goetz, Anita Körner, and Cordula Vesper
Producing music vs. pressing keys together - representing joint action goals

April Karlinsky, Keith R. Lohse, and Melanie Y. Lam
A meta-analysis of the joint Simon effect

Christopher J Luke, Iva Barisic, and Bert Timmermans
The influence of dyadic eye gaze dynamics on objective size judgments and in a subjective preference task
Poster session 1 (contd.)

Sun, 14:00 - 16:00

Jonathan Mendl, Kerstin Fröber, Gesine Dreisbach, and Thomas Dolk
*Do you keep an eye on me? The influence of competition and cooperation on joint Simon task performance*

Markus Franziskus Müller
*How to orchestrate a soccer team - Generalized synchronization promoted by rhythmic acoustic stimuli*

Giacomo Novembre, Manuel Varlet, Shujau Muawiyath, Catherine J. Stevens, and Peter E. Keller
*The E-Music Box: an empirical method for exploring the universal capacity for musical production and for social interaction through music*

Paola Olguín, Julieta Ramos, and Markus Müller
*Rhythms, collectivity and interpersonal synchronization of brain dynamics*

Jessica Podda, Caterina Ansuini, Roberta Vastano, Andrea Cavallo, and Cristina Becchio
*The heaviness of invisible objects: predictive weight judgements from observed real and pantomimed grasps*

Vassilis Sevdalis, Jennifer Mayer, Kathy P. Filer, Peter E. Keller, and Pamela Heaton
*Perception of expressive body movements by individuals with autism spectrum disorder*

Mircea Stoica, Alexander Maye, and Andreas K. Engel
*Similarity of behavior in task space promotes collaboration and joint performance*

James Strachan
*Investigating the effect of joint speech on discrimination of truth*
Anna Strasser
  *Most minimal cases of commitments in joint actions*

  *Investing in Commitment: Evidence that the efforts invested by individual contributors to joint actions enhance their partners’ commitment*

Georgina Török, Natalie Sebanz, Barbara Pomiechowska, and Gergely Csibra
  *Efficiency in joint action: Do we make rational decisions when coordinating with others?*

Chia-huei Tseng and Cheng Meow
  *Self-bias in a joint task with a partner*

Cordula Vesper, Tiffany Morisseau, Günther Knoblich, and Dan Sperber
  *Co-actors Use Ostensive Communication to Distinguish Object Categories*

Basil Wahn, Artur Czeszumski, and Peter König
  *Skill differences predict collective benefits in dyadic and triadic joint visual search*

Jamie A. Ward, Gerald Pirkl, Peter Hevesi, and Paul Lukowicz
  *Activity Recognition in Groups Using Wearable Sensing*
Juan Camilo Avendaño Diaz and Xun He  
*Sustained visual attention in dyads: examining the role of group membership through a minimal group manipulation*

Sonia Betti, Umberto Castiello, Silvia Guerra, Umberto Granziol and Luisa Sartori  
*The role of gaze in social requests*

Nicole Bolt and Janeen Loehr  
*Joint action outcomes influence the sense of joint agency*

Coste A., Słowiński, P., Tsaneva-Atanasova, K., Bardy, B.G., and Marin, L.  
*From individual to social postural signatures*

Dubey, I., and Hamilton, A.  
*Priming Influences Social Seeking Tendencies Differently for with Higher Autistic Traits*

Farmer, H., Tong, H. & Hamilton, A.F. de C.  
*The effect of congruency in automatic imitation on social approach and avoidance*

Silvia Guerra, Andrea Spoto, Elisa Straulino and Umberto Castiello  
*Numbness Illusion in Autism: Implications for Social Interactions*

Kelly Jakubowski, Tuomas Eerola, Nikki Moran, and Martin Clayton  
*Validating computational methods for measuring joint action in music performance from video*

April Karlinsky and Nicola J. Hodges  
*Dyad practice impacts self-directed practice behaviours and motor learning outcomes in a contextual interference paradigm*

Sujatha Krishnan-Barman and Antonia Hamilton  
*The effect of being watched on overimitation of actions in adult dyads*
Kaitlin E. W. Laidlaw, Erin Walton-Ball, Jody C. Culham, and Melvyn A. Goodale

Signalling intentions: The influences of partner response accuracy on social action behaviours

Melanie Y Lam, Jarrod Blinch, Elizabeth M Connors, Jon B Doan, and Claudia LR Gonzalez

Bimanual joint action: correlated timing of “bimanual” movements accomplished by two people

Mary Lavelle, Chris Howes, Patrick G.T. Healey, Julian Hough, and Rose McCabe

The challenge of challenging others: Patterns of communication in interprofessional clinical teams

Manja Luft, Adrian Bangerter, and Lucas Bietti

Coordinating handshakes: An eyetracking study


Frequency properties allowing human-robot unintentional motor synchronization

Antonieta Martínez Guerrero, Mathieu Le Corre, Zeidy Muñoz-Torres, and Markus Müller

Tempo and Attention: Stroop Effect Modulation by Auditory Stimulus

Luke McEllin, Gunther Knoblich, and Natalie Sebanz

Discriminating between coordination and teaching intentions using action kinematics

Moreau Q., Pavone EF. Boukarras S., Tieri G., and Candidi M.

Neural correlates of a joint action in a human-avatar paradigm
Patric C. Nordbeck, Dakotah B. Tyler, Rachel W. Kallen, Anthony P. Chemero, and Michael J. Richardson
   *Phase Transitions Between Co-Present Single and Joint Action Modes*

Anita Paas, Giacomo Novembre, Claudia Lappe, Catherine J. Stevens, and Peter E. Keller
   *The Effect of Agency Ambiguity on Error-Related ERP Components in Musical Ensemble Performance*

Melvyn Roerdink, Niek van Ulzen, and Harjo de Poel
   *When two become one: interpersonal pattern formation in side-by-side and hand-in-hand walking*

Simily Sabu, Arianna Curioni, Cordula Vesper, Natalie Sebanz, and Günther Knoblich
   *Role of Motor Variability in Joint Action Learning*

Kayalveli Sivakanthan and Jacques Launay
   *Social relationships influence high intensity physical activity for university students*

Marco Soriano, Andrea Cavallo, and Cristina Becchio
   *Matching action observation to action execution*

Aafke van Mourik Broekman, Namkje Koudenburg, Ernestine H. Gordijn, Kirsten L.S. Krans, and Tom Postmes
   *The Impact of Art: Exploring the Social-Psychological Pathways That Connect Audiences to Live Performances*

Auriel Washburn and Takako Fujioka
   *Coordinated Timing in Piano Duet Performance: Effects of Musical Role Asymmetries and Auditory-Feedback Delays*
Ed Baggs  
*What roundabouts can teach us about joint action*

Divya Bhatia, Pietro Spataro, and Clelia Rossi-Arnaud  
*Movement Representation and its interaction with Memory*

Hiu-ming Chan and Chia-huei Tseng  
*Perceptual sensitivity of yawning and contagious yawning*

Ciaunica, A., Schilbach L., and Deroy O.  
*Compensatory Strategies in Online Social Interactions: Contrasting the Case of Autism with the Möbius Syndrome*

*Effects of Facial Emotions on Social-motor Coordination in Schizophrenia*

Antonia D. C. D’Souza, Paul A. Skarratt, Margarita Blazevica, and Geoff G. Cole  
*Sex differences in social inhibition of return*

Tehran J. Davis, Ashley Dhaim, and Gabriela Baraknowsi-Pinto  
*Individual task demands influence the organization of joint action: a look across scales*

Lize De Coster  
*Team performance is predicted by synchrony and self-other distinction*

Hannah M. Douglas, Stacie Furst-Holloway, Michael J. Richardson, and Rachel W. Kallen  
*Complexity matching of postural activity during the disclosure of a concealable stigmatized identity*
Georgescu, A.L., Hamilton, A., Falter, C.M., Tschacher, W., and Vogeley, K.

*Evaluating Interpersonal Synchrony in Naturalistic Dyadic conversations Using Motion Energy Analysis: Lessons from Autism Spectrum Conditions and Typical Development*

Janeen Loehr, Sarah Ardell, and Dimitrios Kourtis

*Degree of responsibility influences outcome evaluation in joint action*

Maurici A. López-Felip, Tehran J. Davis, and Till D. Frank

*Dynamics of Collective Behavior in Sport*

R. Lowe, P. Gander, A. Almér, G. Lindblad, C. Vesper, and J. Michael

*Studying the Effects of Affective Memory in Joint Activity*

Lilla Magyari, Natalie Sebanz

*Seeing Togetherness in Motion: Perceptual Cues to Interpersonal Coordination in Joint Dance Improvisations*

Michael, J., Letesson, C, Wozniak, M., Székely, and M., Butterfill, S.

*The Chains of Habit: Evidence that repetition of a joint action enhances the sense of commitment*

Peta Mills, Christopher Stanton, Trevor Mcpherson, and Peter Keller

*The Role of Social Engagement during Interpersonal Coordination: Sensorimotor Synchronisation with an Adaptive Rhythmic Robot*
Orit Nafcha, Simone Shamay-Tsoory, Shai Gabay
*Investigating the influence of Social context on the Social Inhibition of Return*

Henry Powell
*A Social Bernstein’s Problem*

Davide Quarona, Caterina Ansuini, Luca Pascolini, Atesh Koul, Andrea Cavallo, Cristina Becchio
*A kind of magic: the influence of motor expertise on pantomime discrimination*

Eleonora Satta, Simone Ferrari-Toniolo, Alexandra Battaglia-Mayer
*Development of motor coordination skills during joint action in mid-childhood*

Jacob Taylor and Emma Cohen
*Feeling the “click” of successful joint-action predicts social bonding among professional Chinese rugby players during a two-day National Tournament*

Cordula Vesper, Terry Eskenazi, Janeen Loehr, and Floris de Lange
*Observing Interpersonal Synchrony: An fMRI Study*

Thomas Wolf, Natalie Sebanz, Günther Knoblich
*Adaptation rates of musicians to phase-shifted inter-limb coordination in individuals and pairs*

Leshao Zhang
*Does mimicry make someone’s argument more persuasive?*
Abstracts

(in alphabetical order)
Beginning to dance: methods of mutual coordination between novice dancers

Saul Albert¹ and Dirk vom Lehn²

¹Tufts University; ²King's College London

Expert dancers can move together in seamless flows of joint action. They initiate and complete sequences of movement, and anticipate and counterbalance the momentum of one another’s bodies in ways that can appear both effortlessly coordinated and spontaneously responsive to changes in the music and their local environment. While this close coordination is a compelling spectacle, it is designed to be difficult to analyze: audiences are not meant to see how it is done, so analysts of joint action have tended to focus on rehearsals or classes that involve teaching and learning to dance together. However, most studies have focused on advanced students (Keevalik & Broth, 2014) or professional dance rehearsals (Muntanyola-Saura, 2015) and the teaching and learning practices they develop for achieving complex choreographies. This talk explores the coordination of the first few moments of initial steps learned by novices at the start of an introductory partner dance workshop. Using qualitative video analysis and by studying the procedural structure of interaction during the workshop, we show how novice dancers’ joint actions are coordinated using mundane conversational practices and rhythmical entrainments, suggesting a similarly interactional basis for expert dance coordination.
Exploring the effects of interdependence on group effectiveness

Jamie S. Allsop, Dannette Marie, and Lynden K. Miles
School of Psychology, University of Aberdeen

Our ability to accomplish collaborative tasks is largely determined by the extent to which our efforts align with task demands. Previously, we demonstrated that dyadic performance on a simple object movement task was influenced by the spontaneous emergence of interpersonally coordinated behaviour. By employing a more fine-grained measurement of between-person coordination (i.e., magnetic motion tracking), the present study set out to investigate the dynamics underlying the relationship between task performance and interpersonal coordination. Dyads were instructed to either compete or cooperate when emptying a container of approximately 150 small plastic balls as quickly and accurately as possible. By manipulating task-relevant dependencies (i.e., links) between participants, we created a context in which both coordination and performance were expected to vary in systematic ways. The results revealed that stable patterns of coordination enhanced task accuracy, but not overall productivity. More specifically, cooperating dyads spent more time in a stable state of coordination than their competing counterparts. We also found that higher levels of movement stability led to greater accuracy. Importantly, these effects were most prominent when the task involved greater levels of interdependence. These findings are discussed with respect to contemporary theories of coordination and collective performance.
Using unintentional entrainment effect for modelling synchronous interpersonal motor coordination in a context of Human Robot Interaction

Ansermin, E., Mostafaoui, G., Beausse, N., and Gaussier, P.
ENSEA, University of Cergy Pontoise

The entrainment effect plays a crucial role in interpersonal coordination (Kay et al., 1987). Occurring unconsciously, this phenomenon could be the consequence of low level mechanisms: a force entraining the motor control. Bidirectional entrainment can lead agents to perform synchronous rhythmical joint actions. A convenient way to model entrainment between two dynamical systems is to use coupled oscillators (Haken et al., 1985). Here, we use a reservoir of oscillators to control a Nao robot able of learning to synchronously imitate a partner. The human motion, extracted by an optical flow algorithm, is then to be decomposed into the base of oscillators and learned by a neural model. This type of oscillatory motor controller finds justification in several studies highlighting the presence of a strong oscillatory component in motor control (Churchland et al., 2012). A major drawback is here to have a fairly complete reservoir of oscillators at different frequencies and phases to define different motion trajectories. However, we will demonstrate that taking into account the entrainment effect in our neural model allows us to go beyond those limitations by making the oscillators adaptive in frequency and phase. Using the same set of oscillators, our robot is finally able to quickly imitate synchronously different rhythmical movements without previous learning. (DIRAC Project #ANR 13-ASTR-0018-01)
Sustained visual attention in dyads: examining the role of group membership through a minimal group manipulation

Juan Camilo Avendaño Diaz and Xun He

Cognition and Cognitive Neuroscience Research Centre (CCNRC), Department of Psychology, Bournemouth University, UK

Humans are often engaged in similar tasks in the presence of other performing individuals. Research in this field has suggested that performance in co-acting dyads is usually enhanced due to task co-representation or shared reality. However, the effect of sharing the locus of attention has not been well studied, despite that attention sharing is commonly found in real life. Recently, He and Avendaño Diaz (2017) showed a reduced attentional effect when a dyad paid sustained visual attention to the same spatial location than when attending to different locations. In the current study, we examined the contribution of group membership to this attention-reduction effect. Each participant in any dyad was asked to pick one bib from two differently coloured bibs and to wear it during the experiment. A minimal-group status was thus introduced if a dyad shared their colour preference. While the attention reduction effect was replicated in the out-group participants, this effect was absent among the in-group members. Further analysis suggested that this was mainly due to the generally weaker attentional effect in the in-group participants. We hypothesised that sharing attention reduces the attentional effect in a way similar to that of the group membership (He, Lever, & Humphreys, 2011).
What roundabouts can teach us about joint action

Ed Baggs
Bartlett School of Architecture, University College London, London, United Kingdom; Department of Psychology, University of Cincinnati, Cincinnati, Ohio, United States

Joint action research typically seeks to explain multi-actor activity in terms of interpersonal coordination mechanisms. Less attention is paid to the relevance of the spaces in which these activities are carried out. To address this I look at a traffic infrastructure element that relies on interpersonal behaviour: the roundabout. Replacing four-way intersections with roundabouts leads to a striking reduction in collisions, injuries, and fatalities (Rodegerdts et al., 2010). This is true whether the intersection was previously controlled by lights or yields signs. Roundabouts do not give rise to opportunities for the worst collision types: T-bone or head-on crashes. From the perspective of the driver entering the junction, the task is simplified: the driver encounters only traffic heading in the same direction around the roundabout. A problem that requires special treatment is how to accommodate cyclists in the junction. An asymmetry exists: cyclists are vulnerable in a way that drivers are not. The safest roundabout designs for cyclists feature a grade separated path outside the roundabout itself (Reynolds et al., 2009). The roundabout is an interesting paradigm case for thinking about joint action research: it forces us to go beyond interpersonal coordination and to consider how the nature of the task, the contours of the space, and embodied asymmetries between actors give shape to behaviour. This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 706432.
Coordinated physical interaction and response strategies in a dyadic force detection task

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When two persons interact physically with the same object, the interaction force that each partner experiences provides ambiguous information because it is affected by the other’s actions. The two partners need to hold the object in a coordinated manner to ensure that they can get meaningful information from the interaction forces. We investigated whether dyads could achieve such form of coordination in a perceptual task where two subjects had to indicate the direction of a weak external force applied to the object. We identified two different ways in which dyads coordinate their action in this task and resolve its ambiguity: the first behavior required that the dyad split the external force in an approximately equal manner and the second behavior required the individual with information about the external force transmit it to the partner. The strategy was not affected by feedback about the performance but could change when the participants were instructed to maintain the object’s position or minimize the interaction force. This study shows how two subjects interacting physically can coordinate their actions in a joint perception task to gain information about the forces in the environment that might affect jointly-held objects.
Observing eye gaze and body movements provides a relevant source of information for social interaction. This study investigated whether observing other’s gaze - pointing toward an object - affects motor responses in onlookers. By using single-pulse transcranial magnetic stimulation (spTMS) on primary motor cortex (M1), we assessed corticospinal excitability while participants observed actions sequences eliciting or not interactive responses. Results showed an inhibitory pattern in observers’ muscles when the actor’s gaze was pointing to a salient object for the interaction. However, this pattern was in striking contrast with the ‘willingness to interact’, as reported by participants in a following questionnaire. Overall, these data seem to indicate that the joint contribution of gaze and request gesture increases participants’ proactivity (as indicated by the self-reports), so that muscular inhibition is necessary in order to prevent overt reaction.
Movement Representation and its interaction with Memory

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Several previous studies have investigated how the production of movements influences visuo-spatial working memory. Some studies showed that movement during encoding facilitates the recognition of spatial arrays in a visuo-spatial working memory task. Another set of studies examined memory for self and other-performed action phrases, and found that self-performed phrases were recalled better than experimenter-performed phrases. Given these findings, the present study was aimed at investigating the question of how self and others movements interact with visuo-spatial working memory. Participants performed a task that required the maintenance of two consecutive arrays of three or four items, one encoded by visual observation accompanied by pointing movements (performed either by the participant or by the experimenter), the other only by visual observation. We found that self-performed pointing movements facilitated array recognition (at least for three-item arrays), whereas experimenter-performed movements impaired recognition performance. The results suggest that, like in the classical enactment effect, self-performed movements can improve visuo-spatial working memory performance in specific conditions.
Does the perceived reliability of co-actors influence joint action performance?

