



The 24<sup>th</sup> meeting of the  
Association for the Scientific Study of  
Consciousness (ASSC)

# Welcome

We are happy to welcome you to the 24<sup>th</sup> meeting of the Association for the Scientific Study of Consciousness (ASSC).

The past two years have presented unusual challenges and difficulties that affected all of us. The Covid pandemic and its economic, social, political and personal ramifications have impacted the entire world.

The original plan to have the ASSC24 meeting in person in Tel-Aviv- Jaffa in 2020 was postponed to 2021, and the current meeting is an online event. Despite these adversities, the local organizing committee together with the ASSC management have worked hard to ensure that the meeting takes place, as the past year has shown us the importance of continuity and community, perhaps more than ever before.

While we really wanted to see you all in person, we are happy that the ASSC4 can take place, even online. This new format of meeting posed several new challenges (e.g. time zones, community building, zoom burnout) but also allows several benefits (e.g. environmentally friendly, low cost, higher accessibility). We endeavored to build this with the ASSC community, including more grassroots formats such as the Consciousness Salons, and replacing the posters with short talks, taking a more inclusive approach.

We hope that we will all enjoy this meeting, enrich ourselves scientifically and socially, and reinforce our awareness that we are part of something bigger.

Roy & Liad

## We would like to express our gratitude to our generous sponsors



## Local Organizing committee

Dr. Roy Salomon, Chair (BIU)

Prof. Liad Mudrik (TAU)

Prof. Rafi Malach (WIS)

Dr. Nava Levit-Binnun (IDC)

Prof. Ran Hassin (HUJI)

Dr. Aviva Berkovitch Ohana (HU)

Prof. Dominique Lamy

Prof. Leon Deouell (HUJI)

Prof. Oron Shagrir (HUJI)

Dr. Moti Salti (BGU)

Prof. Moshe Bar (BIU)

Event Manager: Tehilla Goldberg

## **Keynotes**



Prof. Rafi Malach  
Weizmann Institute

"A structuralist perspective on human conscious perception"



Prof. Yuval Noah Harari  
Hebrew University

"The Politics of Consciousness"



Prof. Lucia Melloni  
**Max Plank Institute**

"Next Gen Consciousness Studies: on Adversaries, Big Data and Phenomenology"



Prof. Fiona Macpherson  
**University of Glasgow**

"A new theory of illusion and hallucination"



Prof. Mike Shadlen  
**Columbia University**

"Consciousness as a decision to report to an Other's mind"

## **ASSC 24 Symposia**

**Monday, 14 June, 2021, 18:00-19:30**

### **What is the relation between conscious intention and action formation? Empirical, modeling, and philosophical perspectives**

Uri Maoz, Patrick Haggard, Aaron Schurger, Adina Roskies

Voluntary action seems to be accompanied by conscious intention to move—some think conscious intention is causally necessary for voluntary action. Bodily movement without conscious intention often feels involuntary. In contrast, when movement is accompanied by conscious intention to carry it out, that intention is typically experienced as causal for the movement. Although this phenomenological difference is widely recognized, the reasons for it remain highly controversial. For example, classical neuroscientific studies claim that neural precursors of action—and in particular the readiness potential (RP)—predate the onset of conscious intention. This seems to preclude conscious intentions from having any causal role in action and suggests that human experience of volition departs fundamentally from neurophysiological reality of volition. This symposium will showcase a host of current views on the relation between conscious intention and action formation, drawing from recent experimental, modeling, and philosophical work. Patrick Haggard will discuss recent experimental attempts to produce unbiased accounts of the content of conscious intentions and of the RP. Aaron Schurger will present recent computational modeling work that provides explicit and novel predictions about the relation of intention and the RP. Uri Maoz will focus on the relation between intention onset and action in arbitrary and deliberate decision-making, including experimental and modeling work. And Adina Roskies will take a philosophical approach to the broader questions of the role of the RP and the extent to which neuroscience can inform debates about the role of consciousness in action. Liad Mudrik will chair and introduce the symposium.

**Tuesday, 15 June, 2021, 17:00-18:30**

**The development of consciousness, agency and metacognition**

Louise Goupil, Claudia Passos, Joulia Smortchkova, Fernanda Prieto

In this symposium, we will present both new theoretical proposals and new empirical evidence aiming to illuminate the development of reflexive processes and subjective experience. Metacognition is often considered a later developing function of the human mind, requiring access to one's mental states, to be measured through explicit reports. However, alternative methods have recently led to the discovery that young children possess rudimentary forms of metacognition. This discovery has opened up exciting avenues for exploring the relation between metacognition, agency and consciousness in development. To shed light on this relation, this symposium takes a multidisciplinary approach, combining neuroscience, psychology, and philosophy. Claudia Passos will present theoretical arguments suggesting that newborn infants have a sense of agency, one that is initially experiential and later becomes judgmental and fully metacognitive. Louise Goupil will present empirical evidence suggesting that very young children monitor the reliability of their knowledge and decisions, and propose that these abilities rely on a core metacognitive system. Joulia Smortchkova will explore the relation between metacognitive feelings and conceptual change in development, with a focus on the role of metacognitive feelings in resistance to conceptual revision. Finally, Fernanda Prieto will present two exploratory studies about the association between parental factors - such as metacognition - and infant's metacognitive skills and other developmental outcomes. We hope this symposium will make a case that theories of consciousness and metacognition would benefit from considering developmental issues more systematically, and that conversely, research on cognitive development need to consider subjective experience and reflexive processes.

**Wednesday, 16 June, 2021, 17:00-18:30**

**Neurocognitive mechanisms of reality monitoring: what is real and what is imagined?**

Nadine Dijkstra, Jon Simons, Chaz Firestone, Phil Corlett

A large body of literature has shown that neural mechanisms underlying veridical perception also support internally triggered visual experience such as mental imagery, visual working memory and dreaming. This raises a foundational issue in consciousness science: if there is such substantial neural overlap, how are we usually able to dissociate reality from imagination? This is the central question addressed in this symposium. We bring together neuroscientists, cognitive scientists and clinicians to explore reality monitoring from different perspectives. We will start with an overview on the overlap between imagery and perception which will highlight the difficulties in dissociating these two forms of sensory experience. After that, findings on reality monitoring in memory will be discussed which show how the brain determines whether a memory really happened or was imagined. One possibility is that events are categorized as real or imagined depending on the amount of details that are experienced. Next, new experimental data will be presented revealing that we overestimate the amount of detail in our mental images – suggesting a cognitive bias that could contribute to errors in reality monitoring. Finally, systematic errors in reality monitoring such as hallucinations can have far-reaching consequences for daily life. The last talk will address the importance of reality monitoring in different psychiatric disorders. This symposium will bring together different perspectives on the neurocognitive mechanisms of reality monitoring. We believe that this combination of perspectives will lead to new insights and provide exciting avenues for future research.

**Thursday, 17 June, 2021, 17:00-18:30**

**The influence of priors and predictions on conscious perception**

Johannes Fahrenfort, Biyu Jade He, Simon van Gaal, Stephen Fleming

It may seem self-evident that it is impossible to interpret sensory signals without prior information about statistical regularities in the outside world. It would therefore be unsurprising to conclude that priors play a large role in the way organisms perceive their surroundings. Similarly, it would be natural to think that predictions about what one is going to encounter might influence what is actually perceived. Nevertheless, the relationship between priors and predictions on the one hand and conscious perception on the other, is far from clear. Dating back at least to Helmholtz, the idea has been that priors are merely some unconscious precursor to the magic of consciousness itself. A competing idea might be that priors are directly involved in the shaping and generating of conscious percepts themselves. Yet a third idea might be that priors can operate at different levels in a processing hierarchy, and that their influence on consciousness depends on the level at which the prior operates. In this symposium we explore the various ways in which priors and predictions influence conscious perception in the hope of coming to an agreement about the hypothesized relationship between consciousness and prior information in the brain.



## **Consciousness Salon**

**Monday, 14 June, 2021, 19:30**

### **Overconfident or under-confident? Discussion of recent papers on how people set their confidence criterion Lucie Charles, Dobromir Rahnev**

Most recent research on metacognition has focused on metacognitive sensitivity, quantifying it across individuals and across tasks. However, only a few studies have explored the question of metacognitive bias and how people set their criteria for reporting high vs low confidence. This question is of importance however, if we want to understand why observers are sometimes over-confident or under-confident in their choice.

In this Salon, we will have an informal discussion on the question of metacognitive bias and how to set optimally confidence criteria. We will discuss recent papers on the question, discussing how studying the positioning of confidence criteria might bring new lights on known results in the field of metacognition and open new avenues of research.

Anyone interested in formal approaches of metacognition welcome to join!

### **The real stance towards the academic profession Athena Demertzi, Lucina Uddin, Lorina Naci**

As new scholars and researchers in academia, we expect to live the academic dream: show intellectual rigor, get published, participate in increasing knowledge. Overall, we want to make an impact. This view of our work is naturally romantic and very welcome for reaching a successful profile. Yet, it is an inevitably polarized view which, when adopted unexamined, may lead to emotional exhaustion, frustration, and even resignation. With this workshop we aim at balancing the ideal stance towards academia by proposing a more realistic attitude toward our beloved profession. By means of experiential exercises (narrative sharing, role playing, interviewing) our goal is to re-define the role of the successful researcher, ground our expectations about our profession, and find practices which embrace this position when working alone and in teams. We believe that the realistic stance sets a new mindset about happiness in lab life, prepares us for effective leadership of others, and eventually balances the work-life equilibrium. Essentially, this workshop is designed for those who are mentors not only by position but also by role.

### **The Mindfulness Map: A practical classification framework of mindfulness practices, associated intentions and experiential understandings Nava Levit-Binnun, Keren Arbel, Dusana Dorjee**

Meditative practices enable scientific access to a range of mental states. "Mindfulness" is an umbrella term denoting practices involving paying attention to bodily sensations and mental contents, with certain attitudes and intentions. However, to date, there is a lack of a clear framework for the various practices resulting in confusing and even contradictory findings and conclusions. In this workshop, I will present the "Mindfulness Map" developed in collaboration with contemplative scholars and researchers to facilitate more clarity and precision in researching and teaching mindfulness. This classification framework has been constructed around two axes that intersect. The first axis outlines mindfulness practices classified into four groups (MGs), e.g. the MG1 group of practices focus on cultivating attention to the present moment somatic and sensory experience. The second axis outlines possible intentions (INTs) behind teaching and practicing the mindfulness practice groups, e.g. the INT1 intention to gain experiential understanding of how our relationship to experience contributes to wellbeing. I will show how the same mindfulness practice group can lead to different experiential understanding (EUs) outcomes based on the specific intentions applied in their teaching or practice. The presentation of the map will be accompanied by short practices to enable a more fruitful discussion.

## **Music Consciousness and Synaesthesia: visualisation of musical texture & nature of cross-modal associations**

### **Svetlana Rudenko, Noam Sagiv**

Virtual Piano Concert (Dr Svetlana Rudenko) and talk (Dr Noam Sagiv), Q& A/ total 45 min?

Consciousness is one of the most fundamental biological processes of the human brain; enabling us to be aware of ourselves, and to explain and communicate thoughts and experiences with others. What if this inner reality is a fantasy? Through our imaginations we can create things we have never experienced before (e.g. creative outputs in music and visual art) and, for some people, their brains habitually create an additional layer of perceptual experiences (e.g. people with synaesthesia who have visual experiences of music). Piano Program:

Chopin Ballad N2 Op. 38 (live)- Cross-modal Associations, 12 min.

Scriabin Op. 57 N1 Désir - 4D visualisation of Musical-Space Synaesthesia, Rudenko/ Dingliana, video, 1 min  
<https://www.youtube.com/watch?v=3oP6itKqhFE>

Scriabin Sonata N5 Op.53 - Synaesthesia Art by Dr Timothy Layden, Visuals by Dr Maura McDonnell, video, 12 min (could be stopped, 5 min.) <https://vimeo.com/337354023>

“Just as perceptual illusions and deficits can tell us much about how the mind works, looking at positive symptoms like synaesthesia, phantoms and hallucinations can also be instructive. It is becoming increasingly clear that synaesthesia may serve as an interesting test case and perhaps a model-problem for the scientific study of consciousness.”(Dr Noam Sagiv, Brunel University, West London, UK)

## **Understanding dementia as a disorder of consciousness**

### **Jonathan Huntley, Dr. Stephen Fleming, Dr. Daniel Bor**

Background: There are currently 50 million people living with dementia globally. Dementia is defined by progressive impairment in cognition, function and a range of behavioral and psychological symptoms. However what is often overlooked from descriptions of dementia are the effects on conscious experience.

People with dementia demonstrate a range of alterations in consciousness. Changes in awareness of cognitive deficit, self-awareness and introspection are seen early in the disorder, and dysfunction of awareness and arousal progresses with increasing disease severity. Impairments of awareness in dementia are associated with neuropathology in regions that overlap with proposed neural correlates of consciousness. However, heterogeneity of deficits between individuals and a lack of empirical studies in people with severe dementia highlight the importance of identifying and applying biomarkers of awareness in dementia.

Aims. The salon aims to bring together researchers to collaborate and discuss how recent developments in consciousness science may provide theoretical frameworks and experimental approaches to help further understand the conscious experience of people with AD. Recognition of AD as a disorder of consciousness is overdue, and important to both understand the lived experience of people with AD and to improve care.

**Non-human consciousness: current paradigms and debates**  
**Henry Shevlin, Cecily Whitely; Heather Browning; Walter Veit**

This discussion salon brings together four researchers all working in the philosophical and scientific study of consciousness in non-human animals and artificial systems with the goal of hosting a friendly and constructive discussion about current approaches and challenges in this exciting and rapidly developing field.

The salon will be structured around a series of opening brief (2-3 minute) opening statements from each of our panelists describing their current research on the topic. This will be followed by a series of five discussion prompts briefly introduced by a panellist in which all attendees are welcome to participate. These are as follows: (i) challenges for the measurement of consciousness in non-humans; (ii) whether consciousness comes in degrees across different organisms and systems; (iii) biopsychism and panpsychism as paradigms in non-human consciousness; (iv) consciousness and suffering in non-humans; and (v) prospects for artificial consciousness.

**Employing Neurophenomenology to the study of consciousness**  
**Aviva Berkovich-Ohana, Ohad Nave, & Mathis Trautwein**

The scientific study of consciousness requires a rigorous examination of conscious experience itself. This call for a systematic investigation of 1st person experience, in circulation with 3rd person neuroscientific research, has been made most emphatically by Francisco Varela within the neurophenomenological research program. Such attempt to build bridges between the irreducible domains of experience and physical reality has shown to produce meaningful scientific results, but on a more general level, aims to provide a remedy for the hard problem of consciousness.

While corresponding methodologies have hence been emerging, the bulk of scientific investigations of consciousness still minimizes or avoids explicit reliance on 1st person experience (i.e. phenomenology). Thus, a more widespread application of 1st person methods, as well as their integration into neurophysiological research, seems more warranted than ever. To push such developments, in the proposed salon, we will discuss varieties of 1st person methodologies, allowing exchange about participants' already existing experiences with and potential future applications of such methodologies.

In the beginning we will provide a theoretical introduction to neurophenomenology, stimulating discussions with participants.

Following, we will introduce a gradient of different 1st person methodologies, varying from "thin" to "thick" attention to phenomenological detail, and highlight different approaches to integrating 1st and 3rd person methods (e.g. through real-time neuroimaging). This will provide a background to dive into discussions about potential research ideas and methodologies which participants might want to pursue and implement in their own field of inquiry.

**Monday, 14 June, 2021, 20:15**

**The promises and challenges of psychedelic therapy  
Ido Hartogsohn, Keren Tzarfaty, Leor Roseman**

The quickly developing field of psychedelic therapy presents exciting opportunities for the field of mental health, as well as new challenges such as the need for integration of dramatic, mind-bending experiences into existing Western mental health systems and discourses. This discussion will address the promises and perils of the psychedelic therapy revolution, stressing their profound dependency on questions of social and cultural context.

**Consciousness exhibited: The stream of Consciousness in Data and Art  
Charlotte Maschke, Mirko Febbo, Stefanie Blain-Moraes**

The consciousness salon “Consciousness exhibited” aims to provide an alternative perspective on neuroscience of consciousness through the artistic depiction of neurophysiological data. We propose to curate an online gallery space dedicated to artists and neuroscientists who would like to share their artistic research about the neuroscience of consciousness. The starting point of the exhibition would be a set of artworks from a collaboration between Mirko Febbo, Charlotte Maschke and Stefanie Blain-Moraes about the visualization and sonification of EEG-based dynamic functional connectivity in altered states of consciousness. After short opening remarks, the participants would have the opportunity to explore a virtual gallery space. We plan to work with the conference organizers to explore the possibility of opening the virtual space for contributions from other conference participants or the wider public. In the second part of the consciousness salon, we would like to organize a panel discussion between neuroscientist and artists. Our aim is to provide a platform for discussions about individual artworks, the exploration process, and the role of computational arts in research on the science of consciousness.

To illustrate our proposition, we have prepared a demo-version of a possible online gallery:

<https://youtu.be/oeWyZN6qPgM>

**Beyond voluntary mental imagery**

**Giulia Cabbai, Dr. Sophie Forster, Carla Dance, Prof. Julia Simner, Prof. Jamie Ward**

The discussion on the role of mental imagery in consciousness has a long tradition in the philosophical and scientific realm. Being a common experience for most of us, many argued that together with perceptual experience, mental images constitute the basic blocks of consciousness (Thomas, 2006). However, the discovery of people with aphantasia (Zeman et al., 2015), who report being unable to generate mental imagery, has challenged this long-lasting view. Interestingly, aphantasics are able to carry out tasks that should involve the use of imagery, such as mental rotation or working memory tasks (Crowder, 2018; Jacobs et al., 2018). Nanay (2021) recently proposed that aphantasics might still use imagery, albeit unconsciously. However, some aphantasics do report experiencing involuntary forms of imagery (eg in dreams).

This Salon will be an open discussion motivated by the aforementioned literature, exploring unconscious and involuntary imagery. We aim to discuss the following questions: can imagery be unconscious? If so, since by definition unconscious imagery cannot be reported, how can we assess whether someone is experiencing it? How can we distinguish unconscious imagery from other unconscious processes (eg expectations)? Finally, how to define involuntary imagery? Are individual differences in voluntary imagery reflected in differences in involuntary imagery?

**Tuesday, 15 June, 2021, 18:30**

**Beyond 'back vs. front': Making progress on the prefrontal debate**

**Matthias Michel, Megan Peters, Brian Odegaard, Liad Mudrik, Michael Pitts, Omri Raccach, Claire Sergent**

Brian Odegaard, Liad Mudrik, Michael Pitts, Omri Raccach, and Claire Sergent take the stage to debate about the role of prefrontal cortex in consciousness, and how real scientific progress can be made in resolving this controversy. What do we know? What *\*don't\** we know? What (if anything) can be definitively concluded from existing empirical evidence, and most importantly, what crucial experiments or predictions remain untested? We sit at a critical juncture in this field, with strong evidence seeming to simultaneously support both a critical role for the prefrontal cortex in the production of consciousness, and its being completely unnecessary -- depending on where you look and who you ask. Each discussant will have just five minutes to present their position, followed by a dynamic discussion and debate -- including the audience! The salon will be moderated by Matthias Michel and Megan Peters, with the goal of revealing the critical points of disagreement and the potential design of new experiments or theoretical critiques that could pave the way towards making progress on this issue.

**Presidential AMA :-)**

**Axel Cleeremans**

This mentoring event, meant to be somewhat personal, can touch on anything that I may have something to say about: Career choices, the history of ASSC, the study of consciousness, the status of unconscious processing, current controversies, replication, open science, or anything else that you want to discuss!

**Growing up in Consciousness Science**

**Steve Fleming**

This Consciousness Salon will be modeled on the successful "Growing up in Science" series that has been initiated by Wei Ji Ma and Cristina Alberini at NYU (<https://www.cns.nyu.edu/events/growingupinscience/>). I will host a conversation with one or two leading researchers in the field of metacognition and consciousness research, aimed to discover their "alternative" CV - the real, unvarnished story of how they got to where they are today. Growing up in Consciousness Science will encourage the speakers to share their life story, with a focus on struggles, failures, doubts, detours, and weaknesses. Common topics include dealing with expectations, confidence, impostor syndrome, procrastination, luck, rejection, conflicts with advisors, and work-life balance. If you have ever wondered what senior researchers in the field struggled with as students, or what they continue to struggle with now, behind the scenes – this event is for you.

The host, Steve Fleming, directs the MetaLab at University College London, and is a former Executive Director of the ASSC. He has received a number of awards for his research on metacognition, and is the author of "Know Thyself: The Science of Self-Awareness".

**Meditative and Phenomenological Research into the Fluidity of the Sense of Self: An Experiential Workshop**  
**Ohad Nave, Stephen Fulder, Aviva Berkovich-Ohana**

The sense of self is familiar and robust as much as it is elusive. As a fundamental aspect structuring our conscious lives, the sense of self can have a direct bearing on how we understand and study consciousness. Recent cognitive neuroscience research converges with centuries-old contemplative traditions to indicate the flexible and highly intricate organization of the self. In this salon, we intend to bring together these different perspectives manifested in our recent neurophenomenological studies focused on meditative self-boundary dissolution. We will first present different phenomenological aspects of the sense of self, highlighting the pre-reflective (or minimal) self - the subjective knower and agent experienced as immediate embodied presence. Then we will invite participants to explore these notions first-hand in meditative sessions guided by Stephen Fulder, a proficient meditation teacher and co-researcher. Based on this shared experience, we will open a phenomenological discussion on the intricacy of the self and establish the potential and necessity of first-person investigation in consciousness research.

**First-person research and principles of open science**  
**Ema Demsar, Aleš Oblak, Camila Valenzuela-Moguillansky**

Empirical research into experience has recently become a recognized part of consciousness science, with studies using first-person methods such as the micro-phenomenological interview and descriptive experience sampling increasingly being published in major scientific journals. This proliferation has been met with concerns regarding the validity and reliability of first-person methods, both from within and without the first-person research community.

Setting aside principled critiques, researchers seem to agree that ensuring scientific rigor of first-person research requires improving the traceability of its methods, and the transparency of the acquired data and results. However, it is unclear how this requirement is to be implemented in research practice and publications. As there is no established format for reporting studies using first-person methods, articles often lack a clear explication of the method; supplementary materials (including raw data, memos, and research logs) are absent; if presented, first-person descriptions tend to be cherry picked; etc. These issues hinder replicability and often leave no choice but to trust the authority of the researchers and/or the proponents of the method.

This Consciousness Salon aims at an open discussion on how to apply principles of open science to improve the scientific rigor, transparency, and replicability of studies using first-person methods.

**Formal approaches to emergence - current perspectives & possible applications**  
**Nadine Spsychala, Adam Barrett, Pedro Mediano, Anil Seth, Fernando Rosas, Daniel Bor**

The scientific discourse on consciousness and the mind-body relationship often gravitates around the concept of emergence -- loosely understood as the process by which an entity exhibits a property that its parts do not have on their own. Although philosophical work on emergence stretches far back in time, mathematical work to formalise it has a relatively recent history. The next step is to devise ways in which mathematical operationalisations of emergence could be applied to experimental (neuroimaging) data, and to consider how this may inform the neural underpinnings of consciousness.

In this salon, we invite all researchers interested in the broad topic of emergence to join us for a discussion on current theories on emergence, and how we can advance them closer to an experimental setup. Possible discussion points include:

- What do we mean exactly when we make statements like “mind emerges from matter”?
- Can we conceive of aspects of consciousness that are *\*not\** emergent?
- What are the requirements for a theory of emergence to be applicable to empirical data?
- How is emergence different from complexity? Is every emergent system complex, and vice versa?
- What are possible hypotheses about emergence in terms of content & level of consciousness?

**Researcher's introspection as a tool in the scientific study of consciousness - the good, the bad and the ugly**  
**Rotem Krispil, Gal Vishne**

The relationship between introspection and the scientific study of consciousness has resembled for decades the one between family members who enjoy complaining about one another: ever changing, tense, yet inseparable. Introspection has been, and still is, a part of the scientific study of consciousness, and cognitive neuroscience at large, in many forms. Some more obvious, like the use of subjective reports as data, the study of access of stimuli into conscious perception, the study of meditators and meditation, and so on. On the other hand, other forms of introspection are less spoken of. One such form is the use of introspection as part of the scientific work itself: the use of scientists' subjective experience to generate hypotheses, to make sense of data, interpret results, or design experimental paradigms. As the opinions surrounding introspection, its reliability, and its contents, are still highly varied, the use of introspection as a part of our scientific work should be discussed. We propose to host a discussion regarding the place this type of introspection holds in our field of research today, and the place it should hold in the future. Should it be used? Can it be avoided? Should it be used differently?

**Thursday, 17 June, 2021, 18:30**

**Ontology for the mind sciences**

**Patrick Haggard, Liad Mudrik**

Branches of knowledge generally define their objects of interest: biology studies living things, topology studies geometric transformations etc. These definitions implicitly involve both an ontological commitment (the biologist holds that some living things exist, for example), and an epistemological or evidential commitment (the biologist must have some way of knowing that living things exist). What are the objects of interest in psychology? Are they conscious states, behaviours, cognitive processes that produce behaviour, or people? And what evidence is there that these entities cannot simply be eliminated in favour of something else? What kinds of evidence can be used to identify mental entities; are some classes of evidence superior to others? Does subjective experience have special status in establishing psycho-ontology? What can we learn from the case histories of mental states and processes that now seem superfluous, such as 'conation', 'apperception' etc? Why are ontological discussions largely absent from mind sciences? This salon will begin with very brief introductory remarks from a small number of panelists, but open out into a wide-ranging discussion about the concepts we need for the research programs of consciousness science. We believe that broad conversation about the ontological underpinnings can help to advance our science.

**ERC starting grants: tips from previous grantees**

**Nathan Faivre, Simon van Gaal, Aaron Schurger, Roy Salomon**

The European Research Council provides generous support for ambitious projects in all fields of science and humanities. As the scientific study of consciousness is still perceived as marginal in some circles, writing a compelling proposal may be challenging. In this Salon, previous grantees will provide tips on how to write an ERC starting grant on consciousness, share their experience as project leaders, and answer questions from the audience.

**Getting real: more ecological approaches to the study of consciousness**

**Rony Hirschhorn, Itay Yaron, Uri Korisky**

The field of consciousness research has matured substantially in recent decades. A wide arsenal of methods was developed to provide answers to core questions about the functions, scope, and neural substrates of conscious processing. Yet, in most of these paradigms, the manipulations are often based on non-ecological methods that do not mimic real-life conscious and unconscious processes. Consequently, it remains unclear whether findings gathered in tailor-made artificial settings can be generalized to real-life scenarios. In this Salon, we aim to explore the latest developments towards a more ecological consciousness research in the following manner: (1) review the current state of the field, discussing the novel and promising attempts within the field, as well as advancements in other research areas (e.g., attention, working memory, or social cognition); (2) introduce main challenges for ecological consciousness experiments ; (3) briefly present methods by the salon's attendees; and (4) discuss the presented solutions and current state of the field in general, as well as the importance and feasibility of this quest.



### **Using Bayes factors to obtain reliable evidence of unawareness**

**Mateo Leganes-Fonteneau, Ryan Scott**

Knowing whether someone is performing a task consciously or is solely guided by unconscious influences is essential for consciousness research. Existing approaches for achieving this have limitations, making them severely error-prone. This is mainly due to the use of null-hypothesis significance testing to determine awareness states and the occurrence of regression to the mean effects in post-hoc categorizations.

Using Bayes factors, we have developed a new methodology to obtain reliable evidence for the absence of awareness, and this technique can also be resistant to regression to the mean effects.

With this methodology we've been able to verify the existence of implicit Pavlovian conditioning in multiple instances. We think the next step is to apply this method to past and future research on implicit processing, revisiting past experiments and improving future data analyses.

The aim of this salon is to showcase this technique, make a quick tutorial on how to use it and engage in possible collaborations with those interested in improving the measurement of implicit processes.

1. Leganes-Fonteneau, M., Scott, R., Duka, T., & Dienes, Z. (2021). Avoiding pitfalls: Bayes factors can be a reliable tool for post hoc data selection in implicit learning. *Psychonomic Bulletin & Review*, 1-12.

### **Goals for the field of visual metacognition**

**Dobromir Rahnev, Lucie Charles**

Recently, 26 researchers reached consensus on 4 long-term and 2 medium-term goals for the field of visual metacognition (a preprint on the goals is available at <https://psyarxiv.com/z8v5x>). The final goals broadly concern developing computational models, manipulations of confidence/metacognition, expanding research to more complex tasks, and determining the relationship between metacognition and consciousness. The aim of this Consciousness Salon is to engage the wider community in a discussion of these goals, as well as on how progress towards accomplishing them can be best tracked and assessed. We plan for a short, informal presentation (<10 minutes) on the goals, followed up by an open discussion.

**Thursday, 17 June, 2021, 19:00**

**Control theory - a computational framework for enactivist models of consciousness**

**Nadav Amir**

Current theoretical accounts of consciousness, such as the Neuronal Global Workspace or the Integrated Information Theory, attempt to explain consciousness in terms of specific structural or activation patterns in networks of interconnected neurons or neuronal-like elements.

Such theories view consciousness as an internal property of isolated, biological or artificial networks, and consequently have relied primarily on artificial neural network or graph theoretic approaches as the suitable computational tools for modeling consciousness.

An alternative view stems from the enactivist approach which posits that consciousness cannot be fully reduced to any internal brain process or network feature, but rather can be properly understood only in the context of a dynamic cycle of perception and action between an embodied agent and the particular environment she is situated in.

In this salon, I wish to show that control theory, a branch of dynamical-systems theory dealing with the ability of agents to observe (perceive) and control (act on) a given system (environment), provides a promising computational language for enactivist modes of consciousness. Primarily applied today in engineering and robotics, control theory has also strongly influenced prevalent computational models of learning and cognitive function such as reinforcement learning, predictive processing and active inference.

## **Concurrent Talks**

**Tuesday 15.6.21**

### **Agency/Volition**

Moderator: Emilie Caspar

	Title	Authors
19:30	Investigation of the relationship between breathing motor adaptation and its sense of agency: a combined physiological and Virtual Reality study.	Sophie Betka, Florent Jeanpetit, Claire Meuwly, Sunho Lee, Oliver Kannape, Florian Lance, Sixto Alcoba, Olaf Blanke
19:40	The effect of military training on the sense of agency and outcome processing	Emilie A. Caspar, Salvatore Lo Bue, Pedro A. Magalhães De Saldanha da Gama, Patrick Haggard, & Axel Cleeremans
19:50	Neural Synchrony modulates Sense of Agency during Joint Action	Nicolas Coucke, Nicolas Bourguignon, Salvatore Lo Bue, Axel Cleeremans, Emilie Caspar
20:00	Temporal Binding in Multi-Step Action-Event Sequences	Felicitas V. Muth, Robert Wirth, Wilfried Kunde
20:10	Surely It wasn't me: The Sense of Agency and Metacognition in Healthy and Psychosis Patients	Amit Regev Krugwasser, Yoni Stern, Eiran V. Harel, Roy Salomon
20:20	Machine learning approach to study kinematic aspects of Sense of Agency	Asaf Applebaum, Amit Regev Krugwasser, Yonatan Stern, Roy Salomon
20:30	Can we use introspective reports of intention and movement to diagnose psychopathology?	Tomáš Dominik, Roman Procházka
20:40	A psychometric approach to implicit sense of agency: Unrelatedness of interval estimation and the Libet clock	Markus Siebertz, Petra Jansen

**Altered states: meditation & hypnosis**

Moderator: Zoltan Dienes

	Title	Authors
19:30	A Simple Model of Attentional Blink	Nadav Amir, Naftali Tishby, Israel Nelken
19:40	Sleeping brain dynamics: a window to study meditation effects on consciousness	Dr Bindu M. Kutty
19:50	Consciousness from Yoga perspective	Dr. Ramajayam Govindaraj, Dr Arun Sasidharan, Dr Ravindra P. N., Dr Bindu M. Kutty
20:00	On Pure Consciousness of Autopoietic Machines	Julio Alcántara
20:10	A theoretical approach to develop a working model to understand cognition and consciousness by integrating Ancient Indian knowledge system and Affective Neuroscience.	Dr. Ravindra P. N., Dr Ramajayam G., Dr Arun Sasidharan, Dr Bindu M. Kutty
20:20	Evidence synthesis indicates contentless experiences in meditation are neither truly contentless nor identical	Toby Woods, Olivia Carter, Jennifer Windt
20:30	Modulation of Hypnotizability Using Repetitive Transcranial Magnetic Stimulation: A Randomized Control Trial	Afik Faerman, M.S., James H. Bishop, Ph.D., Katy H. Stimpson, M.S., Angela Phillips, Ph.D., Booil Jo, Ph.D., Merve Gülser, B.S., Heer Amin, B.S., Danielle DeSouza, Ph.D., Romina Nejad, M.S., Nolan R. Williams, M.D., David Spiegel, M.D.
20:40	Beyond imagination: Hypnotic visual hallucination induces greater lateralised brain activity than visual imagery	Renzo Lanfranco, Alvaro Rivera-Rei, David Huepe, Agustín Ibañez, Andrés Canales-Johnson
20:50	Some perceptual illusions may be created by phenomenological control	Peter Lush, Ryan B. Scott, Anil K. Seth, Zoltan Dienes