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Previous research shows that during joint action, observing a co-actor reaching to a spatial location can slow one’s own response to the same location, and even deter one from selecting that location in a free choice between alternatives. Some authors have argued that such joint action effects are mediated by higher-level processes that represent both actions and intentions within the same schema. Here we asked whether this particular joint action effect can be modulated by the perceived reliability of a co-actor’s responses: that is, when observers understand them to be accurate or guessed responses. To that end, co-actors alternated responses to either supra- or sub-threshold visual targets, and the reliability of the co-actor was manipulated in two ways. In Experiment 1, the co-actor was believed (or not) to be in receipt of information about upcoming targets; in Experiment 2, they wore a blindfold (or not) which prevented them from seeing the targets. While reliable joint action effects were obtained throughout, neither reliability manipulation modulated them. In this type of joint action task, therefore, it appears that actions themselves are represented irrespective of the underlying intentions.
Joint intentional action and acting as if part of one large agent

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Joint intentional action is a form of cooperative action: Participants treat each other as partners rather than as social tools. An influential way of capturing this is to require that participants act on various interconnected intentions or plans (see e.g. Bratman 2014; Ludwig 2016). While elegant, this theoretical strategy has a cost: it makes joint intentional action complex (overly so, one might think) as well as conceptually and cognitively demanding. The aim of this talk is to consider an alternative strategy. On this strategy (which is embedded in accounts found in Bacharach 2006, Gold and Sugden 2007, Gilbert 2009, and in Pacherie 2011 and 2013), individuals engage in joint intentional action not partly in virtue of having interconnected plans but in virtue of them each conceiving of themselves and the others as parts of a single group-level agent while acting. I argue that this strategy fails. Nothing rules out that the goal-directed activity of the single group-level agent, of which they take themselves to be parts, is implemented through conflict, disagreement and coercion between parts. There is thus still reason to think that joint intentional action is a complex as well as conceptually and cognitively demanding phenomenon.
Joint action outcomes influence the sense of joint agency

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People experience joint agency, i.e., shared control over actions and their effects, when they engage in joint action. Multiple cues influence people’s experience of joint agency, including the degree of coordination between partners and each partner’s role within the joint action. The current study investigated how the outcome of a joint action modulates joint agency. Pairs of participants produced eight-tone sequences that matched a metronome pace. Participants produced tones either in alternation (high coordination) or sequentially (one participant produced the first four tones and the other produced the last four; low coordination). Each participant was the leader, who produced the first tone(s), for half of the sequences. After each sequence, participants received feedback indicating whether or not they correctly matched the pace, and then rated their sense of agency on a scale ranging from shared to independent control. People reported stronger joint agency for correct compared to incorrect outcomes, regardless of coordination requirements, role, and the accuracy and variability of sequence timing. These findings indicate that joint action outcomes are used alongside other cues to inform the sense of joint agency.
Physically interacting individuals estimate the partner’s goal to enhance their movements

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From a parent helping to guide their child during their first steps, to a therapist supporting a patient, physical assistance enabled by haptic interaction is a fundamental modus for improving motor abilities. However, what movement information is exchanged between partners during haptic interaction, and how this information is used to coordinate and assist others remains unclear. In this talk I will present a computational model where haptic information, provided by touch and proprioception, enables interacting individuals to estimate the partner’s movement goal, and to improve their own motor performance. Results of an empirical physical interaction task show that our model can explain human behaviours better than existing models of interaction in literature. This model was verified by embodying it in a robot partner and checking that it induces the same improvements in motor performance and learning in a human individual as a human partner. We further explicit how the hard or soft interaction mechanics modulates the mutual benefits of the interaction and the relative effort between partners. These results promise collaborative robots with human-like assistance, and suggest that movement goal exchange is the key to physical assistance.
Social attention depends on dynamic interactions between perceptions, mental states, and personal relevance

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Social attention refers to changes in attentional behavior in response to information conveyed by other agents. As such, it represents one of the basic building blocks of the human socio-communicative and interactive system. Despite its importance, however, the current understanding of social attention remains fragmented across opposing theoretical positions (e.g., mental vs. perceptual processes) and experimental approaches (e.g., naturalistic vs. laboratory studies). Drawing from the available theories and data, here we outline a novel, unified perspective of social attention. In this new view, social attention reflects joint operations of perceptual, interpretive, and evaluative processes. Three lines of evidence support this perspective. First, perceptual cues, like deviated gaze, contribute to social attention reliably but carry only limited power. Interpretive processes, such as the attribution of mental states, build on perceptual procedures, and modulate the strength of social attention behaviors. Finally, evaluative procedures gate the selection of social information and its relevance via personal and contextual factors. In addition to providing a first unified perspective of social attention, our view also offers a falsifiable way of testing the contribution of each route of processing and allows for meaningful extensions of the field to the study of social attention in multi-agent interactive contexts.
It takes two to adapt: Interacting pairs’ language (but not individuals’) adapts to changing conditions in maze game

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Linguistic choices are affected by linguistic and non-linguistic factors, like the features of the context, and the communicative demands of the task. Speakers adapt to the context in their initial choice of words, but only in interaction they are able to ground their references and build better and more adaptive communication systems. We used a maze game task in which individual participants and interacting pairs had to describe figures and their positions in one of two possible maze types: a regular maze, in which the grid-like structure of the maze is highlighted, and an irregular maze, in which specific parts of the maze are salient. The game is repeated three times, making a systematic approach more suitable for the task over time. Both individuals and pairs were initially affected by the different maze layouts, using more idiosyncratic descriptions for irregular mazes and more systematic ones for regular mazes; however, only pairs of participants abandoned their unsystematic initial descriptions for a more systematic approach as they moved through the game. Our results provide novel insights into the dynamics of adaptation and interactive alignment in situated dialogue.
The kinematics you do not expect: How prior expectations and kinematics integrate for intention detection

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What role do expectations play in understanding others’ intentions? Anticipating a forthcoming stimulus facilitates perception for the expected stimulus but may also hinder perception for less likely alternatives. In this study, we consider how prior expectations about others’ intentions integrate with visual kinematics over time to facilitate (or hinder) the detection of the intention of an observed motor act (grasp-to-pour vs. grasp-to-drink). Using well-established visual psychophysics methods in combination with kinematics, we show that the processes involved in detecting others’ intentions are well described by drift diffusion models in which evidence from current motion is accumulated over time until a threshold level for decision is reached. Testing of several models revealed that when motion contained no discriminative intention information, prior expectations predicted the intention choice. When motion provided discriminative intention information, visual kinematics were predictive of participants’ intention choice. These findings provide evidence for a model in which information about what is probable (expectations) and what is present (visual kinematics) are optimally combined to identify the most probable intention of an observed motor act.
Perceptual sensitivity of yawning and contagious yawning

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Contagious yawning is an automatic urge to yawn in response to viewing or listening to others’ yawning, but the underlying mechanisms for this behavioural contagion is still unclear. In current study, we examined influences from both empathy (i.e. autistic traits) and non-empathy factors (i.e. individuals’ perceptual detection sensitivity to yawning, happy, and angry faces) upon 41 healthy adults. We induced contagious yawning with a 5-minute video and 20 yawning photos stimuli while their eye gaze patterns were recorded with an eye tracker. Additionally, we measured subjects’ autistic traits (with Autistic-spectrum Quotient Questionnaire) and their perceptual detection thresholds for yawning and emotion photos. We found two factors associating with yawning contagion: (1) those more sensitive to detect yawning, but not other emotional expressions, displayed more contagious yawning than those less sensitive to yawning expression, and (2) female participants exhibited significantly more contagious yawning than male participants. We did not find association between autistic trait and frequency of contagious yawning after controlling yawning sensitivity and gender. Our results offered a working hypothesis that perceptual encoding of yawning interplays with the contagion effect of yawning in non-clinical population for future studies to examine on.
Group synchrony and multi-sensory integration in Greek folk dancing

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During many kinds of joint actions, non-verbal communication between individuals allows them to coordinate their movements. Folk dances are a good model to study the influence of different sensory modalities on interpersonal synchronization because dancers rely on auditory, visual, and haptic information. The current study assesses the relative importance of different modes of sensory information to the performance of traditional Greek folk dances. In these dances, groups of participants form a circle and hold hands while performing different sequences of steps with a leader in the middle. We used motion capture to measure the velocity of the balls and heels of 14 dancers’ feet, while they were performing three different dances. In order to evaluate the use of sensory information, dancers performed each dance in three different conditions: one where the dance’s background music was omitted (limiting auditory information), one where participants danced with their eyes closed (limiting visual information), and a condition where they were not allowed to hold hands (limiting haptic information). Group synchronization was assessed using cluster phase analysis, which captures patterning of relative phase relationships in movement time series. Differences in synchronization across dances and conditions will reveal how different sensory modalities support multi-person joint action.
Compensatory Strategies in Online Social Interactions: Contrasting the Case of Autism with the Möbius Syndrome

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Is bodily coupling a necessary and sufficient for socio-emotional understanding? Building upon findings suggesting that individuals with Möbius Syndrome (MS) - a rare congenital facial paralysis preventing facial mimicry (Briegel 2006) - seem less impaired social interactions (Bogart & Matsumoto 2010a) Krueger and Michael (2012) reply in the negative. Here we challenge this interpretation and argue that a comparison between MS- and autistic (ASD) compensatory strategies in coping with disrupted social fluency reveals the constitutive nature of automatic bodily coupling in social understanding. Indeed, the automatic mirroring of others’ emotional facial expressions which facilitates socio-emotional understanding in everyday life (Dimberg 1982) seems impaired in ASD (Rogers & Pennington 1991; McIntosh et al. 2006). Building upon a) the idea that face perception in everyday encounters never occurs in isolation from other sensory modalities (e.g. tactile, auditory), and b) studies revealing differences at the level of multisensory processing in ASD (Marco et al. 2011) we argue that social difficulties in ASD might be imputable to a mismatched automatic bodily coupling with others and a consequent lack of the benefits provided by the socio-emotional markers of intimacy that typically developing people acquire during social interactions.
Effects of Facial Emotions on Social-motor Coordination in Schizophrenia


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Schizophrenia patients are known to be impaired in their ability to process social information and to engage in social interactions. To understand better social cognition in schizophrenia, we investigate the links between these impairments. In this paper, we focus primarily on the influence of social feedback, such as facial emotions, on motor coordination during joint action. To investigate and quantify this influence, we exploited systematically-controlled social and nonsocial feedback provided by a humanoid robot. Humanoid robotics technology offers interactive designs and can precisely control the properties of the feedback provided during the interaction. In this work, a joint-action task with a robot is performed to investigate how social cognition is affected by cognitive capabilities and symptomatology. Results show that positive social feedback has a facilitatory effect on social-motor coordination in the control participants compared to nonsocial positive feedback. This facilitation effect is not present in schizophrenia patients, whose social-motor coordination is similar in social and nonsocial feedback conditions. This result is strongly correlated with performances in the Trail Making Test (TMT), which highlights the link between cognitive deficits and social-motor coordination in schizophrenia.
Visual cues in musical synchronization: How can the conductor influence musicians?

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Ensemble music presents a large-scale case of joint action, wherein up to several dozen musicians coordinate their actions. Often, this process is directed by a conductor who maintains a visual beat and guides the ensemble through tempo changes. This experiment tested the degree to which musicians benefit from a conductor’s movements, and how this benefit might manifest in both instrumental and ancillary movements. We designed a “virtual conductor” that was derived from morphed motion capture recordings of human conductors. Participants were shown the virtual conductor, a simple visual metronome, or a stationary circle, while completing a synchronization drumming task. We measured asynchronies and anticipatory timing in the drumming task, as well as upper-body sway using motion capture. Initial drumming results suggest that the conductor may be improving synchronization by facilitating anticipation of tempo changes in the music, but results are not significant and testing is ongoing. Initial motion capture results show that the conductor visual cue elicited significantly more regular body sway with larger amplitudes than the other two visual cues. The increased body sway could be a result of entrainment to the moving visual cue, and serve to convey a sense of time to co-performers.
How the concept of ownership influences human interaction with objects and other people

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Ownership is a socio-cultural construct pervasive in everyday life, from buying and selling to borrowing and lending. Humans can even feel a sense of ownership over things that they do not legally own, such as their chair at work. Understanding the nuances of ownership relations, legal or psychological, is integral to maintaining a harmonious social environment. Here I will present a synthesis of my motion capture research concerning how the concept of ownership modulates human interaction with objects that have ownership status. I will also explore how such an embodiment of the concept of ownership influences joint action. Supplementary reaction time and judgement based experiments will also be presented. Overall, the synthesized data suggests that concept of ownership is instated in the motor system and it influences individual and joint actions in both self-oriented and other-oriented fashions.
Do listeners use speech rate predictions to time responses during conversation?

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The ability to take turns in a timely manner is core to many forms of joint action, but is especially important during dialogue. Interlocutors continuously switch between speaking and listening, with little overlap or gap between their turns (Stivers et al., 2009). How do they do so? According to Garrod and Pickering (2015; see also Wilson & Wilson, 2005), listeners avoid conversational overlap by tracking or entraining to the speech rate of their partner’s utterance. We tested this hypothesis by having listeners answer yes/no questions (e.g., do dogs have four legs?). Crucially, using time compression methods, we created four versions of each question where speech rate either stayed the same throughout (SLOW-SLOW and FAST-FAST conditions) or changed (SLOW-FAST and FAST-SLOW conditions) on the final word. Listeners responded earlier after a fast context (t=-2.23), showing that they entrained to the base speech rate of the question. Moreover, listeners responded later to a fast-slow than fast-fast utterance and to a slow-slow than slow-fast utterance (t=8.89), suggesting they updated their predictions after encountering a final word differing in rate from the rest of the utterance. These results suggest speech entrainment helps interlocutors time articulation of their turns during dialogue.
From individual to social postural signatures

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Individuals are unique in the way they stand or move. Yet, individuals often adapt their postures and gestures to successfully interact with others. Here, we report a method able to capture both individual and social postural dynamics in order to compare them. After recording the centre of pressure in the antero-posterior direction during a solo or duo postural improvisation task, we estimated the probability density function (PDF) of the participant’s movement. PDFs were compared to each others using the earth mover’s distance, a distance metric that reveals how similar two histograms are. Multidimensional scaling was then used to provide a two-dimensional visual representation of the distances (similarity) between PDFs. In this way, we demonstrated the existence of individual postural signatures from nine participants improvising during 3 weeks (1 weekly session of 3 one-minute trials). In particular, we revealed two essential features of these signatures, i.e., that they were time-persistent and that they differed significantly from those of others. Further, in the presence of others, we discovered that participants tend to change their individual postural signatures towards a common signature called here a social postural signature. Our findings allow us to better understand the inter-relations between individuals and social behaviours.
Mechanically coupled interpersonal coordination in crew rowing

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While ample literature focusses on the perceptual nature of between-agent interaction, agents are often also physically connected, such as in crew rowing. Curiously, antiphase crew coordination may be mechanically more efficient because it reduces the power lost to shell velocity fluctuations (1,2). However, coupled oscillator dynamics predicts the stability of coordination to decrease with increasing stroke rate, which in case of antiphase may eventually yield coordinative breakdowns and transitions to in-phase. We examined pairs rowing on coupled ergometers on ‘slides’ (allowing the ergometer to move with respect to the ground). They rowed in- and antiphase at different stroke rates while kinematics of handles, rowers and ergometer were recorded. To investigate the effect of mechanical coupling, the ergometers could either move independently (perceptual coupling) or were physically connected (both perceptual and mechanical coupling). For both patterns, crew coordination was much more consistent when the pair was mechanically coupled. Moreover, without mechanical coupling more breakdowns from antiphase coordination occurred, and this number was lower for the higher stroke rate. Together this suggests that mechanical coupling may counter the frequency-induced coordinative instability.
Kinematic signatures of joint action learning in reciprocal and non-reciprocal interactions

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To date, little is known about the cognitive and motor processes in place when agents learn how to coordinate their actions over time. Our research aims at investigating the influence of reciprocal prediction and adaptation on joint action learning. We developed a novel experimental paradigm, the Joint Tracking Task, that allow us to study fine graded coordination dynamics and learning processes of complex bi-dimensional movements. In three experiments we manipulated the reciprocity of information flow (Unidirectional vs. Reciprocal Coordination) and role distribution (Leader-Follower) between agents to test how the interaction between roles and the availability of visuo-motor information of the other’s movements foster learning. Our results shed light on how reciprocity of information flow between co-agents is crucial for joint action performance when agents have to overcome individual motor constraints to achieve coordination.
Compete or cooperate: Is feedback processing affected by the social situation?