### **Self & Psychedelics**

Moderator: Roy Salomon

	Title	Authors
19:30	UnReal? The psychophysics of the Sense of Reality	Gadi Drori, Paz Bar-Tal, Yair Zvilichovsky, Yoni Stern, Roy Salomon
19:40	I overthink—therefore I am not: Altered Sense of Self in Depersonalisation Disorder	Anna Ciaunica, Casper Hesp, Jakub Limanowski, Anil Seth, Karl Friston
19:50	Self-boundary dissolution: a phenomenological investigation	Ohad Nave, Fynn-Mathis Trautwein, Aviva Berkovich-Ohana
20:00	Meditation-induced flexibility in networks supporting the embodied-self: A neurophenomenological MEG study	Yoav Schweitzer, Fynn-Mathis Trautwein, Yair Dor-Ziderman, Ohad Nave, Stephen Fulder, Yochai Ataria & Aviva Berkovich-Ohana
20:10	Neural correlates of the DMT experience determined via simultaneous fMRI and EEG	Christopher Timmermann, Leor Roseman, Fernando Rosas, Lisa Luan, Hannes Kettner, Sharad Haridas, David Erritzoe, Enzo Tagliazucchi, Carla Pallavacini, David Nutt, Robin Carhart-Harris
20:20	Drivers of high entropy states in Schizophrenia and Psychedelics	Hardik Rajpal, Pedro Mediano, Fernando Rosas, Chris Timmermann, Stefan Brugger, Robin Carhart-Harris, Henrik Jeldtoft Jensen
20:30	REBUS and/or/as SEBUS: Both Strengthened and Relaxed Beliefs Under Psychedelics	Adam Safron
20:40	Agency and Body Ownership across typical, psychedelic and psychotic populations	Gabriella Panishev, Amir Harduf, Roy Salomon
20:50	The entropic heart: effects of psychedelics on cardiac activity	Fernando Rosas, Pedro Mediano, Christopher Timmermann, Malin Uthaug, Andrea Luppi, Sarah Garfinkel, Daniel Bor, Robin Carhart-Harris

### **Bodily Consciousness**

Moderator: Nava Levit-Binnun

	Title	Authors
19:30	Physiologically implausible warmth, but not cold, suppresses the feeling of limb ownership in the somatic rubber hand illusion	Dominika Radziun, Laura Crucianelli, Henrik Ehrsson
19:40	The Effects of Supraliminal vs. Subliminal Mood Induction on the Rubber Hand Illusion and the Role of Dissociative Symptoms	Franziska A. Schroter, Bianca A. Günther, Petra Jansen
19:50	Perception of one's own body within an immersive realistic environment enhances accuracy and re-experiencing during memory retrieval	Heather Iriye, H. Henrik Ehrsson
20:00	Body representations in self-referential related brain regions	Inbal Linchevski, Noa Zeharia, Or Yizhar, Keinan Poradosu, Yulia Golland, Amir Amedi, Nava Levit-Binnun
20:10	Complex-structured tactile signals override visuo-proprioceptive divergence in the rubber hand illusion	Piotr Litwin, Paweł Motyka
20:20	3D LIVE Streaming Full-body Illusions: a new perspective on Bodily Self-Consciousness	Debbie M.L. de Boer, Patrick J. Johnston, Graham Kerr, Marcus Meinzer, Axel Cleeremans
20:30	Affective touch and the rubber hand illusion – a meta-analysis	Jesper Anell, Andreas Kalckert
20:40	Experiencing the self through touch	Rebecca Boehme
20:50	Uncertainty-based inference of a common cause for body ownership	Marie Chancel, Weiji Ma, H. Henrik Ehrsson

### **Meta-cognition I**

Moderator: Nathan Faivre

	Title	Authors
19:30	Metacognitive bias and optimal criteria for confidence judgments	Lucie Charles, Brian Maniscalco
19:40	Dissociation between objective and subjective judgments in uncertain environments	Clémence Compain, Anil K. Seth, Maxine Sherman
19:50	Variance misperception under skewed empirical noise statistics explains overconfidence in the visual periphery	Charles J. Winter, Megan A. K. Peters
20:00	Effects of expected task difficulty on metacognitive confidence and multitasking	Maxine T. Sherman, Anil K. Seth
20:10	Influence of monitoring motor performance on metacognitive control of behaviour	Polina Arbuzova, Elisa Filevich
20:20	Functional and cortical morphometric basis of metacognitive introspection in Old World monkeys (Macaca mulatta)	Yudian Cai, Zhiyong Jin, Sze Chai Kwok
20:30	Context-induced modification of the reliance on internal or external information when forming metacognitive judgments	Stephan Goerttler, Gaia Corlazzoli, Nicolas Coucke, Axel Cleeremans, Wim Gevers
20:40	Controlling (for) first-order task performance in studies on metacognition: cons & cons	Borysław Paulewicz, Marta Siedlecka
20:50	Metacognitive training: the devil is in the confidence scale	Martin Rouy*, Vincent de Gardelle, Gabriel Reyes, Jérôme Sackur, Jean Christophe Vergnaud, Elisa Filevich*, Nathan Faivre*

### **Meta-cognition II**

Moderator: Stephen Fleming

	Title	Authors
19:30	Enhanced metacognition for unexpected action outcomes	Daniel Yon
19:40	A psychophysiological marker of the metacognitive component of conscious representation	Monika Derda, Michał Wierchoń
19:50	Social cognitive ability influences the strategy used for judging others' awareness.	Branden J. Bio, Michael S. A. Graziano
20:00	Using a higher-order state space model to interrogate the dynamics of awareness reports	Cormac Dickson, Steve Fleming
20:10	The domain generality in the usage of confidence scale	Xiao Hu, Liang Luo
20:20	Brain connectivity profiles associated with perceptual task performance	Johan Nakuci, Jiwon Yeon, Ji-Hyun Kim, Sung-Phil Kim, Dobromir Rahnev
20:30	Difficulty in an incidental decision disrupts instrumental learning	Nura Sidarus, Martina Kavanova, Adrien Kerebel, Vincent Valton, Jonathan Roiser

### **Computational & theoretical models of consciousness**

Moderator: Yair Pinto

	Title	Authors
19:30	An Artificial Neural Network Agent Trained to Control Endogenous Visuo-spatial Attention: Support for the Attention Schema Theory	Isaac R. Christian, Andrew I. Wilterson, Michael S. A. Graziano
19:40	Computational theories of consciousness are incompatible with rationalism	Yair Pinto
19:50	Could a digitally simulated agent have conscious experiences, and could we know this?	Owen Holland
20:00	The First-Person Perspective is Not a Defining Feature of Consciousness	Dylan Ludwig
20:10	How do we define consciousness over extended timescales from perception to evolution?	Lachlan Kent, George Van Doorn, Britt Klein
20:20	The First Prior - from Co-Embodiment to Co-Homeostasis in Early Life	Anna Ciaunica, Axel Constant, Hubert Preissl, Katerina Fotopoulou
20:30	Time and the search for physical properties of consciousness	John Sanfey
20:40	The Yogic Theory of Mind and Consciousness	Vaibhav Tripathi, Pallavi Bharadwaj

### **NCC: states**

Moderator: Athena Demertzi

	Title	Authors
19:30	Brain's reconfiguration to anesthesia predicts recovery of consciousness in unresponsive patients	Catherine Duclos, Yacine Mahdid, Charlotte Maschke, Danielle Nadin, Alexander Rokos, Caroline Arbour, Mohamed Badawy, Justin Létourneau, Adrian M. Owen, Gilles Plourde, Stefanie Blain-Moraes
19:40	Dimensionality reduction of EEG during exposure to propofol has prognostic value for unresponsive patients	Charlotte Maschke, Catherine Duclos, George A. Mashour, Stefanie Blain-Moraes
19:50	A dissociation between conscious state and EEG oscillations in Angelman syndrome	Joel Frohlich, Lynne M. Bird, Joerg F. Hipp, Catherine Chu, Martin M. Monti
20:00	Human sleep impairs top-down auditory processing despite extensive spiking responses: an intracranial iEEG/LFP/single-unit study	Hanna Hayat, Amit Marmelshtein, Aaron J. Krom, Yaniv Sela, Ariel Tankus, Ido Strauss, Firas Fahoum, Itzhak Fried, Yuval Nir
20:10	Isolating Abstract Awareness States: Probing the Neural Encoding of Levels of Subjective Experience Across Stimuli	Benjy Barnett, Lau Andersen, Stephen Fleming, Nadine Dijkstra
20:20	Anodal tDCS over the left DLPFC unable to modulate mind-wandering propensity or underlying dynamic functional connectivity	Sean Coulborn, Davinia Fernández-Espejo
20:30	Mind Blanking is Associated with Rigid Spatio-Temporal Brain Configurations in Typical Wakefulness	Sepehr Mortaheb, Manousos A. Klados, Laurens Van Calster, Paradeisios Alexandros Boulakis, Kleio Georgoula, Steve Majerus, and Athena Demertzi
20:40	Neural Representation of the Relational Self from Infancy to Adulthood	Adi Ulmer Yaniv, Shani Waidergoren, Ariel Shaked, Roy Salomon, Ruth Feldman
20:50	Deviation from criticality in disorders of consciousness and its restoration with anesthesia	Catherine Duclos, Hyoungkyu Kim, George A. Mashour, Uncheol Lee, Stefanie Blain-Moraes



### **Perceptual consciousness**

Moderator: Claire Sergent

	Title	Authors
19:30	motor possibilities and expectations about depth interact in promoting real objects' conscious detection	Uri Korisky, Yael Solar-Priel, Niv Cohen, Mor Farjun, Noa Kaner, Liad Mudrik
19:40	Influence of affective valence on perceptual filling-in	Nils Kraus, Guido Hesselmann
19:50	Neural signatures of consciousness can be reactivated retrospectively.	François Stockart, Elisa Mossé, Claire Sergent
20:00	A blast from the past: Bistable perception alternates between internal and external modes of sensory processing.	Veith Weinhhammer, Meera Chikermane, Philipp Sterzer
20:10	Noradrenergic activity modulates effect of spatial predictions on visual perception	Stijn Nuiten, Jan-Willem de Gee, Johannes Fahrenfort, Simon van Gaal
20:20	Pupil dilation modulations in response to different degrees of visual awareness and different threatening body signals	Marta Poyo Solanas, Minye Zhan, Beatrice de Gelder.
20:30	Retrospective Behavioral Sampling: A dynamic sampling approach to contents of perceptual and memory awareness	Talia Brandman, Rafael Malach, Erez Simony
20:40	A neural signature of conscious perception using auditory thresholds in patients with disorders of consciousness	Martina Corazzol, Mélanie Valente, Fabien Perrin, Jacques Luauté, Lionel Naccache, Claire Sergent

### **Reality & Consciousness**

Moderator: Anil Seth

	Title	Authors
19:30	Where is my voice from? Spatial judgment of self- and other-voice	Wen Wen, Yuta Okon, Atsushi Yamashita, and Hajime Asama
19:40	Modelling Pathological and Psychedelic Visual Hallucinations using Deep Neural Networks	Keisuke Suzuki, David J. Schwartzman, Anil K. Seth
19:50	Posterior parietal cortex neurons distinguish memorized past from what is perceived as reality	Yunxuan Zheng, Yile Jin, Lei Wang, Leyu Huang, Shaomin Zhang, Hakwan Lau, Sze Chai Kwok
20:00	UnReal? A cognitive approach to modeling the subjective Sense of Reality	Paz Bar-Tal, Gadi Drori, Yair Zvilichovsky, Roy Salomon
20:10	Evidence for perceptual insight in a virtual psychophysics experiment	Marianne Broeker, Andra Mihali, Guillermo Horga
20:20	The Power of Uniqueness: Sham Treatment Personalisation Affects Pain Perception	Dasha A. Sandra, Jay A. Olson, Mathieu Roy
20:30	Assessing awareness in severe dementia: A feasibility and pilot study.	Dr Jonathan Huntley, Dr Daniel Bor, Prof Adrian Owen, Prof Robert Howard, , Dr Lorina Naci, Dr Lorenzo Rocci, Dr Stephen Fleming

### **Unconscious processing**

Moderator: Guido Hesselmann

	Title	Authors
19:30	Threat extinction without awareness: evidence from masking and continuous flash suppression	Shani Bachar-Avnieli, Liad Mudrik, Daniela Shchiller, Gideon E. Anholt
19:40	Concurrent implicit learning of multiple visual sequences	M. Sc. Sarah Wilts, Prof. Dr. Hilde Haider
19:50	Informative neural representations of unseen objects during higher-order processing in human brains and deep artificial networks	Ning Mei, Roberto Santana, David Soto
20:00	Stimuli Presented on the Fringe of Awareness Evade Proactive Interference	Alberto Aviles, Howard Bowman
20:10	Tracking contingency unconsciously	Shao-Min (Sean) Hung, Daw-An Wu, Shinsuke Shimojo
20:20	Unconscious processing and regression to the mean: an attempt to improve common practices	Itay Yaron, Yoav Zeevi, Uri Korisky, William Marshall, Liad Mudrik
20:30	A new test for conscious and non-conscious perception in animals: evidence from rhesus monkeys	Moshe Shay Ben-Haim, Olga Dal Monte, Nicholas A. Fagan, Yarrow Dunham, Ran R. Hassin, Steve W. C. Chang, Laurie R. Santos
20:40	Spatial uncertainty does not boost unconscious processing under CFS	Fenja Benthien, Guido Hesselmann

### **The science of consciousness**

Moderator: Matthias Michel

	Title	Authors
19:30	Why do some scientists say they study consciousness	Matan Mazor
19:40	Consciousness Science Without Metaphysics? Yes, Please.	Will Bridewell, Alistair Isaac
19:50	The problem of epistemic indirectness in consciousness science	Ali Yasar
20:00	A mechanistic perspective on the harder problem of consciousness	Andy Mckilliam
20:10	What memory is for	Helge Malmgren
20:20	Perceptual consciousness and moral worth are strongly coupled	Matan Mazor, Arianna Risoli, Anna Eberhardt, Stephen M. Fleming

## **Wednesday 16.6.21**

### **Agency/Volition**

Moderator: Uri Maoz

	Title	Authors
19:30	The Dynamic Self: Serial-dependence effects in embodied sense of agency	Yoni Stern, Inbar Ben-Yehuda, Adam Zaidel, Roy Salomon
19:40	Predictive attenuation of touch and tactile gating are distinct perceptual phenomena	Konstantina Kiltani, Henrik Ehrsson
19:50	Are judgments of agency metacognitive?	Marika Constant, Roy Salomon, Elisa Filevich
20:00	Slow ramping in spiking neurons; a LIF network model of spontaneous actions	Jake Gavenas, Ueli Rutishauser, Aaron Schurger, Uri Maoz
20:10	What is the feeling of effort about?	Juan Pablo Bermúdez
20:20	How Hypnosis Experiments Question the Plausibility of Counterfactualist Mental Causation	Ben Whittington
20:30	Anomalous Self- and World-Experiences in Depersonalisation Traits - a Qualitative Study	Anna Ciaunica, Elisabeth Pienkos, Estelle Nakul, Luis Madeira, Harry Farmer
20:40	Reverse Choice Blindness: People reject what they want when making an error in getting it.	Gabriel Vogel, Lars Hall, Peter Johansson
20:50	Reflectivity as part of an Evolutionary Scenario for Self-Consciousness. Impact on Pre-Reflective Self-Consciousness	Christophe Menant

### **Altered states: sleep & disorders of consciousness**

Moderator: Thomas Andrillon

	Title	Authors
19:30	The brain bases of responsiveness variability under moderate anaesthesia	Feng Deng, Nicola Taylor, Adrian M. Owen, Rhodri Cusack, Lorina Naci
19:40	Predicting lapses of attention with sleep-like slow waves	Thomas Andrillon, Angus Burns, Teigane MacKay, Jennifer Windt & Naotsugu Tsuchiya
19:50	The Dynamics of Affect Across the Wake-Sleep Cycle: From Waking Mind-Wandering to Night-Time Dreaming	Pilleriin Sikka, Katja Valli, Antti Revonsuo, Jarno Tuominen
20:00	Dreams, Sleep and Emotions: Survey findings during Covid-19 pandemic	Dr. Gulshan Kumar, Dr. Ravi Yadav, Dr. Ravindra P. N., Dr. Bindu M. Kutty
20:10	Depression as a Global State of Consciousness	Cecily M K Whiteley
20:20	Cortical Function in Acute Severe Traumatic Brain Injury and at Recovery: A Longitudinal fMRI Case Study	Karnig Kazazian, Loretta Norton, Teneille Gofton, Derek Debicki, Adrian M. Owen
20:30	Brain Glucose Hypo-metabolism in Patients with Disorders of Consciousness: A Meta-analysis	Baris Kaan Ok, Arianna Sala, Jitka Annen, Aurore Thibaut, Steven Laureys
20:40	Interpreting neural measures of consciousness in disorders of consciousness: a role for a comparative, inductive approach?	Jasmine Walter