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People performing joint actions usually cooperate or compete to achieve their goals. Little research has investigated the neural processes underpinning error and reward processing in cooperative and competitive situations. In the present study, we investigated event-related potentials (ERPs) elicited by feedback (i.e., the feedback-related negativity (FRN)) denoting individual and joint errors as well as positive, negative or no monetary rewards in cooperative and competitive situations. Twelve pairs (N=24) of participants performed a joint four-alternative forced choice (4AFC) memory task. At the end of each trial, participants received feedback related to both their individual performances and monetary rewards. Note, the monetary rewards were dependent on the social situation (i.e., cooperative or competitive). Our results suggest that the FRN is not error-specific but instead reward-specific and it is also present after a neutral outcome (i.e., no monetary reward). Moreover, cluster permutation analysis of EEG data revealed significant differences in error processing between cooperative and competitive situations. Taken together, our results suggest that the FRN is influenced by different monetary rewards (i.e., positive, negative or no monetary reward) and more generally, that neural processing of feedback differs in cooperative and competitive situations.
Sex differences in social inhibition of return

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Social inhibition of return (sIOR) refers to the phenomenon in which the initiation of a reaching action is slowed if it is to a location that has just been reached to by another individual. Although sIOR is often argued to have arisen as a result of a Darwinian selection pressure for efficient foraging, the evolutionary theory of the effect has not yet been examined. Since females are thought to have been foragers (Silverman & Eals, 1994), the present study investigated whether females show greater sIOR relative to males. Participants completed the basic sIOR paradigm with the same or opposite sex co-actor, i.e., female only, male only, or mixed sex. Results showed a significantly larger sIOR effect for female co-actors compared to male or mixed sex co-actors. These results thus support the evolutionary explanation for sIOR.
Successful joint actions require the coordination of behaviors across multiple scales. For example, in order for teammates to successfully pass a baton, each member must organize and control the internal activity of any given number of muscles, limbs, and joints so as to meet their individual task demands (e.g., “I must stay upright and keep pace”, “I must lift and guide the baton”); while at the same time coordinating these actions with a teammate so as to optimize the group’s combined efforts (“our hands must meet”). Combined efforts, however, almost never equate to identical efforts. Differences between actors’ skill and abilities typically produce asymmetries in task demands and individuals working together must often perform distinct and complementary actions to complete a shared task. We have investigated how these inherent asymmetries influence and constrain the coordination and planning of joint actions in a variety of tasks including dyadic precision aiming, juggling, and puzzle-solving (Tetris). Two common themes have emerged: 1) an apparent scale-invariance whereby similar patterns of organization are observed at both individual and dyadic levels, and 2) a systematic relationship between the relative demands at the individual level (and corresponding coordination dynamics) and the emergence of complementary roles (e.g., leader-follower) within dyads.
Team performance is predicted by synchrony and self-other distinction

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Working together in teams is a vital aspect of everyday social behavior. In the current study, we aimed to understand how teams work together, and how team performance can be improved. To this end, we invited groups of three people into the lab and had them perform a series of group tasks, including a task during which participants simulated flying an unmanned air vehicle. During these tasks, we measured participants’ physiological responses (cardiac output, heart rate), and we had them perform the imitation-inhibition task (Brass et al., 2000) as an individual measure of self-other confusion/distinction abilities beforehand. Results indicated that increased psychophysiological synchrony - as indexed by pre-ejection period of cardiac impedance - predicted better team performance. Interestingly, both synchrony and team performance were predicted by self-other distinction, i.e. higher self-other distinction led to increased synchrony and performance. Moreover, the effect of self-other distinction on group performance was partially mediated by physiological synchrony and correlations with empathy measures (perspective taking, personal distress) were found. These results point to the importance of physiological synchrony in determining group performance, and to the idea that - next to synchrony - the ability to distinguish self from other is equally important.
Natural asymmetry of between-agent interaction: anisotropic, repulsive and competitive coupling

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Between-agent coordination can be studied from a coupled oscillator approach. Ample literature in this respect has studied effects of a difference between the two agents’ individual component dynamics (e.g., natural frequency mismatch). Recent studies also started to more directly consider the interaction per-se. In this regard, the coupling is mostly considered/assumed to be either symmetric/isotropic (i.e., oscillators are mutually coupled to the exact same degree) or strictly unidirectional (i.e., there is no coupling in the reverse direction, e.g. when moving to a given external rhythm). The argument of the present talk is that between-agent interaction involves a natural coupling asymmetry (‘anisotropic coupling’: bidirectional with a difference in the degree to which components influence each other). Indeed, recent studies highlighted that although on average (effects of) coupling may sometimes appear symmetric, between-agent coupling by definition implies a certain degree and form of ‘leader-follower’ interaction. Moreover, the interaction can also take repulsive rather than attractive shapes: recent developments have provided novel insights regarding antagonistic/’competitive’ coupling in conflictive social movement interactions (e.g., ‘attacker-defender’). These issues converge in a conceptual model to offer relevant new entry points for studying the dynamic nature of the interaction in between-agent contexts.
Future robots are intended to collaborate with humans at work or help them in their every day life. In this context, robots will have to be able to engage and conduct Joint Actions with humans in a natural and efficient way. The presented work focuses on Shared Plans management for Human-Robot Joint Action. In the current state of the art, robots are able to compute and share plans to work with humans. However, these plans are completely synthesized at planning time and all actions are allocated and completely instantiated in advance. In this work, we propose a scheme where the robot reasons at a higher level of abstraction and is able to compute shared plans that are specially built to identify the decisions that should be preferably postponed until execution time. This allows to better identify the meshing subplans in order to reduce useless communications from the robot and give more latitude to the human while avoiding potential conflicts. We will also illustrate how the robot can estimate the humans mental state concerning the shared plans and take them into account during planning and execution.
Towards a computational model of frame of reference alignment in dialogue

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We are interested in how participants align the frame of reference of spatial descriptions such as "to the left of the green cup" in dyadic text dialogues in English and Swedish when they perceive a scene from different locations. How do they identify if a misalignment has occurred, and what strategies do they use to get back on track? We show that there is no general preference of FoR in dialogue but the choice is related to the communicative acts of particular dialogue games (a sequence of dialogue moves centred towards a particular goal). There is also evidence that participants align their FoR locally over a sequence of turns, but not globally; at points of misunderstanding it may be prudent to shift FoR to get the conversation back on track. We isolate several conversational games where the dynamics of the FoR assignment appears to be linked to other properties of interaction between the agents, for example whether they are focusing on a particular part of the scene or whether they are identifying individual objects scattered around the scene. It follows that alignment is consistently used as a strategy but there are other factors that trigger changes in FoR.
Is there a Joint Simon Effect in word recall?

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The Joint Simon Effect (JSE) demonstrates that the presence of a co-actor can influence response speed such that responses to stimuli aligned with the co-actor are slower than responses to identical stimuli in the absence of the co-actor (Sebanz, Knoblich, & Prinz, 2003). On the other hand, memory is improved for words which are read by a co-actor, or to which a co-actor responds with a button-press, as compared to neutral words (Eskenazi, Doerrfeld, Logan, Knoblich, & Sebanz, 2013; MacLeod, 2011). The present study investigated whether these two effects interact. Specifically, how does the spatial relationship between a stimulus and a co-actor impact later memory for that item? Participants performed a word classification task as a pair and individually, followed by a surprise word recall test. Words were presented following a 2 x 3 within-subjects design: screen side (left, right) and category (own-response, other-response, no-response). Preliminary data suggest that own-response words presented near a co-actor were remembered less well than own-response words presented in the same space when participants were alone. Moreover, the magnitude of participants’ JSEs in response speed and in memory performance were correlated. This provides early evidence of a Joint Simon-like effect in memory.
Interpersonal disclosure of a concealable stigmatized identity (CSI) is an important aspect of every-day life for individuals living with such identities. Though people risk stigmatization by disclosing a CSI (e.g., mental illness), positive disclosure experiences are associated with higher quality of life. Research suggests that antecedent goals (approach/avoidance) lead to differences in the disclosure, including nonverbal behaviors. The present research is the first to investigate interpersonal postural activity (PA) during a disclosure. In study 1, we recruited 42 participants who have a CSI. Participants role-played a disclosure event to both a close-other (friend/family) and a professional-other (boss/coworker). PA was recorded at their head and waist using Polhemus motion tracking sensors. Depth array videos were recorded using an Xbox Kinect. PA was characterized as the scaling exponent $\alpha$ using detrended fluctuation analysis (DFA) which estimates the complexity of PA variability. Videos created in study 1 were shown to 90 participants in study 2 as PA was captured at the head and waist. The same DFA procedure was used to estimate the fractal scaling of PA. Correlations comparing $\alpha$ values of the discloser and the confidant revealed complexity matching, or the entrainment of intrinsic dynamics, when viewing approach primed disclosures to professional-others.
Recent research suggests that people seek social stimuli over non-social stimuli even when they need to make higher efforts, suggesting higher social motivation. However, this tendency might not be same for all. It is suggested that priming can have a significant influence on people’s social behaviour. Here, we tested 89 typical adults on tasks evaluating social seeking while they were primed for positive and negative social interactions. We expected that priming might influence social seeking behaviour e.g. positive social priming might enhance and negative social priming might reduce the social seeking behaviour. Recent studies also show that people with high autistic traits might have lower motivation to seek social interactions. Here, we examined if the autistic traits of participants can further influence the effect of positive and negative social priming on their social seeking behaviour. Our results replicate previous findings suggesting that people with high autistic traits show lower social seeking behaviour. Furthermore, we found that negative priming reduced social seeking in all participants but with greater effects on people with high autistic traits. These findings may have implications for understanding how more frequent negative social experience in people with ASD may reduce their general social seeking tendency.
Distinct contribution of right TPJ and left aIPS to imitative and complementary human-avatar motor interactions

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The ability to cooperatively and competitively interact with others is crucial to our survival. These two interactive modalities may require to perform imitative or complementary movements with respect to those performed by our partner. To explore the link between imitative and complementary movements in cooperative and competitive situations with specific neural substrates we combined non-invasive inhibitory brain stimulation (continuous Theta Burst Stimulation) with interaction tasks in which an avatar reacted and changed his movements trial-by-trial according to the performance of his human partner. This procedure allowed us to create a realistic mutually adaptation task. Inhibition of left anterior intraparietal sulcus (aIPS) impaired individuals’ performance during complementary interactions compared to the inhibition of right temporo-parietal-junction (rTPJ), which in turn impaired individuals’ performance during imitative interactions. These results highlight a distinct role of left aIPS and right TPJ in supporting our ability to cooperatively and competitively interact with others. More specifically, while aIPS may underpin the integration of one’s own and the others’ movement required during complementary interactions, rTPJ may underpin the the ability to control the automatic imitation of a partner’s movements that is necessary for efficient imitative interactions.
Left anterior Intra-Parietal Sulcus causally scaffolds complementary joint-actions in freely interacting human-human pairs

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Creating real-life dynamic contexts to study interactive behaviors and thus establishing whether findings emerged in laboratories extend to real-life situations is a fundamental challenge for social neuroscience. Realistic motor interpersonal interactions imply that individuals mutually adapt to each other on-line, a scenario called “closed-loop” in contrast with the “open-loop” where one of the two participants is non-responsive to the other. Here we measured behavioral synchronization performance of pairs of participants engaged in a realistic interaction. Using non-invasive brain stimulation to inhibit the activity of the left anterior Intra Parietal Sulcus (aIPS) of one member of the pair, we investigated whether this region supports real-time interpersonal coordination during complementary and imitative interactions. Behavioral results showed that transient inhibition of left aIPS selectively impairs pair performance during complementary interactions compared to imitative ones as an inverse function of individuals’ ability to mutually adjust. The results highlight the closed-loop nature of our set-up and suggest that left aIPS causally scaffolds the integration of one’s own and the others’ complementary goals during realistic human-human joint actions.
Does it improve cognitive abilities exposure to complex visual art?

Vicente Estrada-González

Mexico

Exposure to some complex aesthetic expressions (classical music) can improve cognitive abilities (Rauscher, Shaw, & Ky, 1993; Rideout & Taylor, 1997). Moreover, works of art lacking complexity do not achieve the same effect (Rauscher, Shaw, & Ky, 1995). Since music and visual art share physical dynamics such as a universality of rank-ordering distributions (Martínez-Mekler, G; 2009), this brings up the question: Could an acute exposure to complex visual art improve cognitive abilities as well as music does? We hypothesize that complexity in visual art can produce a similar effect on the cognitive abilities such as that produced by classical music. Goals: Evaluate the cognitive effect of exposure to complex computer-generated paintings. Method: In the frame of dynamic systems, we have created computer-generated paintings with a stochastic model based on the fact that complexity appears in a phase transition of the dynamic elements of a given phenomenon (Solé, Manrubia, Luque, Delgado, & Bascompte, 1996). We will test the participants with a Paper Folding and Cutting task from the Stanford-Binet Test. Results: Behavioral data to be obtained.
The effect of congruency in automatic imitation on social approach and avoidance

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Imitation can act as a “social glue” leading to greater affiliation between imitator and model. However the mechanisms underlying this effect are poorly understood. One possibility is that matching actions of both partners leads to less “aversive signalling” than when actions are incongruent. The current study examined how people map their approach and avoidance behaviour onto people associated with congruent and incongruent trials in either a Stroop Task (ST) or an Imitation Inhibition task (II). During the study participants carried out a learning task in which they alternated between blocks of the ST and II. For each task participants saw the face of one person who was usually (80%) linked to congruent trials and another who was linked to incongruent trials. They then carried out an approach avoidance task with the faces they saw during learning. For one block they used a joystick to approach faces from the ST and avoid faces from the II, this rule was reversed in the other block. We found that participants were faster to approach faces linked to congruent stimuli and avoid those linked to incongruent stimuli suggesting that the “social glue” aspect of mimicry depends on domain general process involved in conflict avoidance.
Three Dimensions of Cooperation

Anika Fiebich
University of Milan, Department of Philosophy, Center for the Study of Social Action

In this talk, I argue for cooperation as a three-dimensional phenomenon lying on the continua of (i) a behavioural axis, (ii) a cognitive axis, and (iii) an affective axis. Traditional accounts of joint action argue for cooperation as involving a shared intention. Developmental research has shown that such cooperation requires rather sophisticated social cognitive skills such as having a robust theory of mind - that is acquired not until age 4 to 5 in human ontogeny. However, also younger children are able to cooperate in various ways. This suggests that the social cognitive demands in joint action are a matter of degree, ranging from cognitively demanding cooperative activities involving shared intentions that presuppose sophisticated social cognitive skills such as having a theory of mind to basic joint actions like intentional joint attention. Moreover, any cooperative phenomenon can be located on a behavioural axis, ranging from complex coordinated behaviours (potentially determined by rules and roles) to basic coordinated behaviours such as simple turn-taking activities. Finally, cooperative activities may be influenced by (shared) affective states and agent-specificities. Hence, cooperation can be located on the continuum of an affective axis that is determined by the degree of ‘sharedness’ of the affective state in question.
Perspective mechanisms for facilitating joint actions in human-robot collaborations

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When interacting with others, it is advantageous to understand their perspective of the world. Although perspective taking has been studied extensively in a number of disciplines, there are few proposals of computational models that investigate the emergence of this ability. In this work, we present a computational model that adopts the proposal that a mental rotation of the self, also termed "embodied transformation", accounts for this ability. The suggested method proceeds as follows: first, a simulated robot learns a forward model which relates motor actions to their visual and proprioceptive consequences. Objects are then introduced to the interaction, and the forward model is extended to predict spatial relationships between the self and these objects in a probabilistic manner. Finally, the forward model is used to mentally align the self with the other's perspective by reducing the uncertainty of the objects' state as seen from the other's vantage point. We show that our model is compatible with a range of findings in psychological works. We further investigate our proposal that level 2 perspective taking is achieved at a relatively late stage of cognitive development as it requires a mature forward model to predict visual consequences of physical motions.
The Influence of Social and Motor Context on Communication and Restricted and Repetitive Behaviors in Autism

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Joint activities can involve the coordination of either physical activity or language. For children with autism, engagement in restrictive and repetitive behaviors (RRBs) may interfere with these joint actions. In Study 1, we compared the frequency of RRBs in children with autism and explored whether this frequency changed as a function of the level of social and motor engagement. We found that RRBs were higher in those with autism and the frequency of RRBs was lower in both high social or high motor engagement. In Study 2, we evaluated the effects of social context on RRBs and language production during conversations of children with autism. The social context varied based on the primary focus (object or conversation) and the initiator (child or experimenter) of the interaction. We measured the frequency of RRBs and mean length of utterances (MLU). Results indicate that the focus of the task did not matter for the experimenter initiated interactions—RRBs were high in both conditions. However, RRBs were lower for the object- than the conversation-focused task. MLUs were higher for child-initiated tasks and for conversation tasks. Taken together, these results suggest that RRBs are influenced by social context and that the type of tasks effective at lowering RRBs may not be the same as those that develop conversation skills. This research was supported by the US National Institute of Mental Health (R21MH094659).
The collective dynamics of hostility: social attention and sentiment during the 2016 US presidential election

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Conflict plays a crucial role in everyday life (e.g., ensuring family members share house-duties) and in large-scale social events (e.g., political elections, management of refugee crises). The role of conflict in catalyzing social coordination is under-investigated within the cognitive sciences. We rely on a massive public event, the 2016 US presidential debates, to investigate the role of conflict in coordinating public attention and emotion. We collected 10\% of the tweets produced during the debates. Using natural language processing, we rated speech turns in the debate and tweets for emotional content. Our preliminary findings indicate that hostility is a catalyst for shared attention and discussion: more hostile conversational dynamics and contents generate more tweets, which show high level of collective coordination. More hostile tweets generate more online conversation and their emotional tone spreads more widely, generating longer lasting ripples of collective attention and emotion. Ongoing analyses are examining the role of pre-existing political affiliation in these dynamics. Our findings suggest that conflict is a crucial factor in social coordination and that social coordination might have also a dark side. The study furthers our understanding of possible mechanisms involved in large-scale joint action, with a focus on massive online coordination.
Joint Interference in picture description: Evidence for linguistically-detailed simulation of others’ utterances, but only when speaking concurrently

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Speakers use similar mechanisms to speak and to imagine others speak (Tian & Poeppel, 2012). While previous work using joint picture naming showed that imagining another speak interferes with concurrent naming, it also found this interference to be unaffected by the linguistic relationship between produced and imagined speech (Gambi, et al., 2015). In Experiment 1, 20 pairs of speakers described pictures (e.g., of a nun following a doctor) in the active (The nun follows the doctor) or passive voice (The doctor is followed by the nun). The interference effect on description latencies (t=3.35) was unaffected by the linguistic relationship between produced and imagined utterance (as in Gambi et al., 2015). But in addition, descriptions were shorter when participants believed their partner was using the same voice than the opposite voice (t=2.47). However, when speakers either knew (Experiment 2, N=18) or believed (Experiment 3, N=40) that their partner would be speaking after them rather than concurrently, they only showed the effect on description latencies which, again, was not sensitive to linguistic variables. These findings suggest speakers first rapidly represent another’s intention to produce language, and only later begin forming a detailed simulation of another’s utterance, but only when speaking concurrently.
Evaluating Interpersonal Synchrony in Naturalistic Dyadic Conversations Using Motion Energy Analysis: Lessons from Autism Spectrum Conditions and Typical Development

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One of the main diagnostic features of individuals with autism spectrum conditions (ASC) are atypical behavioural contingencies. Due to its complexity and a lack of appropriate automatic tools present, naturally occurring contingencies are poorly understood and only rarely studied. The current project investigates a type of nonverbal contingency: interpersonal synchrony (IPS). For this purpose we invited 30 matched pairs of typically developing (TD), ASD and mixed participant pairs to engage in several short conversational tasks. Videotaped dyadic interactions were analysed in head and body ROIs (regions of interest) using motion energy analysis and cross-correlations of time series. In concordance with previous literature (de Marchena & Eigsti, 2010), results show no significant differences in overall motion energy between ASC and TD groups. Significance of synchrony over pseudosynchrony (a control for coincidental synchrony) was found for all ROIs and across all dyad types (ASC, TD and mixed). Interestingly, however, across all interaction types, all ROIs show significant differences in terms of amount of IPS between the TD dyads on the one hand and the ASC and mixed dyads on the other. This supports previous findings from reduced task and laboratory settings in ASC (e.g. Fitzpatrick et al., 2016; Marsh et al., 2013).
Producing music vs. pressing keys together - representing joint action goals

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Acting jointly presupposes a joint action goal in relation to which actors plan their own actions and represent their coactors’ actions. However, we know little about the specifics of two coactors’ goal representations. For example, do they necessarily represent the same joint action goal? Imagine a piano expert and a piano novice playing a duet together: It seems plausible that whereas the expert easily learns the part of the duet assigned to him, the novice is rather occupied with mastering his. Consequently, the novice might represent his joint action goal on a more concrete level, focusing on aspects of the process like pressing the keys together. By contrast, the expert might represent his joint action goal on a more abstract level, focusing on aspects of the outcome like the jointly produced melody. Thus, coactors might be able to successfully act jointly, even though they do not share the same joint action goal representation. Following this line of thought, our poster wants to outline a theoretical account on the representation of joint action goals. Specifically we want to stress the potential of theories on the construal level (abstractness vs. concreteness) of representations for joint action research.
Numbness Illusion in Autism: Implications for Social Interactions

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The aim of current research was to examine the multisensory nature of body ownership (i.e., the sense of our body belong to us) in individuals with Autistic Spectrum Disorder (ASD) by using a procedure based on tactile conflicts, namely the numbness illusion (NI). The NI is a paradigm involving tactile and proprioceptive stimulation that induces an unreal sense of property for another person’s finger. The NI occurs when one person places his/her palm against another person’s opposite palm and strokes the two joint index fingers with the other hand synchronously. When the stroking is asynchronous the NI is usually reduced or absent. Results suggest that individuals with ASD were more susceptible to the NI than controls, indicating that the illusion occurred independently of the type of stroking. These findings suggested an anomalous sense of finger ownership in individuals with ASD that may be related to a wide range of sensory dysfunctions. In turn, this might have implications at the level of social interactions.
Interpersonal coordination in natural conversations

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Conversation between two people involves subtle non-verbal coordination in addition to speech, but the best characterisation of this coordination remains unclear. We recorded head motion in high resolution as dyads engaged in structured conversation, with 20 dyads in our pilot sample and a further 31 dyads in the pre-registered final sample. In a pre-registered analysis pathway, we quantify cross-participant wavelet coherence of head motion as a measure of non-verbal coordination, and distinguish genuine interaction from pseudo interactions created by shuffling the data. We identify two striking coordination patterns. First, frequencies below 1.5Hz have greater coherence in real interactions compared to shuffled interactions, which probably reflects low frequency mimicry. Second, in the 1.5 - 5Hz frequency band, real conversations show significantly less coherence than pseudo conversations, suggesting that systematic decoupling of head movements occurs in natural conversations alongside spontaneous mimicry. We suggest this decoupling relates to speech turn taking and back-channel communication. These results demonstrate the value of high-resolution, precise quantification of real world interaction behaviour and set a baseline for future studies of how cognitive tasks modify natural interaction dynamics.
A dual-EEG study of shared attention effect in dyads: Sensory processing or top-down control?

Xun He and Juan Camilo Avendaño Diaz

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People often pay attention to or act upon the same location when performing together. It has been suggested that enhanced processing is associated with the information relevant to the other individual in co-acting dyads. However, this is not always true. As recently found by He and Avendaño Diaz (2017), the sustained visual attention effect was reduced when a dyad focused attention at the same location (dual attention). The current study went further to measure electrical brain responses in co-acting dyads (dual EEG) using the same dual-attention paradigm, aiming at understanding whether this attention reduction effect is caused by an early sensory process or a late top-down modulation. Results indicated an enhancement (not a reduction) of attention effect in the sensory P1 component in the attention-shared condition compared with the attention-unshared condition. At a later stage, the opposite pattern was found: the attention effect was reduced in the anterior N2 component when the dyads directed attention towards the same location. The mirroring in the anterior N2 activity and the behavioural performance pattern suggests that the attention reduction effect in co-attending dyads is a result of late top-down modulation instead of early sensory processing.
Embodiment as a Resource for Inter-subjectivity

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Embodiment has a special role in explanations of inter-subjectivity. The basic intuition is that shared embodiment underwrites the possibility of shared understanding. The internal states associated with say, joy and pain, are unobservable however the outward manifestations of these states through gestures, expressions and body movements are publicly observable. Given that we share the same body-plan this suggests the hypothesis is that we recreate or ‘attune’ to another’s experiences by recreating their gestures, expressions and body movements e.g. via ‘mirroring’, emotional contagion or automatic perception-behaviour priming. We argue that these processes cannot solve the general problem of inter-subjectivity. Rather, the critical processes underpinning inter-subjectivity are those that facilitate the expression of difference not similarity. Drawing on evidence from motion capture of conversations about embodied experiences we show that people are most similar when not interacting and as they become more engaged in conversation their embodied behaviour diverges i.e. becomes progressively less similar. We propose that embodiment is a critical resource for interaction not because it guarantees some ‘basic’ level of shared understanding but rather because it provides rich resources for the processes of detecting and addressing differences in interpretation.
The improvisational Mirror Game has been studied in dyads (Noy et al 2011, Himberg...). We extended this game to four people, and are investigating it as a method for studying group dynamics in movement coordination and as a measure of intersubjectivity. Participants stand in a circle, with their right arm and index finger extended towards the centre and are instructed to mirror each others' hand movements. Movement of the finger and torso is traced using optical motion capture. The average velocity of all the markers (the quantity of motion) of each player, can then be cross-correlated with those of the other players, revealing the dynamics of following and leading in the group. Pilot data suggest that the four-person game gives rise to "conflicts" where a performer must make a quick decision about which other player to align their behaviour with. This makes the four-player game very interesting from social psychological point of view. Comparing two games, played before and after a different group improvisation exercise, the latter game produced more group synchrony, and facilitated the introduction of larger movements. This indicates, that the four-player game has potential as an intersubjectivity measure. More data will being collected and analyzed through the spring.
Impact of a shared goal on the perception of the space around the body

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Laboratoire STMS - IRCAM (Sorbonne Universités, UPMC Univ Paris 06)

Peri-personal space (PPS), the space immediately surrounding our bodies, rules the multisensory integration boost of stimuli. Its boundaries are flexible but little is known about their modulation by the presence or interaction with other individuals. We investigated whether PPS boundaries are modulated in the presence of an inactive individual and when participants perform a shared goal task with a partner. We used a modified version of Canzoneri et al. (2012) audiotactile interaction task in two groups of 28 right-handed participants. In each group, participants performed the task both in isolation and with another participant, inactive (audience) or doing the task as well (shared-goal). They had to detect as fast as possible a tactile stimulus administered on their hand, while task-irrelevant sounds were presented, looming from the right and left participants front hemifields. Tactile stimuli were processed when the sound was perceived at varying distances from participant’s body. PPS boundaries were modulated only when participants shared a goal with a partner, in the form of an extension on the right hemispace, and independently of the location of the partner. This suggests that space processing is modified during tasks performed in collaboration, and questions the notion of lateralization during actions in groups.
How humans became caring, cooperative, and conversing, but not conforming: Evolutionary and ecological perspectives

Bert Hodges
University of Connecticut and Gordon College

Humans naturally engage in joint action. Sharing, caring, and cooperating emerge quite early in development (Reddy, 2008), and the level of coordination taken for granted among humans is rare or absent in other apes (Hrdy, 2009), presenting an explanatory problem for evolutionary theory: How did humans become the cooperative, cultural, linguistic beings they are? A three-fold answer is explored. First, a wide variety of accounts focused on bipedalism, and its relation to carrying infants and many other factors, are related to issues raised in Tomasello’s (2008, 2014) interdependence and intentionality account of joint talking and thinking, and Hodges’s (2007, 2009) ecological values-realizing account of action-perception. What emerges is a new hypothesis about how humans came to be caring and cooperative. Second, research from social, developmental, and anthropological psychology is used to challenge assumptions about strong tendencies to imitate, conform, and synchronize. The research indicates that coordination theories need to address pervasive tendencies to diverge as well as to converge (Hodges, 2015). Finally, a values-realizing approach to social interaction and language is briefly explored as a way of integrating insights gained from the dialogue of evolutionary hypotheses and current research in convergence and divergence in joint action.
Coordination in face-to-face conversation

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The home of human language is face-to-face interaction, an environment that embeds spoken language within a rich infrastructure of bodily signals. The present study is a systematic investigation of how these bodily signals influence coordination in interaction, especially its turn-taking system, which is characterized by a remarkable speed—typically, just around 200 ms elapse between two speaking turns. One assumption is that perceiving and integrating bodily signals from a multitude of visual articulators with speech may burden our cognitive system, thus slowing us down. Alternatively, the additional bodily information may facilitate the complex process of coordinating turns in conversation. The present study shows the latter to be the case. 20 dyads conversed face-to-face and on the telephone and we carefully measured all of their turn transitions (and, crucially, treated backchannel responses as separate from turns). The results show that turn transitions are shorter, rather than longer, when talking face-to-face. This suggests that bodily signals play a facilitating role in the coordination of turns in conversation. Results from a reaction time and from an eye tracking study support this conclusion and will also be reported. Together, the findings illuminate our understanding of human language as a joint action.
Do patients with schizophrenia do dialogue differently?

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It is well-known that patients with schizophrenia have problems with language and social cognitive skills, which has implications for patients' experience of social exclusion, yet little research has investigated how these problems impact interaction. In dialogue -- the key form of everyday interaction -- it is well known that disfluencies such as self-repairs, filled pauses such as 'um' and silent pauses are pervasive and can have measurable effects on the dialogue. Despite this, there is no consensus as to whether such disfluencies reflect internal production pressures, or interactive issues -- or how their effects are manifest in dialogue. We report a study on the disfluency behaviours of patients with schizophrenia and their interlocutors who were unaware of the patient's diagnosis, compared to healthy control groups. Results show that patients use fewer self-repairs than either their partners or controls and fewer filled pauses ('er', 'um') than controls. Furthermore, the presence of the patient also affects patients' partners, who use fewer filled pauses than controls and more unfilled pauses than both patients and controls. This suggests that smooth coordination of turns is problematic in dialogues with patients.
Can robots synchronize with humans in tempo changing environments?

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As robots become more prominent in daily life, humans and robots need to work together in teams to achieve common goals [1-4]. A robot can effectively coordinate with people if it can understand how humans coordinate among themselves [4,5]. People accurately time their actions by employing temporal adaptation and anticipation mechanisms to coordinate with others, even in dynamic, uncertain environments [6]. People employ temporal adaptation to compensate for temporal errors, and temporal anticipation to start early enough to coordinate with an external rhythm. If a robot could employ this knowledge, it could more fluently mesh its actions with people [10]. Drawing inspiration from the literature [7-9], we have developed models for robots to better coordinate with human teams. These models leverage temporal anticipation and adaptation mechanisms, particularly for rhythmic, tempo-changing environments [10]. We have performed initial validations of these models through human-robot teaming experiments, where two people and a robot drum together synchronously. The robot observes human actions, and utilizes the developed models to autonomously and synchronously drum with people in real-time as the tempo changes. This work will help enable others in the robotics community to build more adaptable robots in the future.
Joint-improvisation and Expertise

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Although joint-improvisation is an open-ended creative action but also a “normal” daily activity where individuals are engaged in a collection situation (e.g. conversation, dance), defining the nature of social (motor) characteristics of improvisation still remains a complex endeavour. For a rounded approach, it seems important to address how expertise influences the emergence of both individual and the collective improvisation performance. The dissociation between solo and joint-improvisation need to be studied to untangle the influence of the social element of improvisation in the emergence of multi-agent motor coordination. We compared two types of improvisation (solo and joint) and three level of expertise - novice, intermediate and professional dancers (Pairs matched by level). Results revealed that each group possess unique specific movement organisation with an increase of the movement production complexity associated with expertise. The range of movement was higher and performed in a shorter period of time for the expert dancers. The results also revealed that the paired conditions reduced the complexity of the movement organisation of each level of expertise. Dance expertise plays a central role in the emergence of social motor coordination during improvisation and has a direct impact on individual and collective properties on the multi-agent system.
Validating computational methods for measuring joint action in music performance from video

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Although various sophisticated techniques, such as motion capture (MoCap), exist for quantifying joint action, many musical performances take place in ecological settings in which MoCap is not available or feasible (e.g., practice rooms, nightclubs, ritual ceremonies). As such, our aim was to develop methods for measuring joint musical action from video data. We evaluated the efficacy of computational techniques for quantifying interpersonal interactions in 30 videos of jazz duos in comparison to manual annotations of interaction from expert raters. Movement trajectories were extracted from the videos using optical flow (an automated computer vision technique) and the degree of co-performer interaction was quantified using wavelet analysis. Three raters manually annotated ‘bouts of interaction’—movements and gaze patterns suggesting an intention to facilitate co-performer communication—with 72.3% overlap between raters. To maximise the number of agreed bouts, annotations were aggregated at the level of two raters. In a logistic regression analysis with cross-validation, these agreed bouts were correctly classified to a satisfactory level (Area Under Curve of 0.76) using cross-wavelet power of both performers’ movements as a predictor. The results indicate high similarity between manual and computational methods, although the computational techniques identified considerably more bouts than the manual coders.
Acting Interdependently Helps Young Children with Reasoning about Diverse Desires

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Previous studies have found that a short period of cooperation, but not competition, improves young children’s high-level theory of mind (Jin, Li, He, & Shen, in press). However, it still remains unclear what structurally caused such change. In the present study, we compared between two structural elements of social interaction, goal structure (cooperative, competitive) and action interdependency (interdependent, independent), to see which one enhances 4-year-old children’s reasoning about diverse desires. Children played a 3-min interactive game with an adult, and then selected a gift for her from adult-preferred items and child-preferred items. Results showed that only action interdependency had a significant effect on children’s gift selection: children who acted interdependently with the adult significantly tended to select the adult-preferred item for her, while children who acted independently selected randomly. Our findings support the constructivist view of social development, and highlighted the importance of action interdependence in constructing higher-level theory of mind in children.
A meta-analysis of the joint Simon effect

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The purpose of this meta-analysis was to quantitatively review the joint Simon effect (JSE). Using Google Scholar, we identified studies citing the original joint Simon task (JST; Sebanz, Knoblich, & Prinz, 2003) until June 23, 2015. After screening, thirty-nine manuscripts remained eligible for analysis, thirteen of which included individual go/no-go (IGNG) control data. Separate random-effects meta-analyses were conducted for the JST and IGNG datasets, and meta-regression models were used to assess potential moderating effects of ‘control’ and ‘wipeout’ conditions on the strength of the JSE. As expected, there was no compatibility effect across IGNG groups. The JST summary effect-size was small (d=0.26, 95% CI [0.21, 0.30]) and the distribution of effect-sizes was skewed, suggesting significant positive bias. The JSE did not differ under control vs. non-control conditions, but was significantly smaller under wipeout vs. non-wipeout conditions. The small effect-size and positive bias across the literature highlight the difficulty of studying the JSE in small samples and suggest many studies are under-powered. These findings should incite researchers to conduct a priori power analyses based on the currently observed effect-sizes. This practice would encourage strong experimental design and research findings that reflect true effects, to ensure joint action research continues to flourish.
Dyad practice impacts self-directed practice behaviours and motor learning outcomes in a contextual interference paradigm

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Allowing learners to practice in pairs and choose how to schedule practice (i.e., when to switch tasks) are manipulations shown to benefit motor learning. Here we studied dyad practice to determine whether and how turn-taking with a partner impacts self-directed practice scheduling and learning outcomes. The task was to practice three, 5-keystroke patterns, each with a different timing goal. Participants were assigned to be Partner 1 (P1) or 2 (P2). P1s followed a blocked (low switching/interference), random (high switching/interference), or self-directed practice schedule, while all P2s self-directed practice. Day 1 comprised a pretest, paired practice session where partners alternated turns every 9 trials, and posttest. Day 2 comprised two retention tests (with and without feedback). Self-directed P2s showed both partner-dependent and own error-dependent practice. P2s switched patterns more often with random than blocked or self-directed partners. P2s were also influenced by the content of their partner’s practice (matching their P1’s patterns more with a random than blocked partner). For both partners, random practice resulted in better timing accuracy than blocked in the posttest and feedback-retention test. These data give evidence that self-directed practice and to some degree learning outcomes are modulated by vicarious practice experiences surrounding the partner’s practice schedule.
Self-other integration and segregation is modulated by the congruency of shared goals in musical joint action

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Musical ensemble performance is a class of joint action that showcases the ability of groups of individuals to pursue shared goals by coordinating their actions with high levels of temporal precision and flexibility. Such coordination requires self-other merging (integration) while maintaining the distinction between self and other (segregation). Two studies of piano duos investigated how the balance between self-other integration and segregation is modulated by the congruency of co-performers’ goals related to tempo. In one study, small incongruencies in tempo goals (induced via instructions that biased each performer towards a slightly different tempo) encouraged self-other segregation. In the other study, large incongruencies in tempo (induced via instructions for one performer to accelerate while the other decelerates and vice versa) led to co-performers compromising their individual goals in favor of self-other integration. Together, these findings demonstrate that there is a threshold at which it becomes necessary to revise and modify one’s own goals in order to achieve precise interpersonal coordination. The balance between self-other integration and segregation is thus influenced by the degree to which individual goals differ. The size of this difference may be affected by factors including musical experience and idiosyncratic preferences regarding musical expression.
Mirror neuron regions encode intention-related information conveyed by movement kinematics

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Ever since their discovery, it has been proposed that mirror neurons underlie our ability to understand others’ intentions. Despite two decades of research, however, the exact mechanisms implied in this ability are still unclear. In the current study, we investigated whether, in absence of contextual cues, mirror neuron regions encode intention from movement kinematics. Twenty participants observed reach-to-grasp movements performed with either the intention to drink or to pour while undergoing fMRI. In line with previous results, we found that observation of grasp-to-pour and grasp-to-drink movements evoked activity within the fronto-parietal nodes of the action observation network. A multi-voxel pattern analysis revealed successful decoding of intentions in mirror neuron regions, including the inferior parietal lobule and the inferior frontal gyrus. Our results provide the first demonstration that the visual kinematics of an observed motor act can, by itself, form the basis of decoding intentions in the mirror neuron system. These results have implications for understanding the mirroring of others’ intentions and their impairment.
Action representations at the dyad level during joint action planning: Evidence from EEG

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We investigated whether people represent the interpersonal configuration during joint action planning even if their own actions are not fully specified in advance. EEG was recorded from two people, seated at opposite sides of a table and performing coordinated arm reaching movements. A visual cue specified either i) both the type of individual action and the interpersonal configuration, ii) only the type of action, iii) only the configuration or iv) neither. The participants planned their actions accordingly and responded to a go-signal that was presented 1200ms after cue onset, providing full information in all cases. The participants’ responses were faster and better coordinated when the interpersonal action configuration was specified in the cue, regardless of whether the type of action was also specified. The EEG analyses showed that knowledge of configuration affected ERPs associated with structure representation (P600), movement planning and coordination (CNV) and set the brain at state of higher-excitability (suppression of alpha oscillations) before the go signal onset. Our results suggest that when people engage in joint action, they form action representations at the level of the dyad that, although seemingly redundant from the point of view of the individual, optimize the performance of the joint task.
The effect of being watched on overimitation of actions in adult dyads

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Overimitation involves copying features of a goal-directed action that are causally irrelevant to the end goal. Typical adults often show overimitation (Custance, Prato-Previde, Spiezio, Rigamonti, & Poli, 2006; Flynn & Smith, 2012), but there are multiple accounts of what drives this, including affiliative intent and to aid learning. This study examines whether overimitation serves a communicative purpose. 30 pairs of participants played an augmented reality game involving moving blocks in a specified order. In each pair, one player was designated as the leader and was explicitly instructed to copy the trajectory of a computer demonstration, which involved certain exaggerated movements. The follower was not given any such explicit instructions. We found that the trajectory of the follower’s movements was correlated with those of the leader’s movements, as expected for overimitation. More importantly, the strength of this correlation was higher when the leader had her eyes open (and could see the follower’s action) than when the leader’s eyes were closed. This suggests that the follower overimitates in order to communicate with the leader, maybe to show social closeness or enhance affiliation. Further study of what drives overimitation behaviour in dyadic interaction will be valuable.
Changing for the better? Differential effects of meditation based trainings on different components of prosocial behavior