### Interoception

Moderator: Nava Levit-Binnun

	Title	Authors
19:30	The prognostic value of heart-evoked potentials in acute unresponsive patients	Leah Banellis, Damian Cruse
19:40	Past and Future Explanations for Depersonalisation and Derealisation Disorder; A Role For Predictive Coding.	Andrew Gatus, Graham Jamieson (Supervisor), Bruce Stevenson (Co-supervisor)
19:50	Steady-state evoked potentials differentiate between exteroceptive and interoceptive attention	L Kritzman, M Eidelman-Rothman, D Freche, A Keil, G Sheppes, N Levit-Binnun
20:00	Cardiac attribution to oneself is modulated by synchronous heartbeat biofeedback	Paradeisios Alexandros Boulakis, Federico Raimondo, Sepehr Mortaheb, Lionel Naccache, Athena Demertzi
20:10	Frontal midline theta neurofeedback training as a potential intervention for adolescent depression	Suma Bhaskar, Dr Ravindra P. N., Dr Arun Sasidharan, Dr Ramajayam G., Dr Bindu M. Kutty
20:20	Interoceptive sentience as the affective, ubiquitous, homeostatic and most basic form of consciousness.	Ignacio Cea, David Martinez-Pernia
20:30	Mind body coherence	Hannah Biddell
20:40	Interoceptive Attention to Bodily Sensations in Mindfulness	Dar, Omer*; Hadash, Yuval; Veksler, Tanya; Oren-Schwartz, Romi; Levy-Kornbluth, Ma'ayan; Amir, Iftach; Goldstein, Pavel; Bernstein, Amit
20:50	The Effects of mindfulness practice on the association between autonomic interoceptive signals and emotion regulation selection	Ziv Ardi, Yulia Golland, Roni Shafir, Gal Sheppes, Nava Levit-Binnun

### **NCC & bodily consciousness**

Moderator: Nathan Faivre

	Title	Authors
19:30	How the bodily self-interacts with the remembered self: Episodic autobiographical memory for virtual scenes is modulated by different levels of bodily self-consciousness during encoding	N.H. Meyer ,B. Gauthier, E. Franc, F. Lance, J. Potheegadoo, O. Blanke
19:40	Onset times of the referral-of-touch and ownership sensation in the rubber hand illusion	Anantha Krishna Sivasubramaniam, Rachel Pye, Andreas Kalckert
19:50	Differences in cortical working memory coding of biological motion of oneself and others	Mateusz Woźniak, Timo Torsten Schmidt, Yuan-hao Wu, Felix Blankenburg, Jakob Hohwy
20:00	Neurophenomenology of Simple Sensory Experience: An fNIRS Study	Asger Lakkenborg, Esben Kran, Rebekah Baglini, Andreas Roepstorff, Daina Crafa
20:10	Subcortical neuronal correlates of perceptual consciousness	Michael Pereira, Nathan Faivre, Fosco Bernasconi, Jacob Suffridge, Shuo Wang, Victor Finomore, Nicholas Brandmeir, Ali Rezai, Olaf Blanke
20:20	Structural constraints on NCCs	Sascha Benjamin Fink, Holger Lyre, Lukas Kob
20:30	Lempel-Ziv complexity changes across states of consciousness are dominated by spectral effects	Fernando Rosas, Adam Barrett, Daniel Bor
20:40	What could patients teach us about the limits of cognitive-motor dissociation?	Perrine Séguin, Emmanuel Maby, Fabien Perrin, Alessandro Farnè, Jérémie Mattout
20:50	Self-perception under existential threat in mindfulness meditators	Yair Dor-Ziderman, Antoine Lutz, Avi Goldstein, Aviva Berkovich-Ohana

### **Meta-cognition III**

Moderator: Dobromir Rahnev

	Title	Authors
19:30	The role of metacognition in monitoring performance and regulating learning in early readers	Ioanna Taouki, Marie Lallier, David Soto
19:40	The Simultaneous Encoding/ Serial Experience theory of the Perceptual Moment: a Blink of (Meta)-Experience	Howard Bowman, William Jones, Hannah Pincham, Steve Fleming, Axel Cleeremans and Murray Smith
19:50	Do we rely on the outcome of our movements to know how we just moved?	Charalampiki Angeliki, Filevich Elisa
20:00	Dopaminergic modulation of reversal-learning and associated confidence in Parkinson's disease and heroin addiction	Vanessa Fleury, Damien Benis, Astrid Kibleur, Daniele Zullino, Paul Krack, Nathan Faivre
20:10	Zero-shot search termination reveals a dissociation between implicit and explicit metacognitive knowledge	Matan Mazor, Stephen M. Fleming
20:20	"Metacogmission": measuring metacognition across the lifespan and over two cognitive domains via an engaging gamified task	Andrew McWilliams, Hannah Bibby, Nikolaus Steinbeis, Stephen M. Fleming
20:30	Where does metacognitive inefficiency come from?	Dobromir Rahnev, Medha Shekhar
20:40	Evaluating type 1 error rates of traditional and hierarchical measures of metacognitive accuracy	Manuel Rausch, Michael Zehetleitner
20:50	How do humans give confidence? Comparing 12 popular process models	Medha Shekhar, Dobromir Rahnev

### **Models of consciousness**

Moderator: Adam Safron

	Title	Authors
19:30	An academic survey on theoretical foundations, common assumptions and the current state of the field of consciousness science	Jolien C. Francken, Lola Beerendonk, Dylan Molenaar, Johannes J. Fahrenfort, Julian D. Kiverstein, Anil K. Seth, Simon van Gaal
19:40	An Integrated World Modeling Theory for Consciousness	Adam Safron, PhD
19:50	The Consciousness Theories Studies (ConTraSt) database: analyzing and comparing empirical studies of consciousness theories	Itay Yaron, Lucia Melloni, Michael Pitts, Liad Mudrik
20:00	Falsification and Consciousness	Johannes Kleiner, Erik Hoel
20:10	"Demystified" consciousness? Not so fast.	Łukasz Kurowski
20:20	The Exclusion Axiom of Integrated Information Theory of Consciousness	Nithin Nagaraj
20:30	Why consciousness isn't even epiphenomenal	Thomas W. Clark
20:40	What do illusionists mean when they talk about 'what-it-is-likeness' of conscious experience?	Krzysztof Dolega
20:50	Implicit-Explicit Gradient of Consciousness as Such	Zoran Josipovic

### **NCC**

Moderator: Raphael Malach

	Title	Authors
19:30	NCC, P3b, and No-Report Paradigms	Yen-Kuan Chen, Tony Cheng, Chen-Wei Wu, Po-Jang Hsieh
19:40	Electrophysiological correlates of awareness and task relevance in an inattentional deafness paradigm	Torge Dellert, Insa Schlossmacher, Maximilian Bruchmann, Thomas Straube
19:50	Evidence for an active role of inferior frontal cortex in conscious experience	Veith Weilhhammer, Merve Fritsch, Meera Chikermane, Anna-Lena Eckert, Katharina Kanthak, Heiner Stuke, Jakob Kaminski, Philipp Sterzer
20:00	Empirical investigations of the higher-order state space framework.	Oliver Warrington, Nadine Dijkstra, Stephen Fleming
20:10	Directed information dissociates perceiving from reporting during visual bistability	Andres Canales-Johnson, Lola Beerendonk, Robin A.A. Ince, Simon van Gaal
20:20	A no-report paradigm reveals that face cells multiplex consciously perceived and suppressed stimuli	Janis Karan Hesse, Doris Ying Tsao
20:30	The onset of subjective visual experience emerges within the P2/N2 range - evidence from a direct behavioral approach in combination with EEG.	Renate Rutiku, Klaus-Peeter Ladva, Michał Wierzchoń, Talis Bachmann, Chen Song
20:40	Does the Prefrontal Cortex Play an Essential Role in Consciousness? Insights from Intracranial Electrical Stimulation of the Human Brain	Omri Raccach, Ned Block, Kieran C.R. Fox
20:50	Population activity structure rather than response magnitude underlies perceptual stability in the human brain	Rotem Broday-Dvir, Yitzhak Norman, Rafael Malach

### Phenomenal/Access

Moderator: Simon van Gaal

	Title	Authors
19:30	Pupil dilation increases when participants report familiarity for images of faces they have not seen before	Kirsten Ziman, Jeremy R. Manning
19:40	Top-down and Bottom-up Interaction as a Behavioural Marker of Access Consciousness	Zefan Zheng, Shuyue Huang, Yongchun Cai
19:50	Iggy and Ziggy on consciousness. Reconsidering Chalmers' hard, easy, and meta-problems of consciousness	Tobias Schlicht
20:00	Studying P-without-A experimentally: a novel paradigm for isolating phenomenal and access consciousness.	Yoni amir, Yaniv Assaf, Yossi Yovel, Liad Mudrik
20:10	Contending with unconscious phenomenality	Michal Polák
20:20	Draw the line - using temporal experience tracing to capturing subjective experience states	Barbara Jachs, Tristan Bekinschtein, Manuel Camino Garcia

### Perceptual consciousness II

Moderator: Johannes Fahrenfort

	Title	Authors
19:30	Attention modulates information format and information content of intracortical auditory predictions.	Tara Tahseen, Simon Houtman, Laura Imperatori, Alejandro Blenkmann, Robin Ince, Tristan Bekinschtein, Andres Canales-Johnson
19:40	Retro-perception at a cocktail party: can retrospective attention bring to consciousness words that were initially ignored during dichotic listening?	Axel Garnier-Allain, Daniel Pressnitzer, Claire Sergent
19:50	Dissociating conscious perception from decision	N. Sanchez-Fuenzalida, S. van Gaal, S. Fleming, J.M. Haaf, J.J. Fahrenfort
20:00	Maladaptive Perceptual Consciousness in Chronic Pain	Dr Vrinda M, Dr Geetha Desai, Dr Bindu M Kutty
20:10	Young children's subjective and objective thresholds of visual consciousness using a backward masking task	Ryoichi Watanabe, Yusuke Moriguchi
20:20	Perceptual awareness of optic flows paced optimally and non-optimally to walking speed	Paweł Motyka, Zuzanna Kozłowska, Piotr Litwin
20:30	Spatial orientation via geomagnetic sensory augmentation	Frank Schumann, Youssouf Ismail Cherifi, Jean-Baptiste de Saint Aubert, Bilel Abderrahmane Benziane, Denis Sheynikhovich, David Poirier-Quinot, Brian Katz, Angelo Arleo
20:40	How do the blind 'see'? The role of spontaneous brain activity in self-generated perception	Avital Hahamy, Meytal Wilf, Boris Rosin, Marlene Behrmann, Rafael Malach
20:50	Intracranial recordings reveal unique shape and timing of responses in human visual cortex during illusory visual events.	Maartje Cathelijne de Jong, Mariska Vansteensel, Raymond van Ee, Frans S. S. Leijten, Nick F. Ramsey, Chris Dijkerman, Serge O. Dumoulin, Tomas Knapen

### **Perceptual consciousness III**

Moderator: David Carmel

	Title	Authors
19:30	The minimal exposure duration required for neural processing of faces and emotional expressions	Renzo Lanfranco, Andrés Canales-Johnson, Axel Cleeremans, Hugh Rabagliati, David Carmel
19:40	Perceptual incoherence and causal bias of altered consciousness in Schizophrenia	Dr Arun Sasidharan, Dr Ravindra P. N., Dr Ramajayam G., Dr Bindu M. Kutty
19:50	On Intrinsically Valenced Perception	Hilla Jacobson
20:00	Expectation in Perception	Rebecca Keller
20:10	Functionalist and generalist approach to the sensory substitution devices (SSDs) design	Marta Łukowska, Michał Wierchoń, Dominik Osiński, Weronika Kałwak
20:20	Discriminating states of consciousness with responses to natural auditory texture stimulation.	Urszula Górka, Andre Rupp, Yves Boubenec, Tansu Celikel, Bernhard Englitz
20:30	The Perceptual Quality and Performance Judgment Influence Visibility Ratings in a Continuous Colour Estimation Task	Zuzanna Skóra, Kinga Ciupińska, Simon Hviid Del Pin, Morten Overgaard, Michał Wierchoń
20:40	Awareness is required for Autonomic Performance Monitoring in Instrumental Learning: Evidence from Cardiac Activity	Lina I. Skora, James J. A. Livermore, Federica Nisina, Ryan B. Scott
20:50	Investigating the shift between externally and internally oriented cognition with a novel task-switching paradigm.	Sara Calzolari, Andrew P. Bagshaw, Davinia Fernández-Espejo

### **Unconscious processing II**

Moderator: Liad Mudrik

	Title	Authors
19:30	Time Course of Conscious and Unconscious Semantic Processing	Nitzan Micher, Dominique Lamy, Maayan Avneon, Shai Fisher
19:40	Instrumental conditioning requires conscious awareness in humans	Lina Skora, Martin Yeomans, Hans Crombag, Ryan Scott
19:50	Nonconscious chaining of events to form holistic fear memories in the human brain	Aurelio Cortese, Ryu Ohata, Norimichi Kitagawa, Hiroshi Imamizu, Ai Koizumi
20:00	Can we solve arithmetic equations non-consciously? A pre-registered replication.	Surya Gayet, Myrthel Dogge, Marius V. Peelen
20:10	Scene-object processing with and without awareness	Inbal Gur Arie, Itai Linzen, Alyssa Truman, Liad Mudrik
20:20	Prior exposure to supportive contexts improves implicit learning of phrase structure grammars	Lu Zhao, Qingyun Zhang, Xiaoli Ling (the corresponding author)
20:30	Performance and the development of explicit knowledge in implicit sequence learning	Clarissa Lustig, Sarah Esser, Hilde Haider
20:40	Awareness is needed for scene-based contextual effects on perception of ambiguous objects	May Sar-Salom, Tzahi Kravitz, Dan Biderman, Liad Mudrik



## Predictive attenuation of touch and tactile gating are distinct perceptual phenomena

Konstantina

Kilteni, Henrik Ehrsson

In recent decades, research on somatosensory perception has led to two important observations. First, self-generated touches that are predicted by voluntary movements become attenuated compared to externally generated touches of the same intensity (attenuation). Second, externally generated touches feel weaker and are more difficult to detect during movement compared to rest (gating). Researchers today often consider gating and attenuation to be the same suppression process; however, this assumption is unwarranted because, despite more than forty years of research, no study has combined them in a single paradigm. We quantified how people perceive self-generated and externally generated touches during movement and rest. We demonstrate that whereas voluntary movement gates the precision of both self-generated and externally generated touch, the amplitude of self-generated touch is selectively attenuated compared to externally generated touch. We further show that attenuation and gating neither interact nor correlate, and we conclude that they represent distinct perceptual phenomena.

## Experiencing the self through touch

Rebecca Boehme

The clearest experience of the self and its physical borders is the experience of being touched. It is also the earliest sensory experience of the self. Touch is crucial for the sensation of having a body and for learning how to distinguish between self and other. The sense of self is disturbed in many psychiatric disorders, e.g. schizophrenia, dissociative disorders, autism, and anorexia. Here I will discuss my studies in neurotypical participants and people with psychiatric diagnoses (ADHD, autism, anorexia, schizophrenia). We use self-touch and affective touch by others during functional brain imaging to understand how we differentiate between self and other, and how dysfunctions of this process can contribute to an altered sense of self. While we found a sharpened self-other-distinction in ADHD (Boehme et al., 2020), we expect to find a decreased distinction between self- and other-touch-signals in anorexia and schizophrenia (studies ongoing). Symptoms in the self-domain are currently not the focus of available treatment options, and since seldom addressed, they often persist. I propose that detailed insights into mechanisms of tactile self-other-distinction will further our understanding of how a sense of self is established and might offer innovative treatment options for the symptom domain of self-related dysfunction.

## NCC, P3b, and No-Report Paradigms

Yen-Kuan Chen, Tony Cheng, Chen-Wei Wu, Po-Jang Hsieh

Amongst ERPs, the P3b component, which is one member of the p3 family and usually appears around 400ms after the onset of stimuli, is often regarded as present during conscious processing but absent during unconscious processing, according to many studies (e.g., Naccache et al., 2015; Rutiku, 2017). Against this, Cohen et al. (2020) argue “that the P3b is not a signature of perceptual awareness per se and is instead more closely associated with postperceptual processing” (p. 4933, emphasis added). In response, we argue that in Cohen et al. (2020), participants’ attention is not equally distributed between report condition and no-report condition. Consequently, the different allocation of attention causes the observers to perceive different appearance of an item under these two separate conditions and thus influence the amplitude of p3b. Our study showed that participants perceive higher contrast of the stimulus located at the center of the screen (Gabor patches) while they were asked to report on the stimulus. Conversely, participants perceived lower contrast of the stimuli while they were asked to count the pop-out times of green ring. This result supports the hypothesis that the observers allocate less attention to the stimuli that are not required to report.