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Language production is shaped by the social context in which speaking occurs. In a series of experiments we investigate the effect of having a task partner on lexical processing. Drawing upon a well-established effect in language production we investigate the degree of cumulative semantic interference experienced when naming a sequence of pictures together with a partner. Pictures of semantically related objects are either named by participants only, or by taking turns with their partner. Naming latencies increased with each additional within-category picture, confirming cumulative semantic interference. Crucially, naming latencies increased more steeply when in previous trials within-category pictures had been named by the partner (vs. presented only visually but named by no one). This effect is not simply due to hearing additional pictures being named (Experiment 1): Also when participants could not hear their co-present partner naming the picture (Experiment 2) and even when participants merely believed their remotely located partner was naming the picture (Experiment 3), naming latencies slowed down in response to the partner’s naming. Our results suggest that pictures (presumably) named by a partner elicit in participants lexical processes comparable to naming the picture themselves. This is consistent with the proposal that lexicalization processes of task partners are simulated, and implies a profound and lasting effect of having a task partner on speech production.
Signalling intentions: The influences of partner response accuracy on social action behaviours

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When reaching to grasp a glass, action kinematics may subtly change depending on whether an actor holds a social intention (move the glass closer to a friend) or a personal intention (move it out of the way). The actor’s intention can be inferred even for simple reach-to-grasp actions but may sometimes be misread, leading to incongruent responses. The present study examined if an actor’s subsequent movements are impacted by the congruency rate between their partner’s response and the action’s underlying intention. Participants worked to earn points based on the Responder correctly reacting to the intention of the Actor’s movement. Using auditory cues, the Actor would pick up and move an object, intending to either give it to the Responder or to place it on the board. Actors were told that Responders would try to interpret the action and then decide to take or leave the object. In actuality, Responders were privately prompted on how to respond, maintaining action-response congruency at either 50% or 80%. Actor movement timing and kinematics were affected by the likelihood that the Responder would perform the appropriate action; we discuss the results in terms of how a partner’s ability to ‘read’ intentionality may reinforce social signalling.
Bimanual joint action: correlated timing of “bimanual” movements accomplished by two people

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At the individual level, temporal coordination of the limbs has been observed in bimanual pointing movements even when made to targets of different amplitudes. Timing of the limbs is not independent; rather there is a natural temporal coupling. The aim of this experiment was to determine if these findings can be observed under joint conditions. Thirty-two participants made unimanual, bimanual symmetrical and asymmetrical pointing movements alone in the solo condition. In the joint condition, participants were paired and contributed one limb to the joint “bimanual” movements. Temporal coupling and correlation between the limbs were examined. Pointing movements were strongly coupled in the bimanual solo condition, but not in the unimanual solo and bimanual joint conditions. The initiation and termination of the limbs were not correlated in the unimanual solo condition (initiation r=0.01, termination r=0.03). Small-to-medium correlations (r=0.19, r=0.24) were observed in the bimanual joint condition and found to be significantly larger than the unimanual solo condition (p<0.01, p=0.01). As expected, there were large correlations in the bimanual solo condition (r=0.91, r=0.81). Our findings suggest that temporal coupling across the limbs does not occur between individuals but there is evidence for some synchronisation in the bimanual joint condition.
Joint Action with Non-Human Co-actors: Applying Human Joint Action Principles to Robotic and Virtual Co-actors in a Cooperative Pick-and-Place Task

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University of Cincinnati

Based on a behavioral dynamics approach to modeling human co-actors in a joint action pick-and-place task, we developed a behavioral algorithm for both robotic and virtual avatar co-actors that work with humans in a shared task space. Our aim is to apply principles of behavioral dynamics research to human joint action in order to guide the development of artificial agents that can successfully interact with human co-actors in a natural and predictable manner. To this end we will present: 1) a behavioral dynamics model of human co-actors engaged in a joint action pick-and-place task 2) an artificial agent whose behavior is based on the derived model; and 3) results from a human-robot joint action task demonstrating that the behavioral algorithm can also successfully engage in a joint action pick-and-place task with a human co-actor. The application of behavioral dynamics models of human-human joint action to non-human co-actors has implications not only for the design of artificial co-actors, but also for their use in testing otherwise untestable/un-manipulatable aspects of human-human joint action, such as breakdowns in joint action coordination due to restrictions on one of the interacting agents.
Prediction versus coupling: testing two different accounts of inter-speaker coordination

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Accounts of inter-speaker coordination based on internal predictive models propose that spontaneous imitation of the partner’s speech is due to the need to predict his/her behaviour in the immediate future. These accounts predict a tendency toward imitation each time speakers engage in a conversation. According to accounts based on the notion of dynamical coupling, coordination does not require prediction of the partner’s behaviour and imitation is observed only if it directly favours the specific coordinative pattern produced by the interlocutors. To compare the two accounts, we asked 10 Italian speakers to repeat the utterance /topkop/ simultaneously with an artificial agent (AA) designed to repeat that same utterance while coordinating its behaviour with that of a human speaker (HS). In line with accounts based on prediction, we found that HS imitates the intonation of the AA regardless of whether AA is parameterized to cooperate with the HS (by producing its syllables simultaneously with those of the HS) or to compete with the HS (by producing its syllables in-between those of the HS). This occurs even if, as observed in the competitive interactions studied, imitative behaviour does not favour the production of the coordinative pattern targeted by the HS.
The challenge of challenging others: Patterns of communication in interprofessional clinical teams

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Poor team communication is a leading cause of compromised patient safety in clinical settings. A critical aspect of good teamwork, as identified by human factors research, is the ability to ‘speak up’ when lapses or errors in teammates’ performance are identified, enabling correction. However, teams in acute clinical settings are frequently interprofessional. Cultural and educational differences between professions, and a hierarchical team structure, impose barriers to team members’ ability to ‘speak up’. Furthermore, the majority of work in this area to date has focused on specialities such as surgery or anaesthesia, where the patient does not have an active role in the team. Sensitivity towards the conscious patient in ward settings may impose additional constraints to team communication. The aim of this study was to explore how challenges to others’ performance are negotiated in interprofessional clinical teams. Multi-modal analysis of a corpus of simulated interprofessional clinical interactions revealed that explicit actions of ‘speaking up’ were extremely rare. Challenges to task performance were negotiated through coordinated patterns of implicit behaviour (e.g. verbalising actions, requesting information). The professional and temporal patterns of these behaviours and their interactional impact will be discussed.
Degree of responsibility influences outcome evaluation in joint action

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People must often monitor joint action outcomes to evaluate whether their shared goals have been achieved. Recent research has shown that neural activity related to evaluating negative action outcomes is reduced when responsibility for an outcome is shared equally between two partners compared to when responsibility is held by one person alone. The current study examined whether neural activity related to negative outcome evaluation scales with the degree of responsibility people have over an outcome. Participants produced tones in alternation with a partner to produce 6-tone sequences that matched a metronome pace. Responsibility was manipulated by having participants produce 100%, 67%, 50%, or 33% of the tones for a given sequence (i.e., 6, 4, 3, or 2 of the 6 tones). Event-related potentials were measured in response to feedback indicating whether or not the sequence correctly matched the metronome pace. Both the feedback-related negativity and the P3a were reduced for low-responsibility conditions (50% and 33%) compared to high-responsibility conditions (100% and 67%). These results indicate that greater responsibility over a joint task is associated with more negative evaluation of unfavourable joint outcomes.
Dynamics of Collective Behavior in Sport

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Approaches investigating joint actions in team sports have provided limited understanding of how a group of athletes coordinate their actions to achieve a common goal. This body of research has tended to focus on dynamical patterns of teams based on player’s motor movements (walking, running, etc.). While these methods are useful to describe the system under study, very little connection is made to how these observed dynamics relate context within the match. This gulf has created an open debate (among scientists, coaches, and player performance personnel) about the degree to which research on team sports can benefit from concepts and tools from dynamical systems theory. In this light, this talk focusses on 1) reconsidering the conception of the system under study and the relations that hold the emergence of this collective in sports, and 2) our attempts at developing an adequate analysis to capture such emergence. To address the first issue, we discuss implications about the grounding of joint actions in the epistemology (knowledge of the game) and ontology (players’ relations) of the game. To address the second issue, we present a model of multi-agent coordination in a complex environment, and its use to make testable predictions about player performance.
Studying the Effects of Affective Memory in Joint Activity

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In a previous article, we put forward a hypothesis for the existence of a neural-computational mechanism of affective memory that can be used to facilitate Joint Action between co-actors. Our hypothesized affective mechanism provides a value function implementation of Associative Two-Process (ATP) theory. This theory entails the classification of external stimuli according to differentially valuated outcome expectancies. This process can predominate in decision making or choice tasks over an alternative stimulus-response (‘habitual’) memory process. The ATP perspective has been used to describe animal and human action that concerns differentially rewarded outcomes. Until now it has not been applied to social interaction. We present experimental work that attempts to validate our social-affective ATP hypothesis - that affective-ATP memory processes can be exploited both in individual and social contexts. We do this in a scenario that requires human subjects to make stimulus-response choices using a mouse controller in a computer game both in individual scenarios, and in relation to feedback from the choices of a (video recorded) other. The results provide some initial support for our hypothesis - subjects learn from another’s stimulus-outcomes and apply this to their own stimulus-response activity. We contend that follow up experiments are necessary to identify the types of social interaction that exploit, or not, a generalized, versus social-specific, (affective) value function.
Coordinating handshakes: An eyetracking study

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Handshakes initiate many joint actions and are complex joint actions in their own right. But little is known about their coordination. Previous research presented at JAM (Walker, Bischof, & Kingstone, 2013) has analyzed the role of gaze direction and hand extension. However, the exact time course of coordination is unclear. We investigated this issue using eyetracking. Twenty participants (n=10 pairs) arrived separately in different lab rooms and were fitted with eyetracking glasses (ETGs). They were told a cover story about the ETG purpose and then introduced to each other, inducing them to spontaneously shake hands. The handshaking process was captured via the ETGs and a videocamera affording a lateral view of the participants. We coded the onset and offset of the following events: extending arm, clasping hands, retracting arm, gaze target (partner’s face, partner’s arm/hand), saying one’s name. We find that the temporal sequence of coordination involves mutual gaze followed by gaze to the hand region followed again by mutual gaze (coinciding with the exchange of names) and followed by gaze aversion. Descriptive analyses reveal the complexity of what is essentially a series of symmetrical actions (hand extension, grasping, mutual gaze) coupled with asymmetrical verbal turn-taking (exchanging names).
The influence of dyadic eye gaze dynamics on objective size judgments and in a subjective preference task

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We look at how dynamics between two people’s eye gaze patterns depend on task properties and whether they predict people’s judgments. To this end we developed a new methodology, DiVA (Dual interactive eye tracking with Virtual anthropomorphic Avatars), in which people’s eye movements are displayed in real-time by virtual anthropomorphic avatars. Here we validate this methodology in a direct comparison with a typical gaze cursor paradigm, displaying the other person’s eye movements as a point on the screen. Participant dyads were shown either the gaze cursor or avatar and completed a subjective preference choice task (choosing 1 out of 4 patterned balls) and an objective size judgement task (choosing the 1 ball out of 4 that is slightly larger) with the probability of selecting the same target being manipulated for both. After a free-viewing period, participants had to look at their ball of choice. Interactions were measured through use of Multi-dimensional Recurrence Quantification Analysis comparing individual (auto)recurrence with cross recurrence in choice selection and eye movements during each task. We expect coupling (recurrence patterns) to be influenced by the nature of the gaze display (avatar versus cursor) and task, with more coupling in the cursor condition, in the preference task, and more in ambiguous/difficult conditions. We will discuss how gaze cursor and avatar conditions differ, as well as the influence of task type and information ambiguity, and how this influences individual recurrence and cross-recurrence respectively.
Frequency properties allowing human-robot unintentional motor synchronization

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Interacting with a robot will soon become important in our social life. However, several questions still stay unaddressed regarding the way roboticists should design social robots. One crucial synchronization aspect is the quality of frequency of any dyad. The goal of this study is to investigate the frequency properties of human-robot interaction (HRI) in two dual-task experiments. In Experiment 1 we investigated the limits of the synchronization region during non-intentional HRI and in the second, the stability of joint synchronization. The same dual-task was performed for these two experiences. In the intentional task (cover story) participants pushed the button designated by the Nao robot. In the unintentional task (joint-motor coordination task), Nao and the human continuously swung their two legs at their preferred frequency. In experiment 1, we measured the increase of Nao’s legs frequency whereas in the second, we assessed the effect of frequency perturbations between the agents. Altogether, the results showed that 1) humans unintentionally synchronized with Nao at the same frequency they usual do when coordinating with another human (within ±5% of participant’s preferred frequency), and 2) the interaction was stable as long as frequency perturbations stayed within this unintentional synchronization range (of ±5%). This research was supported by an Agence Nationale de la Recherche grant (DIRAC Project #ANR 13-ASTR-0018-01).
Seeing Togetherness in Motion: Perceptual Cues to Interpersonal Coordination in Joint Dance Improvisations

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This study explored how observers perceive the coordination of dancers’ movements during free dance improvisation. We made video-recordings of four dancers improvising together in pairs. The dancers were instructed either to dance together a duet (without touching each other) or to dance alone, moving independently from the partner’s movements. Participants were presented with 20 seconds long video-clips cut out from the improvisation sessions and were asked to judge whether they saw a duet or two solo performances. In the matching condition, participants saw a dancer’s movements together with the partner’s corresponding movements. In the mismatching condition, the partner’s movements were taken from another time-point in the improvisation session. Our results suggest that participants could differentiate actual duet improvisations from solos above chance, which suggests that the coordination in dancers’ movements during free improvisation can be perceived by others. We also found that when dancers’ movements were non-corresponding in duets, recognition decreased to chance level. Solos, however, were recognized above chance in both conditions. This suggests that coordination was recognized based on the relation of the two dancers’ movements.
Heuristics, bounded rationality, and joint action

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Two dichotomies and their relation seem to lie at the heart of the debate on action and joint action: one between mere bodily movement and (intentional) action, the other between emergent coordination and planned coordination. I argue that a focus on these dichotomies leaves us wanting for “something in between”. I investigate this ‘in between’ based on literature on heuristics (ecological or social rationality). Heuristics trigger purposeful behavior, which seems to involve decisions (they are not mere bodily movements) that are however not structured by explicitly available attitudes. I want to follow Bratman’s conceptualization of human agents as planning agents. Such agents can share pro-attitudes, which is a possible way to act together. Bratman argues that, due to time constraints and limited cognitive capacities, planning agents often act based on policies and dispositions. It seems only logical that agents also do this when they act jointly. How can we understand joint action that is based on such habits? Can heuristics structure joint actions? I argue that we can better grasp joint action and interaction based on policies and dispositions when we incorporate ideas on heuristics. I will take the tit-for-tat, imitate-the-successful, and imitate-the-majority heuristics as examples.
Music, as a complex organization of sounds and silences, can be traduced in rhythms, scales, modes and other arrangements, able to generate emotions and promote the appearance of different “mental states”. Furthermore, it has been suggested that rhythm is the crucial property for real-time interpersonal coordination. However, which features of the musical rhythm like tempo or pitch plays a major role in this interaction is unknown so far. The present study aims to provide evidence that music tempo is a crucial parameter, which controls the influence of acoustical rhythms on attentional tasks. Thereby we follow a resonance hypothesis similar to that articulated by Edward Large and colleagues as a potential mechanism responsible for our empirical results. Our study consisted in three behavioral experiments, designed to identify the possible influence of musical tempo in (1) the perception of a visual stimuli and the motor reaction to it, (2) the influence of musical tempo on the performance of an attentional task (Color-Word Matching Stroop Task), and (3) the preference of the participants (likeness and motivation) for a specific tempo. Furthermore, we looked for possible sex differences and disparity of results obtained for women in different phases of their menstrual cycle. Our results provide clear evidence that (a) Rhythmic acoustic stimuli displayed in a specific tempo improves the performance of attentional tasks, (b) tempo preference is gender dependent and (c) there are significant performance changes during the menstrual cycle.
Participation in first social encounters and social networks in schizophrenia

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People with schizophrenia are very socially excluded, with at best 1 in 10 working. However, the proximate mechanisms of exclusion in spontaneous social interaction are poorly understood. This study investigated (1) how patients participate in first encounters with unfamiliar healthy participants (unaware of their diagnosis) and (2) associations with the size and quality of patients’ social networks. We focused on the first 30 seconds of these encounters, shown to be critical in coordinating behaviour and fostering social connection between people. Patterns of participation were investigated during three person interactions. 20 people with a diagnosis of schizophrenia were recorded in a lab based interaction task with 2 healthy participants. Patients’ social networks were assessed using the Social Network Schedule. Three conversation roles were analysed: (i) speaker, (ii) primary recipient - focus of the speaker’s attention and (iii) secondary recipient - unaddressed individual. Multiple regression analyses were conducted with social network as the dependent variable and conversation role as the predictor variable, adjusting for patient symptoms, which would be likely to impact on social networks. Patients who spent more time as the addressed, rather than unaddressed, recipient had better social networks. Hence, patients in the ‘active pair’ early on in these encounters are also more socially included. Further analysis of patient verbal and nonverbal behaviour is warranted to contextualize the findings, which have implications for patients’ wider social functioning where first meetings are critical e.g. in gaining employment and developing relationships.
Discriminating between coordination and teaching intentions using action kinematics

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It has been demonstrated that people are sensitive to movement features associated with different instrumental intentions. For example, participants can reliably predict whether an agent intends to drink or pour from a bottle based on the wrist height or velocity profile during the reach to grasp phase of the observed action (Cavallo et al. 2016). Action kinematics also vary as a function of the social intentions underlying actions. Research on sensorimotor communication has shown that people systematically modulate movement features such as movement height and velocity in order to support joint action coordination (Vesper & Richardson, 2014), and teaching through demonstration (Brand, Baldwin & Ashburn, 2002). The current study investigated whether observers are sensitive to kinematic features underlying joint action coordination and teaching intentions. Using a visual discrimination task in which participants viewed exaggerated or suppressed animations of movement trajectories of a person playing a virtual xylophone, we found that participants used movement height and speed to discriminate joint actions and teaching actions from individual actions. They also used movement height to discriminate between joint actions, and teaching actions. This demonstrates that people are sensitive to movement cues underlying coordination and teaching intentions, thus have knowledge of what makes for effective coordination and teaching actions.
Do you keep an eye on me? The influence of competition and cooperation on joint Simon task performance