## Enhanced metacognition for unexpected action outcomes

Daniel Yon

Metacognition allows us to explicitly represent the uncertainty in our perceptions and decisions. Recent theories suggest that we use predictive models of our environment to optimise these introspective processes, but extant accounts disagree about the role prediction plays: some accounts suggest that we should have more sensitive subjective insight for predictable events, while others stress that metacognition should be enhanced for surprising prediction errors. In this talk, I will describe two experiments that compare these competing accounts. Participants performed actions to generate visual outcomes that could move in expected or unexpected directions. Across both experiments, signal detection analyses revealed enhanced metacognition for unexpected outcomes. A combination of reverse correlation and computational modelling suggest this advantage arises because metacognitive processes are especially sensitive to unexpected information. These results are consistent with higher order inference models of introspective awareness and point to a mechanism that may optimize diverse aspects of cognition and behaviour in an unstable world.

Instrumental conditioning requires conscious awareness in humans.

Lina Skora, Martin Yeomans, Hans Crombag, Ryan Scott

Instrumental conditioning is a crucial substrate of adaptive behaviour, allowing individuals to selectively interact with stimuli in their environment to maximise benefit and minimise harm. The extent to which such complex forms of learning are possible without conscious awareness is a topic of ongoing debate. In light of recent contributions casting doubt on earlier demonstrations of unconscious instrumental conditioning, we revisit the question of its feasibility in two modes of conditioning. In Experiment 1, we used trace conditioning, requiring participants to learn to approach masked reward-predictive stimuli and avoid punishment-predictive stimuli through subsequent monetary reinforcement. In Experiment 2, we used delay conditioning, retaining the structure of the task but presenting the stimuli under continuous flash suppression to allow for an overlap of the stimulus, action, and outcome. Monetary reinforcement was replaced with primary appetitive reinforcement. In both experiments, we found evidence for absence of unconscious instrumental conditioning, showing that participants were unable to learn to adjust their behaviour to approach positive stimuli and avoid negative ones. This result is consistent with evidence that unconscious stimuli fail to bring about long-term behavioural adaptations, and provides empirical evidence to support proposals that consciousness might be necessary for adaptive behaviour requiring selective action.

Neural network models for DMT-induced visual hallucinations

Michael M. Schartner, Christopher Timmermann

The regulatory role of the serotonergic system on conscious perception can be investigated perturbatorily with psychedelic drugs such as N, N-Dimethyltryptamine. There is increasing evidence that the serotonergic system gates prior (endogenous) and sensory (exogenous) information in the construction of a conscious experience. Using two generative deep neural networks as examples, we discuss how such models have the potential to be, firstly, an important medium to illustrate phenomenological visual effects of psychedelics—besides paintings, verbal reports and psychometric testing—and, secondly, their utility to conceptualize biological mechanisms of gating the influence of exogenous and endogenous information on visual perception.

## The domain generality in the usage of confidence scale

Xiao Hu, Liang Luo

The Bayesian inference model for metamemory (BIM) recently proposed by our lab assumes that people use a Bayesian inference process to integrate their prior beliefs about memory ability and the processing experience during memory process to predict their memory performance (Hu et al., in press, Psychological Review). The proportion for the contribution of processing experience to confidence ratings (parameter Pexp in BIM) affects the usage of confidence scale: low Pexp leads to confidence ratings closely distributed around a certain value, and high Pexp results in high variance in the confidence rating distribution. Here we extend BIM to perceptual metacognition and examine the domain generality in the usage of confidence scale. We extracted data from six published experiments in the confidence database (Rahnev et al., 2020), each of which asked participants to perform both perceptual and memory tasks with confidence ratings. We separately fit BIM to the task for each domain (perception or memory) in each experiment, estimated the parameter Pexp in each task, and performed a meta-analysis on the six experiments to investigate the overall correlation between Pexp in two domains. We found a significant cross-domain correlation for Pexp, which was significantly higher than the cross-domain correlation for metacognitive accuracy (meta- $d'/d'$ ), and numerically higher than the correlation for mean confidence. Our results suggest that there is domain generality in the usage of confidence scale.

## How do the blind 'see'? The role of spontaneous brain activity in self-generated perception

Avital Hahamy, Meytal Wilf, Boris Rosin, Marlene Behrmann, Rafael Malach

Spontaneous brain activity has been well documented, but little is known about its functional role. Here, we test whether spontaneous brain activity might underlie internally-generated vision. Specifically, we studied five blind individuals who experience vivid visual hallucinations (Charles Bonnet Syndrome, CBS), and asked whether spontaneous fluctuations in the deprived visual system of these individuals can subserve visual hallucinations. To this end, the fMRI brain activity of CBS participants obtained while they reported their hallucinations (spontaneous internally-generated vision) was compared to the : 1) brain activity evoked by veridical vision (externally-triggered vision) in sighted controls who were presented with a visual simulation of the hallucinatory streams; and 2) brain activity of non-hallucinating blind controls during visual imagery (cued internally-generated vision). All conditions activated large portions of the visual system. However, only the hallucination condition demonstrated unique temporal dynamics, characterized by a slow build-up of neural activity prior to the reported onset of hallucinations. This build-up was most pronounced in early visual cortex and then decayed along the visual hierarchy. These results suggest that, in the absence of external visual input, a build-up of spontaneous fluctuations in early visual cortex may activate the visual hierarchy, thereby triggering the experience of vision.

## Young children's subjective and objective thresholds of visual consciousness using a backward masking task

Ryoichi Watanabe, Yusuke Moriguchi

Visual consciousness studies for humans have mainly focused on adults. However, it is still unknown whether young children's visual consciousness is similar to or different from adults' one. In this study, we examined young children's and adults' subjective (the visibility rate) and objective (the accuracy rate) thresholds of visual consciousness using a backward masking task. In our experiment, 5-to-6-year-old children and adults were given a visual awareness task using a square or a diamond as the target stimulus. Eight conditions of stimulus onset asynchronies (SOAs) were randomly intermixed across trials (20, 40, 60, 80, 100, 160, 200, and 260 ms). We measured the accuracy rate (A square or a diamond?) and the visibility rate (Did you see it?). After the non-linear models (Sandberg et al., 2011) were fitted to the accuracy rate and visibility rate, we compared young children's models with adults' ones. The results showed that young children's subjective and objective thresholds were longer than adults' ones. Moreover, young children's models were more graded than adults' ones. These results suggest that young children need a longer presentation to access consciousness than adults. Therefore, it may be that young children's visual consciousness is different from adults' one.

## How do we define consciousness over extended timescales from perception to evolution?

Lachlan Kent, George Van Doorn, Britt Klein

Implicit within many theories of consciousness is the idea that phenomenal consciousness occurs in "real-time", meaning that we experience it directly within the immediate timescale of "here and now". This contrasts with other mental processes/experiences occurring over extended timescales that, one assumes, are not "directly" experienced. Instead, these are attributed to non-conscious long-term memory processes for individuals and even, at extremely long timescales, non-conscious evolutionary processes for groups or entire species. The question is: Is this assumption correct or are there forms of consciousness that are not directly experienced in real-time? This talk proposes creature consciousness (i.e., what it is like to be a particular "kind" of creature as opposed to another) as a form of consciousness whose dynamic range is over extended, evolutionary timescales and so represents a form of consciousness that is experienced only "indirectly". This means that creature consciousness does not contain phenomenal contents that manifest as concrete objects in the everyday sense of perception and cognition. Rather it presents only abstract impressions of the global structure of consciousness within which local contents are contained. A "mental timeline" for consciousness is proposed ranging from real-time to evolutionary timescales using an evolutionary framework called the Hierarchically Mechanistic Mind.

A no-report paradigm reveals that face cells multiplex consciously perceived and suppressed stimuli

Janis Karan Hesse, Doris Ying Tsao

A powerful paradigm to identify neural correlates of consciousness is binocular rivalry, wherein a constant visual stimulus evokes a varying conscious percept. It has recently been suggested that activity modulations observed during rivalry may represent the act of report rather than the conscious percept itself. Here, we performed high-channel single-unit recordings from face patches in macaque inferotemporal (IT) cortex using a novel no-report paradigm in which the animal's conscious percept was inferred from eye movements. We found that large proportions of IT neurons represented the conscious percept even without active report. However, even on single trials, modulation to rivalrous stimuli was weaker than that to unambiguous stimuli, suggesting that cells may encode not only the conscious percept but also the suppressed stimulus. To test this hypothesis, we varied the identity of the suppressed stimulus during rivalry. We found that we could decode both the conscious percept and the suppressed stimulus from neural activity. Together, our findings indicate that (1) IT cortex possesses a true neural correlate of consciousness, and (2) this correlate consists of a population code wherein single cells multiplex representation of the conscious percept and veridical physical stimulus, rather than a subset of cells perfectly reflecting consciousness.

Cortical Function in Acute Severe Traumatic Brain Injury and at Recovery: A Longitudinal fMRI Case Study

Karnig Kazazian, Loretta Norton, Teneille Gofton, Derek Debicki, Adrian M. Owen

Differences in the functional integrity of the brain from acute severe brain injury to subsequent recovery of consciousness have not been well documented. Functional magnetic resonance imaging (fMRI) may elucidate this issue as it allows for the objective measurement of brain function both at rest and in response to stimuli. Here, we report the cortical function of a patient with a severe traumatic brain injury (TBI) in a critically ill state and at subsequent functional recovery 9-months post injury. A series of fMRI paradigms were employed to assess sound and speech perception, command following, and resting state connectivity. The patient retained sound perception and speech perception acutely, as indexed by his fMRI responses. Command following was absent acutely, but was present at recovery. Increases in functional connectivity across multiple resting state networks were observed at recovery. We demonstrate the clinical utility of fMRI in assessing cortical function in a patient with severe TBI. We suggest that hallmarks of the recovery of consciousness are associated with neural activity to higher-order cognitive tasks and increased resting state connectivity.

Does the prefrontal cortex play an essential role in consciousness? Insights from intracranial electrical stimulation of the human brain

Omri Raccach, Ned Block, Kieran C.R. Fox

A central debate in philosophy and neuroscience pertains to whether prefrontal cortex (PFC) activity plays an essential role in the neural basis of consciousness. Neuroimaging and electrophysiology studies have revealed that the contents of conscious perceptual experience can be successfully decoded from PFC activity, but these findings might be confounded by post-perceptual cognitive processes, such as thinking, reasoning, and decision-making, that are not necessary for consciousness. To clarify the involvement of the PFC in consciousness, we present a synthesis of research that has used intracranial electrical stimulation (IES) for the causal modulation of neural activity in the human PFC. This research provides compelling evidence that IES of only certain prefrontal regions (i.e., orbitofrontal cortex and anterior cingulate cortex) reliably perturbs conscious experience. Conversely, stimulation of anterolateral prefrontal sites – often considered crucial in higher-order and global workspace theories of consciousness – seldom –elicits any reportable alterations in consciousness. Furthermore, the wide variety of IES-elicited effects in the PFC (e.g., emotions, thoughts, and olfactory and visual hallucinations) exhibits no clear relation to the immediate environment. Therefore, there is no evidence for the kinds of alterations in ongoing perceptual experience that would be predicted by higher-order or global workspace theories. Nevertheless, effects in the orbitofrontal and anterior cingulate cortices suggest a specific role for these PFC subregions in supporting emotional aspects of conscious experience. Overall, this evidence presents a challenge for higher-order and global workspace theories, which commonly point to the PFC as the basis for conscious perception based on correlative and possibly confounded information.

A blast from the past: Bistable perception alternates between internal and external modes of sensory processing.

Veith Weinhhammer, Meera Chikermane, Philipp Sterzer

Perceptual history can exert pronounced effects on the contents of conscious experience: When confronted with completely ambiguous stimuli, perception does not waver at random between diverging stimulus interpretations, but sticks with recent percepts for prolonged intervals. Here, we investigated the relevance of perceptual history in situations more similar to everyday experience, where sensory stimuli are usually not completely ambiguous. Using partially ambiguous visual stimuli, we found that the balance between past and present is not stable over time, but slowly fluctuates between two opposing modes: For time periods of up to several minutes, perception was either largely determined by perceptual history or driven predominantly by disambiguating sensory evidence. This finding suggests that the construction of unambiguous conscious experiences is modulated by slow fluctuations between internally and externally oriented modes of sensory processing.

## Evidence for an active role of inferior frontal cortex in conscious experience

Veith Weilhhammer, Merve Fritsch, Meera Chikermane, Anna-Lena Eckert, Katharina Kanthak, Heiner Stuke, Jakob Kaminski, Philipp Sterzer

In the search for the neural correlates of consciousness, it has remained controversial whether prefrontal cortex determines what is consciously experienced or, alternatively, serves only complementary functions such as introspection or action. Here, we provide converging evidence from computational modeling and two functional magnetic resonance imaging experiments for a key role of inferior frontal cortex in detecting perceptual conflicts that emerge from ambiguous sensory information. Crucially, the detection of perceptual conflicts by prefrontal cortex turned out to be critical in the process of transforming ambiguous sensory information into unambiguous conscious experiences: In a third experiment, disruption of neural activity in inferior frontal cortex through transcranial magnetic stimulation slowed down the updating of conscious experience that occurs in response to perceptual conflicts. These findings show that inferior frontal cortex actively contributes to the resolution of perceptual ambiguities. Prefrontal cortex is thus causally involved in determining the contents of conscious experience. "

## The First-Person Perspective is Not a Defining Feature of Consciousness

Dylan Ludwig

It is generally assumed that consciousness is characterized by a "first-person perspective". On one interpretation of this claim, conscious experience is thought to be defined, at least in part, by representations that encode a subject-centered "point of view". But claims about the defining features of consciousness need to be sensitive to the possibility of dissociation: if a neurobiological structure or psychological function is neither necessary nor sufficient for consciousness, it cannot be a defining feature in any robust sense. I appeal to research on emotion, visually-guided action, perceptual constancy and psychiatric disorder in order to argue that the first-person perspective dissociates from conscious experience. This result has substantial implications for future research in the philosophy and science of consciousness.



## Instrumental conditioning requires conscious awareness in humans

Lina Skora, Martin Yeomans, Hans Crombag, Ryan Scott

Instrumental conditioning is a crucial substrate of adaptive behaviour, allowing individuals to selectively interact with stimuli in their environment to maximise benefit and minimise harm. The extent to which such complex forms of learning are possible without conscious awareness is a topic of ongoing debate. In light of recent contributions casting doubt on earlier demonstrations of unconscious instrumental conditioning, we revisit the question of its feasibility in two modes of conditioning. In Experiment 1, we used trace conditioning, requiring participants to learn to approach masked reward-predictive stimuli and avoid punishment-predictive stimuli through subsequent monetary reinforcement. In Experiment 2, we used delay conditioning, retaining the structure of the task but presenting the stimuli under continuous flash suppression to allow for an overlap of the stimulus, action, and outcome. Monetary reinforcement was replaced with primary appetitive reinforcement. In both experiments, we found evidence for absence of unconscious instrumental conditioning, showing that participants were unable to learn to adjust their behaviour to approach positive stimuli and avoid negative ones. This result is consistent with evidence that unconscious stimuli fail to bring about long-term behavioural adaptations, and provides empirical evidence to support proposals that consciousness might be necessary for adaptive behaviour requiring selective action.

## Implicit-Explicit Gradient of Consciousness as Such

Zoran Josipovic

Consciousness is multi-dimensional but is most often portrayed with a 2-D map that has global levels or states on one axis, and phenomenal contents on the other. On this map, phenomenal content is conflated with awareness itself, which contributes to ongoing difficulties in the scientific understanding of consciousness. Previously (Josipovic 2014, 2019; Josipovic and Miskovic, 2020) I have proposed that consciousness as such, or nondual awareness - a basic non-conceptual, non-propositional awareness in itself free of subject-object fragmentation, is phenomenally, functionally and neurobiologically, a unique kind that cannot be adequately specified by a 2-D map of levels/modes and contents. Here, I propose an implicit-explicit gradient of nondual awareness to be added as the third dimension or z-axis, to the 2D map of consciousness. Alternatively, within the multi-dimensional state space model of consciousness, nondual awareness can be specified by several vectors, each representing one of its properties. I explore how including the implicit-explicit gradient of nondual awareness as an additional axis clarifies certain features of everyday dualistic experiences and is especially relevant for understanding the unitary and nondual experiences accessed via different contemplative methods, mind altering substances, or spontaneously. I discuss the relevance of this for current theories of consciousness.

Investigation of the relationship between breathing motor adaptation and its sense of agency: a combined physiological and Virtual Reality study.

Sophie Betka, Florent Jeanpetit, Claire Meuwly, Sunho Lee, Oliver Kannape, Florian Lance, Sixto Alcoba, Olaf Blanke

Breathing-related manipulations modulate the bodily self-consciousness. Such effects are particularly robust for breathing agency that is the feeling of control over breathing. Here, using Virtual Reality (VR), we propose a novel visuo-respiratory paradigm allowing the systematic investigation of the breathing sensorimotor control and its accompanying sense of agency. Thirty-six participants were embodied in a 3-D virtual avatar, using VR. During 15-s blocks, the avatar was breathing either in synchrony (Condition 0) or in asynchrony (Conditions 1-9 with delay) with the participant's actual respiratory signal, using ten normalized delays based on fraction of the participant's breathing cycle duration (BCD; Cond0:  $0 \times \text{BCD}$  – no delay; Cond4:  $4/8 \times \text{BCD}$  – half-a-cycle delay; Cond8:  $8/8 \times \text{BCD}$  - full-cycle delay). Breathing motor adaptation (BMA) as well as agency-related ratings over the avatar's breathing movement were recorded and analyzed using mixed-effects models. Agency-related ratings were best fitted by a quadratic model; while BMA was best fitted by a non-linear sine model suggesting that participants unconsciously synchronized their breathing with the avatar's breathing. No clear relationship was observed between BMA and ratings. Our results increase the knowledge on the contribution of sensorimotor control to the sense of agency by extending and comparing findings from upper-limb and full-body agency to breathing agency, with potential clinical implications.

Modulation of Hypnotizability Using Repetitive Transcranial Magnetic Stimulation: A Randomized Control Trial

Afik Faerman, M.S., James H. Bishop, Ph.D., Katy H. Stimpson, M.S., Angela Phillips, Ph.D., Booil Jo, Ph.D., Merve Gülser, B.S., Heer Amin, B.S., Danielle DeSouza, Ph.D., Romina Nejad, M.S., Nolan R. Williams, M.D., David Spiegel, M.D.

Hypnotizability, one's ability to experience physical, cognitive, emotional, and behavioral phenomena in response to suggestions in the context of hypnosis, is a highly stable trait associated with increased functional connectivity between the left dorsolateral prefrontal cortex (L-DLPFC) and dorsal anterior cingulate cortex (dACC). We conducted a preregistered, triple-blinded, randomized control trial to test the ability of continuous theta-burst stimulation (cTBS) over the L-DLPFC to temporarily enhance hypnotizability. We tested our hypothesis in 78 patients with fibromyalgia syndrome, a functional pain disorder for which hypnosis has consistently been shown to be beneficial as a nonpharmacological treatment option. Pre-to-post cTBS change in Hypnotic Induction Profile (HIP; a standardized measure of hypnotizability) scores was significantly greater ( $t(76) = 2.472$ ,  $p = .016$ , Cohen's  $d = .56$ ) in the Active ( $N = 40$ ;  $M = .63 \pm 1.18$ ) than in the Sham ( $N = 38$ ;  $M = .01 \pm 1.02$ ) group. Change in HIP following stimulation was statistically significant in the Active group ( $t(39) = 3.344$ ,  $p = .002$ ;  $d = .53$ ) but not the Sham group ( $t(37) = .040$ ,  $p = .968$ ). Our findings suggest causal inference to the relationship between L-DLPFC inhibition and hypnotizability. Dose-response optimization should be further examined to formalize guidelines for future clinical utilization.

## Reflectivity as part of an Evolutionary Scenario for Self-Consciousness. Impact on Pre-reflective Self-Consciousness

Christophe Menant

The performance of reflectivity of self-consciousness is traditionally associated to the subject turning its consciousness of objects to its own entity. But such process introduces concerns of circularity and of infinite regress. To avoid them philosophers have postulated a “pre-reflective self-consciousness” understood as a “state of consciousness that is immediately aware of itself, unmediated by reflections”. We propose here that an evolutionary scenario for self-consciousness can introduce reflectivity as a natural performance, bringing pre-reflective self-consciousness to be reconsidered. The evolutionary scenario starts when our ancestors were capable to manage representations while also being able to partly identify with their conspecifics represented as existing in the environment. These identifications have allowed our ancestors to merge the representations they had of parts of themselves with the corresponding representations they had of their conspecifics. These mergers have progressively led our ancestors to begin representing themselves as entities existing in the environment, like conspecifics were represented. Such process has provided our ancestors with an ancestral self-consciousness. And thinking about the represented entity led our ancestors to self-consciousness as object and as subject.

(<https://philpapers.org/archive/MENCOO>). Reflectivity can then be considered as a natural performance of self-consciousness. And postulating a pre-reflective self-consciousness may need to be re-addressed.

## The effect of military training on the sense of agency and outcome processing

Emilie A. Caspar, Salvatore Lo Bue, Pedro A. Magalhães De Saldanha da Gama, Patrick Haggard, & Axel Cleeremans

Armed forces often rely on strict hierarchical organization, where people are required to follow orders. In two cross-sectional studies, we investigate whether or not working in a military context influences the sense of agency and outcome processing, and how different durations (junior cadets vs senior cadets) and types (cadets vs privates) of military experience may modulate these effects. Participants could administer painful electrical shocks to a ‘victim’ in exchange for money, either by their own free choice, or following orders of the experimenter. Results indicate that working in a strictly hierarchical structure may have a generalized negative impact on one’s own sense of agency and outcome processing by reducing it, even when participants could freely decide their action. However, trained officers showed an enhanced sense of agency and outcome processing. This study offers insights on the potential for training the sense of agency and outcome processing.

## Isolating Abstract Awareness States: Probing the Neural Encoding of Levels of Subjective Experience Across Stimuli

Benjy Barnett, Lau Andersen, Stephen Fleming, Nadine Dijkstra

A fundamental feature of human awareness is the ability to report on the contents of our experience. Recent models have attempted to explain how perceptual states become available for conscious report by way of a hierarchical decision process. A central prediction that arises from such models is the existence of abstract 'awareness states.' These neural states are proposed to reflect the perceived presence or absence of a stimulus without encoding any stimulus features. In order to locate and identify abstract awareness states, we reanalyse an MEG study in which subjects viewed different shapes at varying contrast levels while reporting their trial-by-trial awareness using the Perceptual Awareness Scale. We use decoding methods to isolate multivariate neural patterns that correspond to both the awareness and unawareness of stimuli whilst also abstracting over stimuli's sensory features. Additionally, we observe how this effect generalises across time. Finally, we combine decoding with dimensionality reduction techniques to explore the low-dimensional nature of awareness states. This work aims to provide neural evidence for the existence of a higher-order state space that not only encodes the level of awareness of a stimulus, but also underpins its conscious report.

## The Simultaneous Encoding/ Serial Experience theory of the Perceptual Moment: a Blink of (Meta)-Experience

Howard Bowman, William Jones, Hannah Pincham, Steve Fleming, Axel Cleeremans and Murray Smith

The Attentional Blink (AB) is a deficit in \*reporting\* a second target (T2) presented soon after a (correctly reported) first target (T1). One can also investigate how the strength of the conscious percept generated by the T2 is impacted by its temporal proximity to a reported T1, giving what we call the experiential blink. We will present a further blink deficit, which quantifies how well the strength of conscious perception of T2 reflects its report accuracy. We refer to this as the meta-experiential blink, which indexes a subject's metacognitive ability to track their performance in the AB. Lag-1 in the AB, in which T2 immediately follows T1, has a time-frame consistent with the perceptual moment. At this lag, the attentional, experiential and meta-experiential blinks particularly strongly dissociate, with the first very high, the second much lower and the third lower still. Supported by electrophysiological findings, we argue that these results suggest that working-memory encoding can proceed in parallel, i.e. simultaneous encoding, while conscious experience proceeds in series, i.e. serial experience, consistent with a free-recall form of blind-sight. We also show how this dissociation between encoding, experience and meta-experience can be modelled in a readout-enhanced Simultaneous Type/ Serial Token model.

Empirical investigations of the higher-order state space framework.

Oliver Warrington, Nadine Dijkstra, Stephen Fleming

Awareness reports are a central component in the study of consciousness. However, the decision processes by which we say "I am aware/unaware of X" are unclear. The higher-order state space (HOSS) framework characterises awareness reports as decisions about whether the state of our perceptual generative model reflects presence or absence. Under this framework, the representation of awareness is suggested to be orthogonal to as well as hierarchically higher than representations of identity. To test this empirically, we plan to use behavioural, fMRI and MEG measures to determine where and when inference about absence occurs in the brain. The same participants will be tested in all modalities. They will be shown 2-dimensional cues that orthogonally indicate the likelihood of stimulus presence and stimulus identity. Preliminary behavioural results indicate that participants are able to generate predictions and prediction errors on both levels, reflected in lower accuracy for incongruent trials. We hypothesise that, in line with the HOSS model, violating expectations will lead to neural prediction errors at two dissociable levels. Using fMRI we will test the localisation of these prediction errors and MEG to probe differences in their temporal dynamics. We expect that identity violations will be represented in sensory visual regions specific for the stimuli and precede stimulus presence violations which would be represented in higher-order subregions of prefrontal cortex.

Using a higher-order state space model to interrogate the dynamics of awareness reports

Cormac Dickson, Steve Fleming

Our ability to report states of awareness is central to investigations of subjective experience. Yet little is known about the mechanisms which enable us to say, 'I am aware of X'. Recent work, motivated by higher order theories of consciousness, has posited awareness as a metacognitive decision in a higher order state space (HOSS) of perceptual contents, resulting in an asymmetry in the range of perceptual contents possible when aware versus unaware. The current investigation expands the HOSS model to generate empirical predictions for the dynamics of awareness states over time, enabling a comparison of the quantitative and qualitative signatures of higher order probabilistic learning with first-order or "flat" models grounded in signal detection theory. In particular, we will evaluate the hypothesis that a distinct higher-order state of awareness results in abstract predictions about content at the perceptual level on 'seen' vs 'unseen' trials, leading to a generalisation of such predictions across dissimilar stimuli. Such generalisation is not expected for flat, first-order architectures. The model's estimates of surprisal when encountering different stimuli will be validated against reaction times in a simple online behavioural learning experiment.

## Past and Future Explanations for Depersonalisation and Derealisation Disorder; A Role For Predictive Coding.

Andrew Gatus, Graham Jamieson, Bruce Stevenson

Depersonalisation (DP) and derealisation (DR) refer to states of dissociation in which one feels a sense of alienation in relation to one's self and environment respectively. Whilst transient episodes (i.e. those lasting minutes to weeks) often diminish without treatment, chronic experiences of DP and DR may last for years, with common treatments such as pharmacological intervention, psychological intervention, and transcranial magnetic stimulation failing to show reliable symptom reduction. We propose a theoretical explanation of DP and DR based on interoceptive predictive coding. Further, we propose a hypothetical, experimental method of testing this model and inducing these experiences in the non-clinical population using virtual reality. Finally, we discuss how the neural correlates of DP and DR may be identified using electroencephalography and electrocardiography data, and propose how this may be incorporated into an experimental paradigm to better measure these experiences in the non-clinical population. Ultimately, this experimental design, if successful, would shed light on how the brain constructs our sense of self and reality, suggesting a possible physical and functional mechanism through which this may occur.

## A new no-report paradigm reveals that face cells multiplex consciously perceived and suppressed stimuli

Janis K Hesse, Doris Y Tsao

A powerful paradigm to identify neural correlates of consciousness is binocular rivalry, wherein a constant visual stimulus evokes a varying conscious percept. It has recently been suggested that activity modulations observed during rivalry may represent the act of report rather than the conscious percept itself. Here, we performed high-channel single-unit recordings from face patches in macaque inferotemporal (IT) cortex using a novel no-report paradigm in which the animal's conscious percept was inferred from eye movements. We found that large proportions of IT neurons represented the conscious percept even without active report. However, even on single trials, modulation to rivalrous stimuli was weaker than that to unambiguous stimuli, suggesting that cells may encode not only the conscious percept but also the suppressed stimulus. To test this hypothesis, we varied the identity of the suppressed stimulus during rivalry. We found that we could decode both the conscious percept and the suppressed stimulus from neural activity. Together, our findings indicate that (1) IT cortex possesses a true neural correlate of consciousness, and (2) this correlate consists of a population code wherein single cells multiplex representation of the conscious percept and veridical physical stimulus, rather than a subset of cells perfectly reflecting consciousness.

## The role of metacognition in monitoring performance and regulating learning in early readers

Ioanna Taouki, Marie Lallier, David Soto

Metacognition refers to the capacity to reflect upon our own cognitive processes. Although there is an ongoing discussion in the literature on the role of metacognition in learning and academic achievement, little is known about its neurodevelopmental trajectories in early childhood, when children begin to receive formal education in reading. In the present talk, we will present the results of a longitudinal behavioral study carried out in a cohort of children aged between 6 and 7 (N=60), for which we evaluated their metacognitive efficiency (meta-d'/d') in linguistic (lexical decision, visual attention span) and non-linguistic contexts (emotion recognition), and related this to the children's performance in general standardized tests of cognitive abilities. We show that a) there is no evidence of associations between metacognitive ability (i.e. how confidence ratings track accuracy in the task) and students' performance in standardized tests of reading ability and general cognitive skills in this early stage of reading acquisition, b) domain-specific resources are more likely to support metacognition at this age and c) metacognitive efficiency is a significant predictor of longitudinal learning in both a linguistic and a non-linguistic task context, which highlights its importance as a tool in life long learning.

## Informative neural representations of unseen objects during higher-order processing in human brains and deep artificial networks

Ning Mei, Roberto Santana, David Soto

Despite advances in the neuroscience of visual consciousness over the last decades, we still lack a framework for understanding the scope of unconscious processing and how it relates to conscious experience. Previous research observed brain signatures of unconscious contents in visual cortex, but these have not been identified in a reliable manner, with low trial numbers and signal detection theoretic constraints not allowing to decisively discard conscious perception. Critically, the extent to which unconscious content is represented in high-level processing stages along the ventral visual stream and linked prefrontal areas remains unknown. Using a within-subject, high-precision, highly-sampled fMRI approach, we show that unconscious contents, even those associated with null sensitivity, can be reliably decoded from multivoxel patterns that are highly distributed along the ventral visual pathway and also involving prefrontal substrates. Notably, the neural representation in these areas generalised across conscious and unconscious visual processing states, placing constraints on prior findings that fronto-parietal substrates support the representation of conscious contents and suggesting revisions to models of consciousness such as the neuronal global workspace. We then provide a computational model simulation of visual information processing/representation in the absence of perceptual sensitivity by using feedforward convolutional neural networks trained to perform a similar visual task to the human observers. The work provides a novel framework for pinpointing the neural representation of unconscious knowledge across different task domains.

## A new test for conscious and non-conscious perception in animals: evidence from rhesus monkeys

Moshe Shay Ben-Haim, Olga Dal Monte, Nicholas A. Fagan, Yarrow Dunham, Ran R. Hassin, Steve W. C. Chang, Laurie R. Santos

Many animals perform complex intelligent behaviors, but the question of whether animals are aware while doing so remains a long debated but unanswered question. Because many complex human behaviors and high-level functions can be performed without conscious awareness, it was long considered impossible to untangle whether animals are aware, or just conditionally or non-consciously behaving. Here, we developed a new approach to assess whether non-human animals have conscious awareness by utilizing a well-known double dissociation of visual awareness – cases where people behave in completely opposite ways when stimuli are processed consciously versus non-consciously. Using this method, we found that one non-human species –the rhesus monkey— exhibits the very same behavioral signature of both non-conscious and conscious perception. This opposite double dissociation of awareness firstly allows stripping away the long inherent ambiguity when interpreting the processes governing animal behavior, and can thus be used as a reliable test for animal consciousness in the species of interest. Taken together, our results in rhesus monkeys strongly support the existence of both non-conscious processing, as well as functional human-like visual awareness in a non-human animal.