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Social interaction plays an important role in human life. While there are instances that require cooperation, there are others that force to compete rather than to cooperate in order to achieve certain goals. So far, however, laboratory attempts to investigate the underlying processes of such opposing challenges failed to provide a consistent picture. By manipulating the in-/dependence of individuals via performance-contingent incentives (i.e., Task 1: each one receives what s/he achieves; Task 2: each one receives the half of what both achieved OR the winner takes it all) in a visual go-nogo Simon task, the current study aimed at improving our understanding of complementary task performance in a joint action context. While our particular reward manipulation might be responsible for the quite fast responses observed, that as such possibly vanishes to replicate previous modulations of the joint Simon effect (JSE) as a consequence of the interdependency of interacting individuals, sequential trial-by-trial adjustments even extend past findings. More precisely, selective trial-by-trial transition effects in the competition group seem to further highlight the crucial role of favoring one’s own actions to enable proper discrimination of alternative action events and thus proper performance in complementary tasks.
The Chains of Habit: Evidence that repetition of a joint action enhances the sense of commitment

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In this study, we tested the hypothesis that the mere repetition of joint action can enhance the sense of commitment. To this end, we designed a paradigm in which participants either coordinated for 120 rounds with the same virtual partner (Repetition Condition) in a joint decision-making task, or with a different virtual partner in each round (No Repetition Condition). On the task, participants could choose either a cooperative option, which would add points to their joint total, or an alternative option, which would add points only to their individual total. To measure participants’ sense of commitment to the joint goal, we varied the degree to which the alternative option was tempting. We predicted that participants would be more resistant to the temptation in the Repetition Condition, i.e. that the threshold for choosing the alternative option would be higher than in the No Repetition Condition. We also measured various parameters of the mouse with which they selected their responses (trajectory, velocity, initiation time). We predicted that these data would reveal more conflict in participants in the Repetition Condition when choosing the alternative option. Preliminary analyses support both of these predictions.
The Role of Social Engagement during Interpersonal Coordination: Sensorimotor Synchronisation with an Adaptive Rhythmic Robot

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The ability to coordinate movement between multiple actors is important in many domains of human life, but the role of social factors (e.g., how interactive a partner is) is not fully understood. We used an adaptive drumming Nao robot that modulated the timing of its drum strokes in response to participants’ drum timing to investigate synchronisation with an interactive social partner versus a static non-interactive partner. Participants (n = 33) drummed with either ‘SocialBot’, a robot that used speech and eye gaze to interact with participants, or ‘MetroBot’ a noninteractive robot that remained static except for the drumming movement. Both conditions included three levels of adaptivity, from minimally to moderately adaptive. Results indicated that participants synchronized more accurately when the robot was more adaptive; however there was no effect of robot interactivity on synchronisation. While ‘SocialBot’ was rated higher in likeability, some participants rated ‘MetroBot’ as easier to synchronise with (despite identical difficulty across conditions). Interestingly, these participants were more accurate than those who found it easier with ‘SocialBot’ or who thought both conditions equally difficult. Individuals who were better at the task thus found it easier with a partner that may be perceived to be more predictable and stable.
The emergence of procedural coordination in joint activities: No evidence is better than negative evidence

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When participants use dialogue in joint activities, they rapidly converge on referring conventions for coordinating within the activity. Convergence is inherently interactive, relying on participants providing each other with both positive and negative evidence of understanding (Clark, 1996; Healey, 2007; Pickering and Garrod, 2009). In addition to reference, recent work has demonstrated that participants rapidly establish procedural conventions for identifying, signalling, and resolving procedural co-ordination problems in the activity (Mills, 2014, Fusaroli et al, 2016). To investigate how procedural coordination develops, we report a computer-mediated task which presents dyads with the recurrent coordination problem of ordering their actions and contributions into a single coherent sequence. All turns are intercepted automatically by the server, which detects and selectively blocks participants' displays of positive and negative evidence of understanding. The results show that dyads whose signals of positive evidence were blocked completed fewer trials, made more errors and exhibited more effortful interaction, confirming the basic predictions of the grounding model (Clark, 1996). Surprisingly, participants who had both positive and negative signals blocked performed better than baseline participants. We argue this is due to the doubly-blocked participants being forced to develop new, and consequently more robust, routines for establishing and sustaining coordination.
Neural correlates of a joint action in a human-avatar paradigm

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A large variety of everyday actions take place in a social context that need to be shared by interacting agents. Successful motor interactions require agents to anticipate what a partner is doing in order to adjust their own movements. To investigate the neurophysiological basis of joint actions we developed a human-avatar interactive joint-grasping task where: i) we recorded the kinematics of reach-to-grasp actions in different social contexts to test the ability of individuals to synchronously and jointly grasp objects; ii) we recorded electrophysiological activity (EEG) of subjects during synchronous joint actions. Our experimental choice to couple EEG and kinematics recordings offers a great opportunity to study the dynamics of social neuromarkers at the body and brain level. Modulation of the EEG activity both in the time domain (late ERPs) and time frequency domain (beta and mu modulation over sensorimotor areas) together with robust kinematics indices offer greater understanding of brain-behavior dynamics and provide a clearer comprehension of social interaction in joint actions.
Making and breaking procedural conventions: partner-specific effects

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Teamwork requires precise interpersonal coordination on a common time frame, oftentimes with scarce or even without any verbal communication. Prominent examples of such generalized synchronization are orchestras or team sports. However, musicians benefit continuously from the score, the acoustic feedback of the whole ensemble and the external driving of the conductor, while the coupling between teammates is reduced by a limited visual sector and a restricted acoustic radius such that joint action emerges in a self-organized manner. Here we show, by using soccer teams as a testing ground, that acoustic stimuli may improve significantly the interplay between teammates. We provide quantitative evidence that the collectivity as well as scoring rate of male soccer teams improves significantly when playing under the influence of an appropriate acoustic environment. Unexpectedly, female teams do not show any improvement under the same experimental conditions. The effect is not due to motor entrainment, as we could show by a follow up experiment. Instead we argue that the rhythmic acoustic stimuli modulate the attention level of the protagonists according to the Dynamic Attention Theory, such that the marked gender difference can be explained by a nonlinear resonance effect.
Investigating the influence of Social context on the Social Inhibition of Return

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Understanding others’ actions and intentions, is important in order to successfully act in the environment. It was suggested that when we are observing another person action toward a specific location, an inhibitory process is initiated at that location. This effect was termed Social Inhibition of Return (SIOR; Welsh et al., 2005). In a series of studies we examined this effect by developing a dyadic computerized task in which each participant, in his turn, respond to a peripherally presented target in two successive trials. The first trial is preformed after the other participant response and is aimed to examine SIOR. The second trial for each participant is aimed to study the self-induced IOR. Participants did not see the other participant’s action, only received information regarding the location to which s/he reacts on. Results depicted that participants were slower to react to targets appearing in the same location as the previous target, regardless if they or their counterpart responded to it. Importantly, when participants preformed the same task, with the same visual display, only without a counterpart, the SIOR was abolished. These findings suggest that the perceived social aspects, but not the visual aspects of the task, are crucial for eliciting SIOR.
Transforming simple pursuit to rhythmic rocking: Recent developments in emergent coordination using the virtual shepherding task for the development of adaptive human-robot systems

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An application to investigating human-human (joint) action is to guide the design of robotic systems that can serve as adaptive partners which maintain a natural interaction for the user. The virtual shepherding task was designed as a testbed to investigate emergent coordination in human-human and human-robot systems in the herding of autonomous agents. The task involved pairs of participants using controllers to contain virtual “sheep” to the center of a target region. Initially, all pairs engaged in a Search and Recover behavior, where each player pursued the sheep farthest from the task goal on their side and repelled them towards the center. A subset of pairs after some time, however, discovered the Coupled Oscillatory Containment mode of behavior, where participants switched from focusing on individual sheep, to performing oscillatory movements with their partner to contain all the sheep to the center - a functionally superior behavior. A task-dynamic model that can incorporate both modes of behavior is summarized and embedded in an artificial system that can successfully perform the task with novice participants. Extensions of the original work to incorporate more complex herding scenarios, such as the transportation of the herd from one location to another is also discussed.
Phase Transitions Between Co-Present Single and Joint Action Modes

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Joint action research on dynamic systems has extensively captured phase transitions between stable states of affordance enaction and their collapse. Control parameter scaling pushes the system through those different behavioral modes, with switches occurring within task-specific ranges of control parameter values. Scaling beyond this range is usually followed by the destruction of one or more stable modes, demonstrating multistable subspaces where all task-defined action possibilities exist. The current experiment explores this subspace through a ball-transportation task, where single and joint action possibilities are always co-present. Participants transported balls from a starting area to a bin located eight meters away and the sequential presentation of balls was guided by a changing time interval, ranging twelve (long) and two seconds (short interval). The experiment was restarted if more than one ball accumulated in the starting area and the experimenter stood by the bin offering cooperation on any presented ball. Results demonstrate characteristic phase transitions between single and joint action modes, displaying hysteresis as interval was scaled from long to short and back, and a critical point transition in the opposite direction. These results set the scene for future research involving well established social psychological concepts, which affordance research has yet to more fully incorporate. The two most pressing predictions involves experimenter race, and/or gender, and if these social constructions alter transition points in traditionally predictable ways.
Interpersonal synchrony enhanced through 20 Hz phase-coupled dual brain stimulation

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Synchronous movement is a key component of social behaviour in several species including humans. Recent theories have suggested a link between interpersonal synchrony of brain oscillations and interpersonal movement synchrony. The present study investigated this link. Using transcranial alternating current stimulation (tACS) applied over the left motor cortex, we induced beta band (20 Hz) oscillations in pairs of individuals who both performed a finger-tapping task with the right hand. In-phase or anti-phase oscillations were delivered during a preparatory period prior to movement and while the tapping task was performed. In-phase 20 Hz stimulation enhanced interpersonal movement synchrony, compared to anti-phase or sham stimulation, particularly for the initial taps following the preparatory period. This was confirmed in an analysis comparing real vs. pseudo pair surrogate data. No enhancement was observed for stimulation frequencies of 2 Hz (matching the target movement frequency) or 10 Hz (alpha band). Thus, phase-coupling of beta band neural oscillations across two individuals’ (resting) motor cortices supports the interpersonal alignment of sensorimotor processes that regulate rhythmic action initiation, thereby facilitating the establishment of synchronous movement. Phase-locked dual brain stimulation provides a promising method to study causal effects of interpersonal brain synchrony on social, sensorimotor and cognitive processes.
The E-Music Box: an empirical method for exploring the universal capacity for musical production and for social interaction through music

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Humans are assumed to have a natural - universal - predisposition for making music and for musical interaction. Research in this domain is, however, typically conducted with musically trained individuals, and therefore confounded with expertise. Here we present a rediscovered and updated invention - the E-Music Box - that we establish as an empirical method to investigate musical production and interaction in everyone. The E-Music Box transforms rotatory cyclical movements into pre-programmable digital musical output, with tempo varying according to rotation speed. The user’s movements are coded as continuous oscillatory data, which can be analyzed using linear or nonlinear analytical tools. In a series of experiments, we studied joint music making among individuals who never received musical training. We made a series of original observations indicating that non-musically trained individuals interact one another according to conventional musical practices such as leader/follower roles or low-pitch dominance. Furthermore, we show that certain personality traits that are normally enhanced in musicians are also higher in non-musicians that best coordinate with their partners during joint musical action. By bringing music making within everyone’s reach, the E-Music Box opens novel pathways towards empirical research of the human predisposition for joint music making across developmental, cross-cultural and even therapeutic contexts.
Rhythms, collectivity and interpersonal synchronization of brain dynamics

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Hyperscanning is the simultaneous registration of the electrical brain activity of two or more subjects. In the present study we investigate possible interpersonal synchronization of male and female couples, while subjects perform a common task under the influence of the same acoustic. We used the synchronization and genuine correlation methods for the quantification of neuronal synchronization between two neuroelectric signal in different frequency bands. In a first pilot study we found a pronounced gender difference for the interpersonal synchronization, extended between zero and 25Hz. The female pairs increase synchrony while doing the task, male pairs decrease interpersonal synchrony. Furthermore, different tempos of the rhythmic acoustic stimuli imprint slightly different characteristics of the interpersonal synchronization pattern. Most surprising, the synchronization between monozygotic male twins is more pronounced than other male couples.
Humans are the ultimate social animals. But how deeply do our capacities as humans depend on social interaction? A growing body of evidence suggests that our higher rational capacities - particularly false belief understanding and explicit reasoning - are dependent on social interaction. So far, however, it has remained unclear how social interaction engenders these capacities. Here we identify a uniquely human collaborative process which we believe is responsible. We call this ‘Joint Attention to Mental Content’ (JAMC). Joint attention is the process whereby two individuals focus together on a single referent, each with their own perspective on that object. JAMC is that process but applied to abstract objects like the content of mental states such as beliefs, desires, or plans. We argue that it is the onset of JAMC that explains the acquisition of explicit false belief understanding and explicit reasoning, and ultimately makes possible species-unique forms of collaborative problem-solving and cultural transmission.
In skilled action, including music performance, errors are rare but important events that have consequences and require adaptation. When acting together, as in musical ensembles, these consequences are shared amongst partners. However, when performing the same action simultaneously with the same expected goal, it can be difficult to tell who is responsible for the outcome; agency of the action becomes ambiguous. Electroencephalography (EEG) studies have revealed specific patterns of neural activity for own errors. However, whether and how agency ambiguity might affect these patterns is unknown. To address this question, we recorded EEG while paired pianists played piano exercises in unison and octave parts. We examined neural responses evoked by correct and erroneous keystrokes, and compared those across agency ambiguity conditions (high/unison vs low/octaves). Results indicated that producing an error evoked a positive potential with a fronto-central topography peaking around 170 ms after the error. The amplitude of this component was larger in the error-unison condition (high ambiguity) than in the error-octaves condition (low ambiguity). These findings suggest that the degree to which the effects of own and other’s actions are integrated affects the operation of an internal modelling process that controls joint performance.
The heaiveness of invisible objects: predictive weight judgements from observed real and pantomimed grasps

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The behavior of others supplies a rich source of information about the world around us. As such, observing other agents acting upon objects involves a form of shared experience, which enhances our own direct experience of objects as well as our understanding of others’ intentions and expectations. This is a core feature for a successful joint action. We report results that suggest a similar form of shared experience may be gathered from the observation of pantomimed actions, i.e., actions aimed at pretended objects. Put simply: can we share through others’ actions the characteristics of an object that is not there? In a weight discrimination task, participants were asked to observe a hand grasping either a real or imagined glass, and to predictively judge its weight. We found that participants were able to discriminate whether the glass was empty (i.e., light) or full of iron screws (i.e., heavy) above chance level (0.50) for both real and pantomimed grasps, solely using the available kinematic information. This finding suggests that, by observing others’ movements, we can make predictions and form expectations about the characteristics of objects that exist only in others’ minds.
Because a motoric goal does not specify the way in which it should be reached, a problem emerges: how does the motor system come to select a particular action that achieves a motor goal? Importantly, for any system capable of motor actions, the complexity of this selection problem will scale as the number of degrees of freedom contained in that system increases. The greater the degrees of freedom, the greater the number of ways in which a given motor action can be achieved. This problem (known as “Bernstein’s problem”) is a problem for how degrees of freedom are controlled for individual motor actions. In this poster presentation, I suggest that coordination problems in mechanically linked joint actions (such as carrying a heavy or awkwardly shaped object together) can be understood as instantiations of a social Bernstein’s problem. When two people are mechanically linked by an object they form a single bio-mechanical system - a system containing the degrees of freedom of both of the actors. This massive increase in degrees of freedom means that this system has many more action options available to it. This raises a question: how do groups deal with and contain degrees of freedom in mechanically linked joint actions?
A kind of magic: the influence of motor expertise on pantomime discrimination

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Professional magicians regularly use pantomimed actions to deceive audiences. To do so, with experience, they learn to shape their hands similarly for real and pantomimed actions. Here we tested whether this form of motor expertise provides a measurable benefit to the processing of pantomimed actions performed by others. To this aim, in a one-interval discrimination design, we asked 17 professional magicians and 17 naïve controls to watch video clips of reach-to-grasp movements and judge whether the observed movement was a real grasp or a pantomimed grasp, i.e., a grasp aimed at an imagined object. All video clips were edited to produce a spatial occlusion of the to-be-grasped object (i.e., either present or imagined). Whereas magicians and controls performed similarly with ‘real’ grasps, magicians were faster and more accurate at discriminating pantomimed grasps. These results suggest that learning to perform fake actions also improves one’s ability to detect others’ fake actions.
The dynamics of collective behaviour: opinions, judgements and jazz

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In our Hive (http://eyethink.org/thehive). People move a dot on their device, and a large central screen displays the task and the dots of everyone participating. We have used this methodology to study the dynamics of collective behaviour as people express opinions, make judgements and collaborate with musicians in a live jazz improvisation. When participants’ conformity depends on their rewards. Surprisingly, being rewarded as individuals increases group conformity, whereas being rewarded as a group increases individuality. When a group engages in creative collaboration with musicians, we find that within the group, leader and follower relationships emerge which predict how people enjoyment of the music. Collective behaviour is governed by interactions between identity and motivation at both the personal and collective level.
When two become one: interpersonal pattern formation in side-by-side and hand-in-hand walking

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When two persons are walking together, their footsteps sometimes spontaneously adjust to one another. Such episodes of entrainment may enhance when holding hands; such mechanical coupling affects arm-leg coordination of each walker and hence between-walker stepping. We examined the effects of detuning (pairs with either similar [n=8] or different [n=8] uncoupled cadences) and coupling (hand-in-hand or side-by-side) on spontaneous pattern formation. Pairs walked 10 minutes alternately hand in hand and side by side on a huge treadmill (1.3km/h). Full-body 3D kinematics were captured with Kinect v2. We observed a greater occurrence of phase locking for hand-in-hand walking. Two interpersonal patterns prevailed: synchronizing of left and right legs (ipsilateral phase-locking) or synchronizing of inner and outer legs (contralateral phase-locking). These two coordination patterns occurred more often in the low-detuning group. We also observed diverse other coordination patterns, one involving an absence of swing in the coupled hands. We conclude that both coupling strength and detuning independently affect the occurrence of spontaneous phase locking in paired walking, a task affording a rich repertoire of coordination patterns.
Role of Motor Variability in Joint Action Learning

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Wu et al., 2014, suggests that an individual’s natural motor variability can predict the rate at which she learns a motor task. They demonstrated that motor learning was faster when individuals exhibit higher motor variability, presumably due to exploring a wider space of motor parameters. Thus variability seems to enhance individual motor learning. In joint action, variability reduction is adopted as a coordination strategy for enhancing predictability of one’s movement (Vesper et al., 2011). The current study aims at investigating how variability is exploited when individuals learn a motor task jointly with a partner. We hypothesize that a partner producing high variability will be advantageous in joint learning: individuals who learn the task with a highly variable partner will learn faster and hence reduce their spatial error rapidly because the confederate’s movement variability enhances action exploration for the individual. In a joint sequence learning paradigm, participants learned the motor task jointly with a confederate who is either highly variable or less variable in his movements. In the task, the confederate’s movements directly affect the participant’s movements. Our results indicate that the high variability group participants learned the task rapidly and adapt better to a novel situation compared to the low variability group.
Two agents, one melody: dual-person motor plans and interpersonal coordination in JA

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While playing face-to-face in turn-taking with a partner, participants performed two actions on a cube-shaped response-box (grasping the sides vs. pressing the top), generating two different tones. In a Joint Action (JA) condition participants shared with the partner the overarching goal of playing a pre-learned melody together; in a control, Independent (IND) condition, participants’ and partners’ actions and tones were unrelated. Unbeknownst to participants, 50% of trials required either physically congruent or incongruent movements, and in 50% of trials the association between the partner’s action (grasping vs. pressing) and the ensuing effects (i.e. a high- vs. low-pitch tone) was inverted. Performance in the IND control condition was influenced by physical congruency of the movements independently from action-tone associations; on the contrary, JA performance was affected when the partner’s action-tone association was reversed, independently from physical congruency. Three control experiments replicated and confirmed these results. A parsimonious explanation of the specific interference induced in JA by partner’s reversed action-tone associations is the activation of a dual-person motor plan that depends on the JA shared goal: this informs the agent’s action simulation mechanisms and channels expectations about the effects of the partner’s actions, which constitute his/her contribution to the interaction success.
Development of motor coordination skills during joint action in mid-childhood

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Development of motor coordination skills during joint action in mid-childhood. The ability to act jointly with others is crucial for human development. In last years, growing attention has been devoted to studying motor coordination strategies applied by dyads performing joint action. However, when in the course of human development inter-personal coordination strategies emerge is still unexplored. Here we studied the motor behavior of dyads of peers aged from 6 to 9 years and adults in a task requiring to perform the same action (i.e., exerting a force on an isometric joystick in order to bring a visual cursor toward a target) in a “solo” and in a “joint action” condition. The results revealed that, during joint action, younger children use a coordination strategy based on an increase of the predictability of the own behavior, which allows dyads to synchronize the onset of their actions. A critical age is 8 years, when another coordination strategy, based on the online monitoring of the peer’s behavior, seems to emerge during the execution phase of joint action. The use of either of coordination strategies seems mediated by the development of individual motor skills and the propensity to take into account a partner’s performance during joint action.
On individualism and interactionism in social cognition

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Many recent theories attempt to explain social cognition in terms of interaction (deJaegher, DiPaolo, Gallagher 2010) or joint intentions in the we-mode (Gallotti & Frith 2012). But they end up being circular since engaging in scenes of shared intentionality or achieving the relevant coordinated interaction presupposes a kind of social understanding: At least one agent must consider the other as a potential candidate for interaction or collaboration (Searle 1990). Since this enables interaction/joint intentions, it cannot be explained in these terms. How is this basic kind of social cognition—which underlies joint action—achieved?