## “Metacogmission”: measuring metacognition across the lifespan and over two cognitive domains via an engaging gamified task

Andrew McWilliams, Hannah Bibby, Nikolaus Steinbeis, Stephen M. Fleming

There is conflicting evidence about how metacognition – “thinking about your thinking” – changes across the lifespan, and whether it generalises across cognitive domains. Metacognitive measurement techniques have sometimes suffered confounding effects from an individual’s task performance levels and general levels of self-confidence. Models derived from Type 2 signal-detection theory circumvent these issues by returning an “efficiency” parameter, quantifying confidence sensitivity given a certain level of task performance. However, fitting these models requires high trial numbers, meaning experiments require highly-motivated subjects. Working with a technology firm and mental health service user advisers, we developed Metacogmission – a gamified metacognitive task – which we piloted at public engagement events and with a neuropsychiatric clinical population. We then measured metacognition for memory and visual perception in 304 healthy volunteers (18-83 years), recruited via a crowdsourcing website. We use Bayesian modelling to derive metacognitive efficiency (meta- $d'/d'$ ), quantifying changes with age across two domains. Meta- $d'$  model fits were robust, as assessed with MCMC convergence diagnostics. Preliminary results indicate that as people age, performance on first-order cognitive tasks was preserved. Although raw confidence (“bias”) decreased to middle age, metacognitive efficiency remained stable and was correlated across cognitive domains. Experience accrued through life may bolster metacognitive performance into older age.



## A Simple Model of Attentional Blink

Nadav Amir, Naftali Tishby, Israel Nelken

The attentional blink (AB) effect is the reduced ability of subjects to report a target stimulus that appears shortly after another target in a rapidly presented sequence of distractors. The AB effect has been shown to be reduced following intensive mental training (mindfulness meditation), with a corresponding reduction in evoked P3b brain potentials, which are believed to index attentional resource allocation. However, the mechanisms underlying these effects remain unknown. We propose a dynamical-systems model of the AB, in which attentional load is a function of the incoming stimuli. Additive noise is used to represent mental activity which is unrelated to the task, and which may be modulated via mental training. The AB effect occurs due to an overload of attentional resources. The model suggests a theoretical proxy for the P3b potential evoked by target stimuli. Taken together, the model provides a novel account of the AB, relating behavioral performance, target evoked brain potentials and mental training induced modulation of mental noise levels in a single, simple computational framework.

Pupil dilation increases when participants report familiarity for images of faces they have not seen before

Kirsten Ziman, Jeremy R. Manning

Pupil dilation can reflect changes in the environment, such as brightness, as well as internal cognitive processes, such as emotional response, expected value, surprise, and familiarity. Because many factors can affect pupil dilation, important questions remain about how pupil dilation changes reflect high-order cognitive processes. In this study, we examined pupil responses during a recognition memory task involving photographs of faces and scenes. Over the course of the task, participants made recognition memory judgements about photographs they had seen before, as well as novel photographs (as a control measure). We found that participants' pupils dilated strongly when they mistakenly rated novel photographs of faces as "familiar". This pupillary discernment of false familiarity highlights a disparity between conscious feelings of familiarity (self-report) and subconscious, physiological responses (pupil dilation).

## Reflectivity as part of an Evolutionary Scenario for Self-Consciousness. Impact on Pre-Reflective Self-Consciousness

Christophe Menant

The performance of reflectivity of self-consciousness is traditionally associated to the subject turning its consciousness of objects to its own entity. But such process introduces concerns of circularity and of infinite regress. To avoid them philosophers have postulated a “pre-reflective self-consciousness” understood as a “state of consciousness that is immediately aware of itself, unmediated by reflections”. We propose here that an evolutionary scenario for self-consciousness can introduce reflectivity as a natural performance, bringing pre-reflective self-consciousness to be reconsidered. The evolutionary scenario starts when our ancestors were capable to manage representations while also being able to partly identify with their conspecifics represented as existing in the environment. These identifications have allowed our ancestors to merge the representations they had of parts of themselves with the corresponding representations they had of their conspecifics. These mergers have progressively led our ancestors to begin representing themselves as entities existing in the environment, like conspecifics were represented. Such process has provided our ancestors with an ancestral self-consciousness. And thinking about the represented entity led our ancestors to self-consciousness as object and as subject.

(<https://philpapers.org/archive/MENCOO>). Reflectivity can then be considered as a natural performance of self-consciousness. And postulating a pre-reflective self-consciousness may need to be re-addressed.

Reverse Choice Blindness: People reject what they want when making an error in getting it.

Gabriel Vogel, Lars Hall, Peter Johansson

In choice blindness (CB) experiments, participants often accept a manipulated outcome as their actual choice. In a typical CB experiment the manual actions that participants perform are always correct (pointing, writing, etc.), while the outcome is mismatched. However, what would happen if an error was induced at the motor level, but the outcome nevertheless remained correct? We investigated this by having participants drag a mouse cursor across the screen to the face they found the most attractive, while we manipulated either the outcome (classic CB), or the cursor (forced motor deviation), or sometimes both. Interestingly, what we found was that when the cursor was manipulated but not the outcome, the motor ‘wrongness’ would override the goal ‘rightness’, and participants ended up rejecting the outcome they actually wanted. In the presentation we will discuss the implications of this new reverse choice blindness effect for theories of authorship judgement, self-monitoring and agency.

Investigating the shift between externally and internally oriented cognition with a novel task-switching paradigm.

Sara Calzolari, Andrew P. Bagshaw, Davinia Fernández-Espejo

Despite the brain's constant need to flexibly balance internal and external information, research on cognitive flexibility has focused solely on shifts between externally oriented tasks. In contrast, the costs of switching across internally oriented processes (especially self-referential) or between internal and external domains have never been investigated. We developed a novel cued task-switching paradigm to induce shifts between external and internal monitoring, and tested it behaviourally with 38 healthy volunteers. In each trial, participants performed one of 4 possible tasks on written words (2 externally oriented, 2 internally oriented), depending on pre-stimulus cues. 40% of trials were switches to another task: 1/4 within-internal tasks, 1/4 within-external, 1/4 internal-to-external, and 1/4 external-to-internal. We found evidence of switch costs (task repetition elicits faster RT than switching) both in the internal and external domains (main effect of switching:  $p < .001$ ,  $BF_{10} = 1.995e+10$ ; post-hoc internal and external domain:  $p < .001$ ). Moreover, within-domain switches were faster than between-domain switches ( $p < .001$ ;  $BF_{10} = 54700.27$ ). We demonstrated the presence of switch costs in self-referential tasks for the first time and observed increased effort in shifting across domains compared to staying within domain, possibly suggesting competition between different underlying networks. We introduce a new method to explore the interplay of these ubiquitous processes.

The Dynamic Self: Serial-dependence effects in embodied sense of agency

Yoni Stern, Inbar Ben-Yehuda, Adam Zaidel, Roy Salomon

Sense of Agency (SoA), the feeling of control over our body's actions, arises from the continuous integration of sensorimotor predictions and afferent signals. SoA contributes to our experience of embodied selfhood that is typically perceived as stable and unwavering over time. Nonetheless, recent theoretical accounts highlight the experience-dependent and dynamic nature of the embodied self. In the current study we examined how recent experiences (i.e., serial-dependence) modulate SoA, and disambiguated the unique contributions of past stimuli and choices. We analyzed two datasets of the Virtual Hand (VH) task ( $N = 100$  participants). In Dataset 1, which included only temporal alterations, we found that previous stimuli recalibrate the perception of the current stimuli, such that the current delay is judged relative to the previous trial's, whereas previous choices induced a repetition bias. Thus, previous objective stimuli and subjective choices exert opposing influences. We replicated these findings in Dataset 2 that included alterations in temporal and spatial domains. Importantly, previous stimuli induced a recalibration effect that spans across domains of alteration. Thus, SoA is as a unifying construct modulated by previous subjective choices and objective stimuli, organizing our experience of the embodied self over time and across perceptual domains.

## Assessing awareness in severe dementia: A feasibility and pilot study.

Dr Jonathan Huntley, Dr Daniel Bor, Prof Adrian Owen, Prof Robert Howard, Dr Lorina Naci, Dr Lorenzo Rocci, Dr Stephen Fleming

**Background:** Understanding the lived experience of people with severe dementia, and specifically the extent and nature of their awareness is central to maximising their quality of life and enabling person-centred care. However, there have been no studies examining objective biomarkers of awareness in this growing and vulnerable population. We present the results of a feasibility and pilot study to investigate awareness in severe Alzheimer's disease (AD). **Methods:** Participants with severe AD, (sMMSE score 0/30, n=2) and healthy older adult participants (n=7) were recruited. This study assessed the feasibility of using transcranial magnetic stimulation combined with electro-encephalography (TMS- EEG), event related potentials (ERPs) and functional magnetic resonance imaging (fMRI) to assess awareness in people with severe dementia. **Results:** We successfully collected data from participants with severe AD, demonstrating the feasibility of using these approaches in severe AD. Preliminary data including the perturbational complexity index and ERPs in severe AD will be presented. **Conclusion:** This feasibility work has led to an ongoing study investigating awareness in severe dementia. This novel understanding will support meaningful interactions between caregivers and people with severe dementia, and enable the targeting of interventions to improve awareness, quality of life and care for people with severe AD.

## The Perceptual Quality and Performance Judgment Influence Visibility Ratings in a Continuous Colour Estimation Task

Zuzanna Skóra, Kinga Ciupińska, Simon Hviid Del Pin, Morten Overgaard, Michał Wierchoń

The Perceptual Awareness Scale (PAS) is used to capture conscious experience, but the assumptions behind the scale are rarely tested. In a continuous colour estimation task, we focused on two aspects of the scale's validity: How well does PAS follow changes in perceptual quality as compared to the estimation task? How does the estimation task itself affect ratings? Over 3 experiments, we varied perceptual quality by manipulating the number and presentation time of stimuli in a simultaneous presentation and target position in a sequential presentation. In all experiments, PAS ratings closely followed colour precision. However, the rating was affected by task-induced response bias. To assess its influence, we replicated the experiment except for the estimation part. Even the judgment of possible task difficulty, without performing the task itself, affected the rating. In conclusion, the estimation task and PAS can be used as measures of consciousness, assuming that changes in perceptual quality underlie changes in conscious access. Secondly, PAS seems vulnerable to bias induced by performance judgment. However, it affects the absolute rating rather than the scale's ability to capture changes in perceptual quality. Reported studies shed light on factors influencing scales outside of the scale formulation and construction.

## Consciousness Science Without Metaphysics? Yes, Please.

Will Bridewell, Alistair Isaac

Consciousness understood pretheoretically is inherently subjective, yet scientific data are irreducibly intersubjective. One way to bridge this evidential and explanatory gap is to adopt a substantive metaphysical position, for instance, by identifying consciousness with some physical or informational signature. Any work that takes the study of neural correlates of consciousness to be coextensive with the study of consciousness itself implicitly makes such an assumption. This unsavory toll may appear inescapable, but we claim that scientists can retain a healthy metaphysical agnosticism and still bridge the evidential gap. In recent work we have developed a genuinely metaphysics-neutral methodology for studying consciousness. This method advocates computational models that integrate data and theories from across the cognitive sciences by simulating, in successive stages, increasing amounts of consciousness-relevant phenomena. At each stage, models that accurately capture the target phenomena are taken to provide data about what consciousness is not. By encompassing an increasing array of consciousness-relevant phenomena, a sequence of such models makes genuine progress on a scientific understanding of consciousness, even though no particular model is treated as conscious, and thus no metaphysical conceit is needed to validate it. This approach follows an apophatic logic, defining an ineffable concept by what it is not.

## Uncertainty-based inference of a common cause for body ownership

Marie Chancel, Weiji Ma, H. Henrik Ehrsson

Many studies have investigated the contribution of different senses to body ownership, i.e., the perception of our body as ours. However, the multisensory processes involved in subjectively experienced body ownership have only been qualitatively described, and the computational principles determining such sensations remain unclear. We developed a novel detection-like task to quantify the ownership participants felt towards a model hand in a version of the classic rubber hand illusion. The tactile stimulation they felt on their real hidden hand was synchronized with the visual stimulation on the rubber hand or presented earlier or later (0-500 ms). For each degree of asynchrony, the percentage of trials for which the participants felt that the rubber hand was theirs was registered under three different visual noise levels. The probability of emergence of the illusion increased with the visual noise and was well predicted by a causal inference model in which the observer computes the probability that the visual and tactile signals come from a common source. This model outperformed a non-Bayesian model that does not take into account sensory uncertainty. Finally, specificity of body ownership is discussed by comparing behavioral performances and computational outcomes from this perception to the ones from synchrony judgment.

## Variance misperception under skewed empirical noise statistics explains overconfidence in the visual periphery

Charles J. Winter, Megan A. K. Peters

Perceptual confidence typically corresponds to accuracy. However, observers can be overconfident relative to accuracy, termed 'subjective inflation'. Inflation is stronger in the visual periphery relative to central vision, especially under conditions of peripheral inattention. Previous literature suggests inflation stems from errors in estimating noise, i.e. 'variance misperception'. However, despite previous Bayesian hypotheses about metacognitive noise estimation, no work has systematically explored how noise estimation may critically depend on empirical noise statistics which may differ across the visual field, with central noise distributed symmetrically but peripheral noise positively skewed. Here we examined central and peripheral vision predictions from five Bayesian-inspired noise-estimation algorithms under varying usage of noise priors, including effects of attention. Models that failed to optimally estimate noise exhibited peripheral inflation, but only models that explicitly used peripheral noise priors incorrectly showed increasing peripheral inflation under increasing peripheral inattention. Our findings explain peripheral inflation, especially under inattention.

## A psychometric approach to implicit sense of agency: Unrelatedness of interval estimation and the Libet clock

Markus Siebertz, Petra Jansen

Research concerning the sense of agency seeks to employ objective, implicit measures. One such measure is intentional binding, i.e. the shortening of the perceived temporal interval between an action and its consequence. Various paradigms have been used to measure trait sense of agency implicitly in healthy and clinical populations. We compared the two most often used paradigms in the same participants: interval estimation and the Libet clock paradigm. We expected the two measures to be positively correlated. Using Bayes factors as a stopping criterion for data collection in a correlational study design resulted in a valid sample of 46 healthy adult students. Although both measures showed good reliability, Bayes factors indicated moderate evidence for intentional binding measured via the two paradigms to be uncorrelated. With growing research questioning whether the temporal binding of action and consequence actually measures perceived agency or rather causality between events, our results suggest that this line of questioning needs to take the characteristics of different paradigms into account.

## Does the Prefrontal Cortex Play an Essential Role in Consciousness? Insights from Intracranial Electrical Stimulation of the Human Brain

Omri Racah, Ned Block, Kieran C.R. Fox

A central debate in philosophy and neuroscience pertains to whether PFC activity plays an essential role in the neural basis of consciousness. Neuroimaging and electrophysiology studies have revealed that the contents of conscious perceptual experience can be successfully decoded from PFC activity, but these findings might be confounded by postperceptual cognitive processes, such as thinking, reasoning, and decision-making, that are not necessary for consciousness. To clarify the involvement of the PFC in consciousness, we present a synthesis of research that has used intracranial electrical stimulation (iES) for the causal modulation of neural activity in the human PFC. This research provides compelling evidence that iES of only certain prefrontal regions (i.e., orbitofrontal cortex and anterior cingulate cortex) reliably perturbs conscious experience. Conversely, stimulation of anterolateral prefrontal sites, often considered crucial in higher-order and global workspace theories of consciousness, seldom elicits any reportable alterations in consciousness. Furthermore, the wide variety of iES-elicited effects in the PFC (e.g., emotions, thoughts, and olfactory and visual hallucinations) exhibits no clear relation to the immediate environment. Therefore, there is no evidence for the kinds of alterations in ongoing perceptual experience that would be predicted by higher-order or global workspace theories. Nevertheless, effects in the orbitofrontal and anterior cingulate cortices suggest a specific role for these PFC subregions in supporting emotional aspects of conscious experience. Overall, this evidence presents a challenge for higher-order and global workspace theories, which commonly point to the PFC as the basis for conscious perception based on correlative and possibly confounded information.

## The Effects of Supraliminal vs. Subliminal Mood Induction on the Rubber Hand Illusion and the Role of Dissociative Symptoms

Franziska A. Schroter, Bianca A. Günther, Petra Jansen

The main goal of the study was to investigate the effects of a sadness induction using supraliminally or subliminally presented pictures, compared to neutral pictures on the rubber hand illusion in 122 students, with varying stroking conditions (slow (3cm/s) vs. fast (30cm/s) and synchronous vs. asynchronous). Due to possible emotion processing changes in people with dissociative symptoms, we included a questionnaire on dissociative symptoms as covariate. The results demonstrated that supraliminal sadness induction was associated with a stronger subjective illusion strength, but not with a higher proprioceptive drift. Besides, we found a stronger drift after slow, and a stronger subjective illusion after fast stroking. Compared to asynchronous stroking, synchronous stroking led to a higher drift and subjective illusion. Slow and synchronous stroking were reported to be more comforting than the respective counter conditions. Furthermore, participants with higher dissociative symptoms experienced a more pronounced subjective illusion than subjects with low symptoms, especially in the supraliminal sadness condition, pointing towards increased body plasticity after supraliminal emotion induction. Accordingly, we suggest considering interindividual differences in emotion processing when investigating the relation of body ownership and emotions. Proprioception and the subjective sense of embodiment may not be equally involved in emotion processing.