1. It will be shown that Schmid’s (2014) suggestion of introducing the notion of plural prereflective self-awareness does not work.

2. An alternative is introduced, starting from the finding that we represent objects and agents differently, giving rise to physical and social affordances respectively, i.e. possibilities for action in the world or interaction with others. Affordances are cashed out in terms of Millikan’s pushmi-pullyu-representations: They describe the world and prescribe possible actions (or interactions) in it. Developmental research suggests an innate representational capacity (Spelke 2003) of perceiving agents as potential collaborators (or competitors). This representation includes a presentation of possibilities for interaction. Only then can interaction be achieved and modulate or enable new levels of social understanding.
Synchronization Dynamics Underlie Coordination in Natural Joint Actions

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Previous research has observed spontaneous synchronization of bodily movements when people interact and demonstrated that this synchronization has psychological consequences. It has been proposed that the dynamics of coupled oscillators are the causal mechanism that provides the foundation of such interpersonal synchrony. However, the ability of this research to generalize has been criticized because it has investigated tasks with artificial social goals and simple behaviors in which the co-actors move identically and in a sinusoidal fashion. The purpose of this talk is to provide evidence that synchronization dynamics appear to be creating interpersonal synchrony in more realistic interactional tasks as well. We used a competitive sports task (i.e., an Aikido attack/defense) and a structured conversation task (i.e., telling a series of jokes to each other) to test whether we would see activity patterning predicted by a coupled oscillator model of interactional synchrony. We differentially weighted the bodies of interactors to see whether the frequency detuning of their bodies would reveal the model predicted lag-lead relative phasing pattern in the coordinated movements. We also investigated how the skill of the participant and availability of perceptual information affected the observed dynamical synchrony patterns. By learning more about this dynamical process of human interaction’s “dance-like” synchronization we hope to gain insight to how humans socially connect and cooperate.
How do we represent others’ action sequences?

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When performing tasks that require single manual actions, e.g., pressing response buttons, people acting side by side tend to represent each other’s tasks. However, the actions we perform in everyday life are more complex, often consisting of a sequence of actions leading up to a final goal. How do people represent others’ action sequences when they act together? Do they represent only the final goal (i.e., the endpoint) of the whole sequence or also the actions constituting the sequence? In the present study, pairs of participants performed action sequences side by side, aiming to synchronize the endpoint of their sequences. We predicted that if co-actors represent the actions constituting each other’s sequence, they should experience conflict when both co-actors perform the same actions yet in a different order (e.g., one actor performing the sequence A-B and the other the sequence B-A). Our results show that co-actors moved more slowly when performing the same actions in a different compared to the same order, indicating that representing the actions constituting a co-actor’s sequence disturbed performance. These findings extend previous research on co-representation, providing first evidence that people represent the order in which a co-actor performs the actions within an action sequence.
This paper takes as its starting point a problem in the developmental literature on perspective-taking. The literature distinguishes between level-1 perspective-taking tasks, in which perceivers judge what another can see; and level-2 tasks in which perceivers judge how another sees a visual object. Level-1 tasks are passed at around 2.5 years of age and thus two years earlier than their level-2 counterparts. It is often, and to my mind convincingly, argued that solving level-2 tasks requires an ‘engaged allocentric’ or ‘alter-ego-centric’ spatial framework in which subjects are able to imaginatively simulate perspectives other than their own. By contrast, it is not clear what kind of spatial framework underwrites level-1 perspective taking. It is sometimes hypothesized that level-1 perspective taking is the result of the ability to imaginatively extend another’s line of sight, which is achieved by means of an act of simple triangulation in egocentric space. I argue that this view is unsatisfactory and that we need to introduce the notion of a social frame of reference in order to explain the capacity for level-1 visual perspective-taking. I develop the view that this framework begins with joint peripersonal space, in which objects are presented as ready-to-hand if they are close to either the subject’s own or her co-operator’s location. I conclude by highlighting the implications of this approach for a theory of demonstrative reference.
Perception of expressive body movements by individuals with autism spectrum disorder

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Individuals with autism present impairments in social interaction and communication. Little is known about how music and dance are processed by these individuals, especially regarding the expressive and perceptual properties of such signals. The present study investigated the perception of biological motion by individuals with Autism Spectrum Disorder (ASD) in point-light displays depicting dance. Adult participants with ASD and a matched typically developing control group watched point-light displays (1-5 seconds long) depicting expressive and inexpressive dance movements in visual-only, audiovisual-congruent (i.e., synchronous music to movement) and audiovisual incongruent (i.e., asynchronous music to movement) conditions. The task was to identify the dancer’s intended expression intensity (i.e., expressive vs. inexpressive). A signal detection analysis indicated that expressive body movements were identified reliably even for displays of 1s, and equally well in both ASD and control groups, with discrimination accuracy improving with increasing stimulus duration. Accuracy did not differ across visual-only, audiovisual congruent, and audiovisual incongruent conditions. Although individuals with ASD scored significantly lower than controls on self-report empathy and alexithymia scales, no relation between these measures and perceptual discrimination accuracy was found. The results are discussed in relation to the potential of music and dance signals to stimulate the latent communicative skills of ASD individuals.
How Motor Representation Grounds Cooperation

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Which mechanisms enable our actions to be cooperative when we act together? Cooperation in acting together has been explained as a matter of our actions being appropriately related to a special kind of intention-like attitude, a ‘weintention’ (Tuomela and Miller 1988; Searle 1990), or to a special kind of commitment (Gilbert 2013), or to an intention of which you and I are both subjects (Schmid 2009), or to intentions on the part of each of us that we act because of, and in accordance with, each other’s intentions (Bratman 2014). One possibility not yet considered is that more primitive representations and processes are also relevant to understanding what enables agents to perform cooperative actions. In this talk we conjecture that differences in the degree to which actions are cooperative can arise in virtue of motor representations and processes. Cooperativeness in acting together is not only a matter of intention and commitment: sometimes it is motorically grounded. This conjecture generates predictions about how motor processes affect cooperation, and about how being more cooperative may affect how actions are represented motorically.
Evidence suggests that movements made in the presence of another person are affected by that person, but there is little data about how the type of relationship (i.e. friends vs. strangers) can have an influence when people perform high intensity (e.g. sports) activities. Previous literature has found that individuals increase effort levels when competing against an out-group member in comparison to an in-group member (Lount and Phillips, 2007), but we could alternatively expect that friends provide support which encourages more effort and better performance. In this experiment thirty-two university students performed 2 sets of five minute High Intensity Interval Training (HIIT) exercises with a stranger and a friend (order counterbalanced) in a repeated measures design. Self-reported performance was significantly better when performing with strangers compared with friends ($p = 0.031$, two-tailed), and physiological data (movement, heart rate and galvanic skin response) were also collected. To conclude, we found that students perform better when exercising with a stranger compared with a friend, which may be the result of greater competition with a stranger.
On the Edge of Our Seat. Sensing Conversational Engagement from Pressure on Chair Seat Covers

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Body movements contain a great deal of information about patterns of participation in conversation. For example, speakers and addressees move their hands in systematically different ways. Existing approaches to identifying patterns in social interaction typically employ relatively complex sensing devices such as fixed cameras or mobile phones. Here we present a new, nonintrusive method for sensing patterns of social interaction using only chair covers. Drawing on informal observations of people’s movements during seated conversations, we developed textile pressure sensors, made of conductive fabric and resistive foam, that can be integrated into chair covers. Deploying eight sensors distributed across the seat and back of the chairs, we test whether we can detect people’s involvement in a in three-way conversations using only pressure changes on the seats they are sitting in. The results show that even from this impoverished data from simple embedded sensors we can distinguish between talking, backchanneling and laughter; each state is associated with distinctive patterns of pressure change across the surface of the chair. We speculate on the possible applications of this new, unobtrusive form of social sensing for architecture, performance and augmented human interaction.
Matching action observation to action execution

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Since the seminal work by Fadiga et al. (1995), several TMS studies have documented the activation of one’s corticospinal system during the observation of others’ actions. Despite nearly two decades of research, however, there are three aspects of the mirror response to action observation that are not yet clear: muscle specificity, timing, and directionality (Naish et al., 2014). The aim of this study was to clarify these aspects by directly matching data from action observation to those from action execution. To this end, we first recorded electromyographic activity during the execution of grasping movements toward small vs. large objects. Next, by combining single pulse TMS and EMG, we recorded Motor Evoked Potentials (MEPs) from FDI and ADM hand muscles while participants watched videos of the recorded reach-to-grasp movements. Our results demonstrate, first, that the pattern of corticospinal modulation is muscle-specific and, second, that the timecourse of MEP modulation during action observation is tightly coupled to the changes in muscle activity during action execution. As for the direction of modulation, we found a decrease in corticospinal excitability relative to intra-block baseline, but not relative to pre/post session baseline, suggesting that direction is influenced by variations in baseline measurements.
Similiarity of behavior in task space promotes collaboration and joint performance

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Joint action relies on our ability to collaborate with others towards the achievement of a common goal. We set out to identify behavioral and physiological markers of collaboration in a target-tracking tablet game in which two subjects jointly control the position of a virtual ball through finger movements. This condition was contrasted with a non-collaborative control condition. We investigated behavioral coupling in both motor space (finger movements) and task space (in-game behavior). In addition, 64 channel EEG was recorded from both participants and cross-brain phaselocking analysis was performed. We hypothesized that relevant measures should distinguish the two task conditions, should correlate with joint performance, and should correlate with the subjective ratings of collaboration recorded after each two-minute game. From a large set of potential coupling measures only a dynamic time warping distance capturing the similarity of players' relative speed and distance to the target satisfied these criteria, even after controlling for the correlation between subjective ratings and performance. Furthermore, this measure significantly correlated with between-brain phase synchronization in the beta range in right occipito-parietal locations, specifically in the collaborative condition. Our results suggest that it is not the coupling of actual movements, but that of action in task space, that promotes joint performance and the appraisal of collaboration. This work was supported by the European Union through the H2020 FET Proactive project socSMCs (GA#641321 / H2020).
People in groups frequently coordinate their actions with others to produce joint actions - even when such joint actions incur motor costs with no clear goal (e.g. a Mexican wave at a football match) - and this is likely done to increase one’s sense of group cohesion, affiliation, and social connection with other actors (Hove & Risen, 2009; Marsh, Richardson, & Schmidt, 2009). One example of joint action is joint speech (found in many religious and cultural practices; e.g. communal prayer, the United States Pledge of Allegiance, or chanting at a football match), which unlike other instances of joint action can vary in terms of semantic content. That is, in addition to the prosocial consequences of performing in synchrony, joint speech may have the additional effect of manipulating participants’ beliefs or attitudes related to what is being said. We present preliminary work that explores this, where participants read true and false factual statements aloud either individually or as a pair, and made individual and joint decisions about their veracity. We find no evidence that joint speech production influences participants’ beliefs about statement veracity, suggesting that the cognitive consequences of joint speech production have limited effect on epistemic evaluations.
Most minimal cases of commitments in joint actions

Anna Strasser

Commitments provide the security social agents need to rely on each other in joint actions. Standard conceptions characterize commitment as a relation between two agents and a specific action. But Michael et al. (2016) showed that interesting minimal forms are neglected: they argue that components of a commitment can be dissociated. A single occurrence of one component elicits a minimal sense of commitment. An agent can entertain such a minimal sense by directing an expectation to another agent, even though the other is not committed. In standard cases, expectations are justified by the commitment of the other agent. But how do we justify expectations in dissociated cases? Is it sufficient to require that they are directed to another agent? What specific notion of agency should we assume? Presupposing that a sense of commitment gets stronger the more likely it is that the counterpart fulfills the expectation, I explore how weak such a sense can get before it stops to be a sense of commitment. For this aim I discuss modulating factors and other characteristics such as dispositions and capacities which can be required regarding the target subjects to justify an expectation.
Investing in Commitment: Evidence that the efforts invested by individual contributors to joint actions enhance their partners’ commitment

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Michael, Sebanz and Knoblich (2016) have recently proposed a theoretical framework for investigating the cognitive and motivational factors underpinning the sense of commitment in joint action. This framework generates the prediction that one individual's sense of commitment can be generated and/or enhanced by her/his partner's investment of time, effort or other costs. In order to test this prediction, we implemented a within-subjects-design experiment with 26 participants based upon a simplified, 2-player version of the classical snake game. Each participant played twenty rounds of the snake game together with a (virtual) partner, with the participant controlling the left-right axis and the partner controlling the up-down axis. Before each round, the partner had to perform a cognitive task that was either easy (Low Investment Condition) or difficult (High Investment Condition). We hypothesized that participants would feel more committed to the joint task in the High Investment Condition than in the Low Investment Condition. If so, then participants should persist longer in the High Investment Condition than in the Low Investment Condition. This prediction is supported by the results: the mean persistence was significantly higher in the High Investment Condition than in the Low Investment Condition.
Robot Perception of Social Engagement Using Group Joint Action

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As robots become situated in environments such as manufacturing, healthcare, and education, they will be expected to have an understanding of group interaction [1-7]. Robots can do this by understanding social joint action (SJA), e.g., reading social cues, such as gestures, postures, and conversational feedback [8]. To date, no system exists which can autonomously analyze SJA in real-time. This motivated us to design such a system. We explore SJA in the context of HRI to design robots that leverage knowledge of SJA to sustain social interaction with groups of people. Our system can do this by: 1) detecting SJA, 2) modeling time-varying group engagement, and 3) performing behavioral-appropriate actions in response to perceived group engagement level. This enables us to evaluate our understanding of group dynamics to facilitate improved interaction between robots and people. We evaluate engagement using a dynamical systems approach to determine the temporal dynamics of SJA in groups and how it is affected by the robot’s actions [9-10]. This approach to SJA in groups will prove fruitful for robots to appropriately sustain long-term interaction with groups of people in the real-world [11].
Feeling the "click" of successful joint-action predicts social bonding among professional Chinese rugby players during a two-day National Tournament

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We hypothesise that the “click” of successful joint-action experienced as part of exertive and coordinated group activities like dance, music, or sport is evidence of a key mechanism through which such activities generate social bonding (Marsh et al. 2009). Successful joint-action would function to increase perceived click, and athletes who felt higher levels of click would report higher levels of social bonding, and lower feelings of fatigue. To explore this prediction in the real-world, 174 Chinese professional rugby players (male = 93, mean(age) = 21.67 (s.d = 3.67, range = 17-32)) were surveyed before, during (twice), and after a two-day National Tournament. Results showed a significant relationship between perceived joint-action success and social bonding, and a significant interaction between joint-action success and feelings around individual and team performance on bonding (controlling for various objective measures of performance). Effects were moderated by technical competence, such that higher level of competence predicted higher levels of bonding. Fatigue increased significantly throughout the Tournament, but athletes who self-reported higher levels of technical competence reported lower than expected fatigue. Results suggest that perceived joint-action success may be an important psychophysiological generator of social bonding in group exercise contexts, and that technical competence may play a role in buffering the stresses of exercise. Controlled experimental research is required to further test these predictions.
Walking in Sync and Sensing groups

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Our recent work explores two directions in interpersonal behavior: gait synchronization and group formation. Gait synchronization while walking and talking has been shown to be an indicator of agreeableness and companionship. Using high frequency accelerometer data from a dedicated smartphone app developed with our open sensing framework Sensing Kit (http://sensingkit.org.uk), we perform a number of controlled experiments on a number of individuals in different group configuration. Our results bring an interesting insight: it is the non-verbal social signals such as the gaze, head orientation and gestures that is the key factor in synchronization, not necessarily the number or configuration of the walkers. These early results can assist us with detecting relationships between individuals or detecting the group formation and numbers for crowd-sensing applications when only partial data is available. In order to investigate this further we then develop a system for detecting stationary interactions inside crowds using the Received Signal Strength Indicator of Bluetooth Smart (BLE) sensor, combined with the Motion Activity of each device. By utilizing Apple’s iBeaconTM implementation of Bluetooth Smart, we are able to detect the proximity of users carrying a smartphone in their pocket. We then use a Graph Theory based algorithm to predict interactions inside the crowd and verify our findings using video footage as ground truth. Our approach is particularly beneficial to the design and implementation of crowd behavior analytics, design of influence strategies, and algorithms for crowd reconfiguration.
Efficiency in joint action: Do we make rational decisions when coordinating with others?

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Do we make rational decisions that maximize joint efficiency when coordinating with others (i.e. minimize the total costs of actions for a dyad instead of its constituent actors)? In joint object manipulation tasks, adults make efforts to reduce their partner’s discomfort. One explanation for such behavior might be that people aim to share their efforts to minimize aggregate costs (maximizing joint efficiency). Alternatively, they may only aim to reduce their partner’s effort (maximizing individual efficiency). Here, we put these two explanations to test. We used a dyadic motor coordination task in which actors transported an object to a goal area with their partner, in an environment with two potential paths. We systematically manipulated the costs of available movement options and analyzed path choices. Our results suggest that the tendency to choose the individually efficient or inefficient option in neutral trials (with no differences in related joint costs) varied widely across participants. However, in trials where an action could be executed in less and more joint-efficient ways, participants seemingly based motor decisions on aggregate costs and acted to maximize the dyad’s efficiency, even at the expense of compromising individual efficiency. We propose that rational decision-making based on calculating joint costs might account for sequential joint action planning.
Self-bias in a joint task with a partner

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Self-bias refers to the advantage processing toward an arbitrary item when it associates with self. Unlike advantage associated with significant others (e.g. mother, friends), this advantage is robust and not easy to be reduced or removed with rewards. Method: We ask whether this self-related bias is enhanced when a partner is present. Participants judged whether three arbitrary geometric shapes were accurately paired with pre-assigned three names (own, partner, and a neutral stranger). Half of the trials were colored in red, and the other half were in green. The color served as a go/no-go signal, and each subject only had to respond to one color. Participants either performed the task alone, or with a partner responding to a complimentary color. Results: We found that trials associated with own name were more accurate and required shorter response time (i.e. self-bias) than trials associated with the partner’s name or the stranger’s name. The response time in a joint task was also significantly faster, for all three kinds of trials. Our result suggests that identity-inferential information is enhanced with the presence of a partner, and the physical presence is crucial for such effect. It has important theoretical implication of how we process self-other related contents.
Interaction, cognitive diversity and abstraction

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Capacities for abstract thinking, category-formation and problem solving are central to human cognition. Processes of abstraction allow the transfer of experiences and knowledge between contexts helping us make informed decisions in new or changing environments. While such reasoning processes have often been related to individual minds and brains, they may in fact be contingent on human-specific modes of collaborative interaction and shared attention. In an experimental study, we test the hypothesis that constitutive properties of social interaction - the negotiation of diverse perspectives - enhance cognitive processes of abstraction. Through three sessions of increasing complexity, individuals and dyads were presented with a task requiring them to categorize a set of visual stimuli. To assess the character of participants’ representations, after each training session they were presented with a new set of stimuli that differed in appearance, but shared relations among features with the training set. We found that dyads outcompeted individuals in training sessions across different levels of complexity. More importantly, dyads were superior to individuals in the transfer phase suggesting a more abstract character of problem representation. Interestingly, variation in performance among dyads was predicted by diversity in dyad members’ linguistic contributions supporting the hypothesized link between cognitive diversity and abstraction.
Planning and coordinating actions with others enables us to accomplish many action goals we could not accomplish alone. It also inherently introduces ambiguities in deriving a sense of control over one’s actions, as it is often unclear how one’s action contributions translate to the joint performance. One way to overcome ambiguities in deriving control is by adopting a “we-mode”, in which the sense of control is mostly derived from perceptual cues about the joint performance instead of individual contributions. Here, I will provide evidence suggestive of we-mode control, and indicate potential boundary conditions. Dyads performed goal-directed joint actions (i.e., displacing a dot through joystick movements from a start location to one of two possible target locations) while each actor’s objective level of control over action outcomes varied across conditions (by varying the target locations). They also provided ratings on their sense of control. The results suggest that dyads engaged in we-mode processing, but only when the action proceeded as they intended. Understanding the experiential nature of joint actions is important, as misperceptions of control may result in unduly claiming credit. In egregious cases, this may subsequently obviate a willingness to cooperate with a joint action partner altogether.
In four experiments we examined whether solidarity can be transferred from an active target group onto a ‘passive’ audience. During a festival, two field experiments were conducted in which participants watched live dance performances of dancers displaying either mechanical, organic or no solidarity. Both solidarity conditions (vs. no solidarity) increased the audiences’ experience of solidarity with the dancers, but through different pathways: When observing mechanical solidarity, feelings of solidarity were high because the audience perceived unity among the dancers. When observing organic solidarity, feelings of solidarity were high because audiences perceived both unity and individual value among the dancers. Moreover, the solidarity displayed, influenced post-performance behaviour. Specifically, audiences in the mechanical condition cooperated in a highly structured way. Audiences in the organic condition took longer to form structure, although they did so to the same extent in the end. However, audiences in the no solidarity condition were less structured overall. We successfully replicated these findings in two lab experiments, where participants either performed or observed music performances. We conclude that audiences are able to recognize and experience solidarity differently depending what type of solidarity they see. This, in turn, can have consequences for how audience members relate to one another.
Co-actors Use Ostensive Communication to Distinguish Object Categories

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When multiple people coordinate their actions towards performing a common goal, they often rely on different forms of communication to facilitate their joint action. While the functionality of e.g. spoken language for coordination is undeniable, less is known about how people explore new ways of providing information to each other in cases when conventional communication systems are unavailable. The present study aimed at exploring in which ways ostensive communication may emerge in joint action. To that end, we designed a task in which objects belonging to different categories had to be non-verbally matched between an informed communicator (‘Leader’) and an uninformed receiver (‘Follower’). The objects were distinguishable on different levels: Whereas ‘visible feature’ objects could be distinguished from ‘default’ objects based on overtly perceptible features, the distinguishing features of ‘invisible feature’ objects were hidden and therefore not directly accessible for an observer. Results from two experiments demonstrate that marking object categories ostensively may be beneficial or even crucial for establishing a successful communication system when task-relevant information can neither be perceptually highlighted nor unambiguously communicated by means of conventional or iconic signals. Ostensive communication may therefore provide a powerful mechanism for real-time coordination in joint action.
Observing Interpersonal Synchrony: An fMRI Study

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Interacting with other people in synchrony establishes a variety of social phenomena such as feeling of togetherness, group unity, cooperativeness, and a general positive attitude towards others. But how is interpersonal synchrony interpreted by an observer? The current study investigated brain activity in response to observed interpersonal synchrony. Study participants watched short movie clips of two people who clapped in synchrony or not in synchrony. As a second experimental factor, participants were told that the actor pairs were either instructed to clap in synchrony or not, or that they did not receive such instructions, suggesting they spontaneously clapped in synchrony or not. Results indicate that observing others intentionally synchronizing their movements recruits the reward network (ventral striatum) compared to observing others intentionally moving asynchronously. In addition, activation in the mentalizing region (media-frontal cortex, MPFC) increased during observation of others spontaneously falling into synchrony compared to observing others moving asynchronously. These findings suggest, first, that observing synchrony is pleasant and rewarding for the observer and, second, that observers ascribe a shared mental state to other people moving in synchrony.
Two trackers are better than one: Information about the co-actor's actions and performance scores contribute to the collective benefit in a joint visuospatial task

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When humans collaborate, they often distribute task demands to reach a higher joint performance compared to performing the same task alone (i.e., a collective benefit). Here, we tested to what extent information about the actions of co-actors and performance feedback contribute to the collective benefit in a collaborative multiple object tracking task. Specifically, pairs jointly tracked a subset of target objects among several moving distractor objects on a computer screen. At the end of each trial, they either received performance feedback, or the co-actor's target selections, or both. In all conditions, pairs' performances exceeded the individual performances and the hypothetical performance that would be reached if co-actors act independently. In comparison to receiving either the performance feedback or the co-actor's selections, when receiving both types of information, pairs improved faster, and divided task demands more efficiently. However, over time, performances converged to similar levels in all conditions, suggesting that pairs' coordination strategies become equally effective. Overall, pairs in a spatial collaborative task benefit from information about actions of their co-actor as well as performance feedback and the most from having both types of information available. (Grant #269716 / H2020)

Note, this abstract is based on “Wahn, B., Kingstone, A., & König, P. (submitted) Two trackers are better than one: Information about the co-actor's actions and performance scores contribute to the collective benefit in a joint visuospatial task.“
Skill differences predict collective benefits in dyadic and triadic joint visual search

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When humans perform tasks together, they often reach a higher performance in comparison to performing the same task alone (i.e., a collective benefit). Previous studies showed that interindividual skill differences predict collective benefits for several types of joint tasks. However, it is unknown whether this is also the case for joint visuospatial tasks. Moreover, it is unknown whether dyads and triplets reach a collective benefit in a joint visuospatial task, even when they are not allowed to exchange any information. We addressed these issues in a joint visual search task, which participants performed either alone, in dyads, or triplets. We found that dyads reached a collective benefit. However, the performance of triplets did not exceed the performance of the best dyad. Nonetheless, skill differences significantly predicted the collective benefit for dyads and triplets. Overall, present findings further support the view that skill differences are a general predictor for collective benefits in joint tasks. Note, this abstract is based on "Wahn, B., Czeszumski, A., & König, P. (in preparation) Skill differences predict collective benefits in dyadic and triadic joint visual search." Acknowledgements: We acknowledge the support by H2020 - H2020-FETPROACT-2014 641321 - socSMCs (for BW) and ERC-2010-AdG #269716 - MULTISENSE (for PK).
Activity Recognition in Groups Using Wearable Sensing

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Understanding the mechanisms behind joint action can provide clues to aid the automatic recognition of such actions. Activity recognition (AR) is an active research topic within wearable computing, where the ultimate aim is to provide real-time computer support to users based on inferred information about their current activities. To achieve this AR uses diverse sensor data from body-worn sensors which is then analysed using pattern recognition methods to automatically detect the activities of interest. Where traditional AR was restricted to activities by single users, our research is aimed towards sensing and recognising joint activities within small groups. We recorded a dataset of 4 actors working on a shared physical task (building a large video wall). Minimal instruction was given so as to encourage spontaneous coordination of actions and collaborations within the group. Each actor wore an eye tracker, an inertial measurement unit (IMU) on both wrists and head, and a microphone. Using only IMUs we detected moments of sensorimotor information sharing (e.g. haptic coupling) and used these to help spot joint actions (e.g. carrying heavy objects). We plan to extend this approach to further recognise joint task planning and coordination using shared gaze and vocal patterns.
Coordinated Timing in Piano Duet Performance: Effects of Musical Role Asymmetries and Auditory-Feedback Delays

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Recent research in human behavioral dynamics has demonstrated that co-actors often successfully achieve joint goals by adopting functionally asymmetric patterns of behavior. To better understand the evolution of such patterns in a naturalistic musical context, the current study examined how auditory-feedback delays and individual musical roles affect collective temporal stability and relative adaptability during duet performance. The delays between pianists were short (10-40 ms), bidirectional, and remained constant during a single trial, simulating those typical in internet-mediated performance. Preliminary results show increasingly reduced collective stability for longer delays along with a distinct pattern of asynchronies across the points where temporal synchrony would be expected, in which individuals exhibited consistent alternation between playing before or after their co-performer. Furthermore, asynchronies became greater when the two musical parts were less similar. Thus, emerging coordinative dynamics appear to be shaped both by asymmetries in co-performers’ assigned roles and external constraints on shared information.
Self-Referential Delays Facilitate Anticipatory Synchronization During Artificial Agent-Human Interaction

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Work investigating the dynamics of coupled physical systems with unidirectional slave-master coupling has demonstrated that the incorporation of delayed feedback within the slave system allows it to achieve anticipation of chaotic master system behavior. This counterintuitive phenomenon of self-organized anticipatory synchronization has been observed for a variety of systems including coupled electrical circuits, laser semi-conductors, and neurons. Our own research has also shown that individuals can achieve the same kind of anticipation during interpersonal interaction following the introduction of perceptual-motor feedback delays. Understanding such human behavior as defined by the same universal dynamical laws as other physical systems provides a novel opportunity to inform the advancement of artificial agents. The goal of the current project was therefore to harness the phenomenon of anticipatory synchronization in developing an artificial agent capable of achieving adaptive anticipation during interaction with a human co-actor. Here individuals interacted with a robot avatar defined by a time-delayed, low-dimensional dynamical model via a virtual reality headset. This agent displayed prospective coordination with seemingly unpredictable human behavior, making this work the first to employ the understanding of anticipatory synchronization in physical systems for the creation of an artificial agent capable of anticipating complex human behavior in real time.
“I’ve got my eye on you”: Faces with sudden direct gaze are processed more efficiently than faces with averted gaze

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The direction of another person’s gaze provides the observer with important cues about who or what is the focus of that other person’s attention. Previous research has revealed that faces with direct gaze (gaze oriented at the observer) are processed more efficiently than faces with averted gaze (gaze oriented away from the observer). This direct gaze advantage may arise because direct gaze indicates to the observer that they are the subject of another person’s attention. Across a series of experiments using a visual search task, we found that there are additional processing advantages for faces that suddenly adopt direct gaze (abruptly shift from averted to direct gaze) relative to static direct gaze (always in direct gaze), sudden averted gaze (abruptly shift from direct to averted gaze), and static averted gaze (always in averted gaze). The present studies revealed a critical role for the observation of eye motion in the sudden direct gaze effect because this effect emerged when the eyes moved within static faces that were statically oriented towards or away from the observer. Overall, our work indicates that this sudden direct gaze likely emerges due to the additive effects of social (specifically direction of eye gaze) and motion cues.
Making music often requires inter-limb coordination that is neither in phase nor in anti-phase. Some of these intermediate phase relations are specified in the score, others come from the technical requirements of the instruments. Nevertheless, musicians achieve high temporal coordination regardless of the phase relation between their limb movements. This is remarkable given that research on inter-limb coordination showed that it is very hard for humans to maintain intermediate phase relations (Kelso, 1984), both intra-personally as well as inter-personally. A study by Mechsner et al. (2001) revealed that focusing on the perception of visual outcomes rather than focusing on the underlying actions enables participants to maintain intermediate phase relations. In the current study, we investigated whether musicians are able to quickly (within one session) adapt to a new phase relation, when they focus on aligning auditory outcomes rather than focusing on their out-of-phase movements. Furthermore, we investigated whether weak coupling (joint uni-manual condition) allows for faster adaptation rates than strong coupling (individual bi-manual condition). The results suggest that musicians readily adapt to a new intermediate phase relation when they focus on auditory outcomes and that they adapt faster when the inter-limb coupling is weaker (joint condition) than when it is stronger (bimanual condition).
Joint Expressive Action: A Philosophical Analysis

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Hursthouse 1980 drew the attention of philosophers of action to kinds of action which is intentional but which does not seem aimed at achieving any kind of goal. Such actions include spontaneous but voluntary expressions of emotion. More recently, Gilbert, Helm, Huebner, Schmid, Kruger, Salmela, Salmela and Nagatsu, and others have discussed a variety of joint and collective emotional phenomena. In this paper, I address two questions. The first is whether joint emotions should be regarded as giving rise to intentional actions analogous to the kind of action with which Hursthouse is concerned, and in particular whether there are joint, shared, or collective actions which can be regarded as expressions of collective emotion. I give a positive answer to this question. The second is whether and how well existing accounts of joint action can accommodate these as examples of bona fide collective action. Here I give a more qualified answer: I suggest that some such accounts can accommodate some of the phenomena we might wish to recognise here, but that some of the phenomena that seem likely to be of most interest from a developmental point of view seem especially hard to accommodate.
Does mimicry make someone’s argument more persuasive?

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Previous research has demonstrated a mimicking artificial intelligent (agent) in an immersive virtual environment (IVE) is more persuasive than a non-mimicker. In this study, we investigate the effect of different forms of responsiveness in human-agent interaction. Using live motion capture used to drive an avatar presented via a head mounted display we have created an experimental platform that enables systematic fine-grained manipulations of non-verbal interaction. Using this we can manipulate an interlocutor avatar's head movements in real-time. We compare the effects of mimicry, non-mimicry, and real responses. This work extends an approach we have used for manipulating verbal interactions mediated by text-chat and builds on earlier work using live optical motion-capture data to drive avatars in real-time and tested hypotheses drawn from detailed observational studies about the effects of specific non-verbal cues to the co-ordination of turn-taking, signals of mutual understanding and clarification and repair.
Participants

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<th>Educational/Research</th>
<th>Residential</th>
<th>Facilities</th>
<th>Information</th>
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<tr>
<td>ArtsOne</td>
<td>Albert Stern Cottages</td>
<td>Advice and Counselling Service</td>
<td>Visitors who require further</td>
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<td>ArtsTwo</td>
<td>Albert Stern House</td>
<td>Housing Hub</td>
<td>information or assistance should</td>
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<tr>
<td>Arts Research Centre</td>
<td>Beaumont Court</td>
<td>Bookshop</td>
<td>please go to the main reception</td>
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<tr>
<td>Bancroft Building</td>
<td>Chapman House</td>
<td>Careers Centre</td>
<td>in the Queens' Building.</td>
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<tr>
<td>Bancroft Road</td>
<td>Chesney House</td>
<td>Clock Tower</td>
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<tr>
<td>Teaching Rooms</td>
<td>Creed Court</td>
<td>CopyShop</td>
<td></td>
</tr>
<tr>
<td>Peter Landin Building (Computer Science)</td>
<td>France House</td>
<td>The Curve (R)</td>
<td>The smoking of cigarettes</td>
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<tr>
<td>Engineering Building</td>
<td>Feilden House</td>
<td>Disability and Dyslexia Service</td>
<td>or tobacco products are only</td>
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<tr>
<td>G.E. Fogg Building</td>
<td>Hatton House</td>
<td>Drapers' Bar and Kitchen (R)</td>
<td>permitted at designated smoking</td>
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<tr>
<td>G.O. Jones Building</td>
<td>Ifor Evans Place</td>
<td>Canalside</td>
<td>areas/shelters indicated on this</td>
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<td>Geography</td>
<td>Lindop House</td>
<td>Ground Café (R)</td>
<td>map.</td>
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<tr>
<td>Informatics Teaching Laboratories</td>
<td>Lodge House</td>
<td>The Hive</td>
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<td>Joseph Priestley Building</td>
<td>Lynden House</td>
<td>Infusion (R)</td>
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<td>Library (R)</td>
<td>Maurice Court</td>
<td>IT Services</td>
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<td>Maynard House</td>
<td>Mucci's (R)</td>
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<td>Health Service</td>
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<td>Varey House</td>
<td>Octagon</td>
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<td>Queens' Building</td>
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<td>Temporary Building</td>
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<td>Sports Hall (R)</td>
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<td>Santander Bank (€)</td>
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<td>Security (38/54)</td>
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<td></td>
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<td>Westfield Nursery</td>
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</tbody>
</table>

**Key**
- Library/bookshop
- Fitness centre
- Refreshment:
  - Bar/Eatery/Coffee place
- Staff car park
- Bicycle parking
- Bicycle lockers
- Cash machine
- Smoking area / shelter