## Are judgments of agency metacognitive?

Marika Constant, Roy Salomon, Elisa Filevich

Judgments of agency, our sense of control over our actions and the environment, are often assumed to be metacognitive. However, it is unclear if the assumed link between agency and metacognition is expected to hold at the level of neural implementation, computational mechanisms, or just at the broad conceptual level. We examined this assumption at the computational level by comparing the effects of perceptual noise on agency judgments to those on confidence judgements, which are widely accepted to be metacognitive in nature. In two tasks, participants rated either agency, or confidence in a decision about their agency, over a virtual hand that tracked their movements, either synchronously or with a delay, under high and low noise. We compared the predictions of two computational models to participants' ratings and found that agency ratings, unlike confidence, were best explained by a model involving no metacognitive noise estimates. We propose that agency judgments reflect first-order measures of the internal signal, without involving metacognitive computations, challenging the assumed link between the two cognitive processes. Our findings also demonstrate, however, that participants can make meaningful metacognitive confidence judgments about agency decisions, which we suggest is better considered the metacognitive level of an agency processing hierarchy.



Do we rely on the outcome of our movements to know how we just moved?

Charalampaki Angeliki, Filevich Elisa

We can monitor and describe our intentional movements and infer agency when appropriate. But which information is more relevant to do so? For example, when throwing a ball to hit a target, do we monitor how exactly the ball flew or do we rely solely on whether we reached the goal (hitting the target) to metacognitively assess our performance? We ran a self-replication of a previous study, addressing several confounds and extending the analysis. Participants played a virtual version of a ball-throwing game, with the goal of hitting a target. After each ball throw, they discriminated which of two trajectories displayed on the screen corresponded to the one followed by the virtual ball, and then rated confidence in their own decision. We compared two conditions that differed on whether the outcome of the alternative trajectory shown matched or differed from that of the actual trajectory. Participants incorporated information about the outcome of the movement into their discrimination and confidence responses. However, information about the outcome did not affect the precision of their confidence ratings. We interpret these results as showing that different sources of information affect different action monitoring processes distinctively, although they are often treated indiscriminately in the literature.

## Dissociation Between Objective and Subjective Judgments In Uncertain Environments

Clémence Compain, Anil K. Seth, Maxine Sherman

Confidence judgements usually incorporate sensory uncertainty, such that both performance and confidence increase as the uncertainty decreases. However, in some cases performance and confidence can dissociate. This suggests that objective and subjective ratings may use different information, or integrate the same information differently. In this pre-registered study, we investigated whether and how environmental uncertainty (changes in stimulus probability over time) influences objective and subjective judgments. 51 participants performed a motion discrimination task. We manipulated expectation by having trial periods where either leftward or rightward motion was more likely. We manipulated environmental uncertainty by changing the length of those trial periods: the more probable motion direction changed either frequently (every 50 trials) or infrequently (every 100 trials). As we predicted, participants' responses were more biased by expectations in more stable environments. We found that confidence was higher when the response was congruent with the expectation, and that metacognitive sensitivity was higher when the response was incongruent with the expectation. However, these effects did not increase in a more stable environment. The fact that objective judgments are influenced by volatility, but not subjective judgments, suggests that they do not use the same information, or that they use the same information differently.

## Why consciousness isn't even epiphenomenal

Thomas W. Clark

Consciousness, in particular phenomenal, qualitative experiences like pain, is not the sort of thing that can be seen, measured, weighed, or otherwise observed from an external perspective. Consciousness is arguably a categorically private phenomenon of representational content, non-identical to its publicly observable, neurally instantiated representational vehicles. I will suggest that consciousness and its correlates inhabit two mutually non-interacting explanatory spaces, 1st person (phenomenal content) and 3rd person (vehicles and functions), respectively. Since well-formulated 3rd person causal and functional explanations of behavior are restricted to public observables such as brains, bodies and environments, private experiences such as pain are barred from playing a causal or functional role in such explanations. This constitutes a clean solution to the problem of mental causation: consciousness and its physical correlates don't causally interact since they are in different explanatory spaces, one having to do with content, the other its representational vehicles. This means that consciousness isn't epiphenomenal with respect to observable behavior: a phenomenon can only be fairly described as epiphenomenal (causally inert or inefficacious) with respect to another if they inhabit the same explanatory space. Associated paper: <https://www.naturalism.org/philosophy/consciousness/respecting-privacy>

## Directed information dissociates perceiving from reporting during visual bistability

Andres Canales-Johnson, Lola Beerendonk, Robin A.A. Ince, Simon van Gaal

Visual perception and its cognitive consequences are typically confounded as neural activity is recorded when participants have to report what they see. What are the neural mechanisms distinguishing perceiving from reporting? We asked participants to report and to don't report changes in a bistable stimulus that can be perceived as two distinct visual contents: integrated (one content) and differentiated (two contents). We combined simultaneous EEG and eye-tracking recordings with novel neurodynamical analyses of directed information and information differentiation. When perceptual changes were reported, we observed an increase in directed information from anterior to posterior signals before the stimulus was reported as integrated. Interestingly, this effect was also present when perceptual changes were not explicitly reported, i.e. when visual contents were inferred from eye movements instead of from button presses. On the other hand, before the stimulus was reported as differentiated, we observed higher information differentiation of anterior signals during the same time window. However, this information differentiation effect was not observed during the passive observation of perceptual switches. Our results suggest a differential role of neural information during perception and reporting: while frontoparietal directed information drives changes in the content of perception, frontal information diversity reflects changes in the cognitive process of reporting.

## Drivers of high entropy states in Schizophrenia and Psychedelics

Hardik Rajpal, Pedro Mediano, Fernando Rosas, Chris Timmermann, Stefan Brugger, Robin Carhart-Harris, Henrik Jeldtoft Jensen

Antipsychotics have been the primary treatment measure for Schizophrenia. Psychedelic drug models have been extensively used to mimic the behavioural alterations that occur in schizophrenia. Both psychedelic and schizophrenic states of mind are known to exhibit high signal diversity in EEG/MEG recordings of the resting state. In this study we discuss two different mechanisms that give rise to these high entropy diverse signals, corresponding to the Schizophrenic and the Psychedelic states, through a resting state predictive processing model. These mechanisms are supported by empirical findings of altered information flow, among the cortical regions, in both conditions. The analysis also sheds light on the role of antipsychotics as a treatment rather than a cure for the illness.

## Self-perception under existential threat in mindfulness meditators

Yair Dor-Ziderman, Antoine Lutz, Avi Goldstein, Aviva Berkovich-Ohana

We are conscious of 'being' in a world and interacting with others, and constantly create narratives about our self-identity, its characteristics and its social relations. However, this autobiographical story, like any story, has a beginning and an end. Terror-management research has shown powerful and automatic death-denial mechanisms, or 'defenses', operating beneath the radar of consciousness, impervious to the undeniable knowledge of our mortality. We claim that death-denial hinges on self-specific prediction-based neurocognitive mechanisms, i.e., attributing death to the other (non-self). We present a novel neurophysiological biologically-relevant visual mismatch response paradigm in which self-related stimuli (faces) are coupled with linguistic death-reminders. We show that this coupling, and only this coupling, downregulates the automatic predictive brain response, thus shielding the self from existential threat at a non-conceptual perceptual level of processing. Finally, we address the question of whether these processes are amenable to change via mental training. We present preliminary data of a unique large cohort of Buddhist meditators who had undergone a specialized training in self-other boundary dissolution. We show that meditation dramatically changes the self-specificity of death-denial processes, leading to a more realistic approach towards existential threat.

## Meditation-induced flexibility in networks supporting the embodied-self: A neurophenomenological MEG study

Yoav Schweitzer, Yair Dor-Ziderman, Fynn-Mathis Trautwein, Ohad Nave, Stephen Fulder, Yochai Ataria & Aviva Berkovich-Ohana

The nature of self-experience and its function in health and disease are of great concern to philosophers, psychologists and neuroscientists. A fundamental aspect of self-experience regards the embodied-self, a pre-reflective foundational level of selfhood tied with the sense of agency and body ownership and establishing a self-word distinction. Pilot results showed proficient meditators were able to volitionally induce such embodied-self alterations in the magnetoencephalography (MEG) lab, and that these were marked by decreases in beta-band power over medial and lateral parietal regions. Building on these proof-of-concept studies, we initiated a large-scale neurophenomenological study of the embodied self, combining neural measures (MEG), behavioral tasks and phenomenological interviews. Forty-six long-term meditators received a 3-weeks training enhancing their abilities to volitionally alter their SB, while their brain was scanned in the MEG. We show reduced SB states to be characterized by diminished self-world boundaries and a reduced sense of ownership, agency and first-person perspective. Furthermore, we were able to confirm beta-band reductions to be a neural signature of flexible and reduced SB. The results are interpreted and discussed within a predictive processing framework of self-consciousness, marking reduced top-down priors in regions of multi-sensory integration.

## The prognostic value of heart-evoked potentials in acute unresponsive patients

Leah Banellis, Damian Cruse

Predicting recovery of consciousness after severe brain injury is a challenge of modern medicine, with implications for care and rehabilitation decisions. Such disorders of consciousness are defined as dysfunctions in awareness of the environment and the self. Despite these dual diagnostic criteria of consciousness, research has focused almost exclusively on responses to exteroceptive stimuli. Yet, the processing of visceral signals from the body (i.e. interoception) have been found to be important for embodied selfhood, emotion, and other high-level cognitive processes. Indeed, heart-evoked potentials (HEPs) have been observed to predict visual consciousness, reflect self-recognition, bodily self-consciousness, and vary with self-processing dimensions, thus their detection may predict the recovery of conscious self-related processes. Here, we will investigate the prognostic potential of resting HEPs in acute unresponsive patients in the intensive care unit. We hypothesise that HEP amplitude and variance will be predictive of outcome at 3 and 6 months, measured via the Glasgow Outcome Scale Extended. Furthermore, we expect HEP properties to improve the accuracy of prognoses relative to behavioural standards alone (i.e. Glasgow Coma Scale). Our expectations would demonstrate the potential of HEPs for predicting the recovery of awareness from acute unconscious states, potentially via self-cognitive mechanisms.

## Surely It wasn't me: The Sense of Agency and Metacognition in Healthy and Psychosis Patients

Amit Regev Krugwasser, Yoni Stern, Eiran V. Harel, Roy Salomon

The Sense of Agency (SoA) is the sensation of control over our actions and is thought to rely primarily upon the comparison of predicted and actual sensory signals. Thus, inducing sensorimotor conflict between actions and observed movements reduces SoA. Deficits in SoA have been suggested to underlie abnormal self-other delineation as found in psychosis, such as passivity symptoms. Furthermore, it is yet unclear if psychosis patients are aware of their deficits in SoA. We designed a study that explores both SoA and metacognition of SoA, in healthy and psychosis patients populations. We discovered striking differences between the populations in SoA - patients were less sensitive to sensorimotor conflicts (i.e. recognized an altered movement as such to a lesser extent compared to healthy participants) and showed a strong bias to attribute altered movements to themselves. Using these results, we created an automatic classifier based on SoA, allowing 89% classification accuracy. Furthermore, we discovered deficient metacognitive processing of SoA in the psychosis patients, as confidence ratings were similar to the healthy group despite reduced accuracy in the psychosis group. This deviant performance of the psychosis patients indicates that not only do they suffer from aberrant SoA processing, they also have no metacognitive insight of their deficit. Our results shed light on the cognitive mechanisms underlying the weakening of self-other boundaries in psychosis and may allow the development of new tools for early diagnosis and treatment of psychosis.

## Contending with unconscious phenomenality

Michal Polák

Current orthodoxy defines phenomenality through consciousness: phenomenal features are conscious features. The central claim of the paper is that phenomenality can be separated from consciousness and treated independently (dual model). Perhaps the most serious consequence of this separation is that it opens up the possibility of unconscious phenomenality. First, I will analyze what follows when we conditionally take the model of unconscious phenomenality at face value, and try to explore how it changes our thinking about phenomenality, consciousness and what-it-is-likeness. In the second part, I will address following objections against a case of unconscious phenomenality:

- 1) It is conceptually true that phenomenality and consciousness are inseparable. Consciousness simply is an essential feature of phenomenality.
- 2) Multimodal perceptual experiences have features that cannot be processed without consciousness.
- 3) Psychophysical experiments and neural research show that unconscious processing does not involve any phenomenal features as all perceptual features are processed on sub-personal level.

I will attempt to show that the power of these arguments depends on both the theoretical position held and the empirical questions as yet unanswered. If so, this allows us to consider the dual model as a fully-fledged alternative framework for phenomenality.

## The Exclusion Axiom of Integrated Information Theory of Consciousness

Nithin Nagaraj

Integrated Information Theory of Consciousness or IITC is a leading scientific theory of consciousness (Oizumi et al. 2014; Tononi and Koch 2015; Tononi et al. 2016) with promising possibilities. IITC begins by making observations about Consciousness (or Conscious Experience) which are self-evident and hence constitute axioms for the theory. The five axioms are 1) Intrinsic existence, 2) Composition, 3) Information, 4) Integration and 5) Exclusion. While, these axioms have been critically examined previously (Bayne, 2018), the goal of this paper is to point out that the exclusion axiom constrains Consciousness (or rather its contents) spatio-temporally which is not necessary. The first 4 axioms of IITC do not require 'space' or 'time' to be fundamental in constraining Consciousness or its contents. It is only in the Exclusion axiom (#5) that space and time are posited. By employing axioms 1-4, one can define (or reduce) 'space' and 'time' as two specific difference relations on a sequence of conscious perceptions. The difference relation that exists in conscious experiences (Axiom #3) is indeed fundamental (Chalmers, 1995; Bateson 1979) and sufficiently powerful to build concepts pertaining to space, time, geometry, probability and dynamics. The implications of this on the postulates of IITC will be discussed.

## Depression as a Global State of Consciousness

Cecily M K Whiteley

First-person reports of Major Depressive Disorder reveal that when an individual becomes depressed, a distinctive phenomenological change occurs. The depressed individual reports that a 'profound shift' has occurred with respect to the way they are 'rooted' in the world or in reality; a distinctive change which is connected to the elusive sense in which depression involves a feeling of detachment from the world and other people. This paper outlines and motivates a new hypothesis about depression which, drawing on recent developments in consciousness science, can account for and illuminate the distinctive phenomenology of depression, as well as several of its notable neurobehavioral features, in naturalistic terms. This is the hypothesis that when an individual becomes depressed, the individual departs from a state of ordinary wakefulness and enters a distinctive global state of consciousness. On this view, the changes a depressed individual undergoes are profound and resemble the changes to their experience that occur when they depart from waking consciousness and start dreaming, or when they enter a psychedelic state. I conclude by outlining three new lines of research - on the dimensions of global states of consciousness, the mechanistic basis of depression and psychedelic psychiatry - which this hypothesis uniquely facilitates.

## Effects of expected task difficulty on metacognitive confidence and multitasking

Maxine T. Sherman, Anil K. Seth

In daily life, repeated experiences with a task (e.g. driving) will generally drive the development of beliefs about one's ability ("I am a good driver"). Here we ask how such beliefs - self-efficacy - interact with metacognitive confidence. Across three pre-registered experiments, participants made perceptual judgements and reported retrospective confidence. We induced blockwise contextual beliefs about performance (our operationalisation of self-efficacy) by manipulating the ratio of easy to difficult trials. Results showed that context and difficulty interacted in a multiplicative fashion, consistent with confidence combining decision evidence with a prior (contextual) belief on being correct. This occurred despite context having no effect on performance itself. We then reasoned that performing tasks in easy contexts may reduce "load", and tested this by instructing participants to perform two tasks concurrently. Indeed, and consistent with a reduction in load, the effects of context transferred from influencing confidence on our primary task to improving performance on the secondary task. Taken together, our results reveal that contextual beliefs about performance facilitate multitasking, potentially by reducing the load of tasks believed to be easy, and they extend psychophysical investigations of perceptual decision-making by incorporating 'higher-order' beliefs about difficulty context, corresponding to intuitive notions of self-efficacy.

## Anodal tDCS over the left DLPFC unable to modulate mind-wandering propensity or underlying dynamic functional connectivity

Sean Coulborn, Davinia Fernández-Espejo

Research has shown anodal transcranial direct current stimulation (tDCS) over the left dorsolateral prefrontal cortex (DLPFC) was able to increase mind-wandering propensity. However, subsequent studies failed to replicate these findings thus questioning tDCS' ability to modulate self-generated processes. In our study, 20 participants received 20 minutes of anodal or sham tDCS over the left DLPFC while in the MRI scanner, in 2 separate sessions (counterbalanced). In each session, they completed two runs of a sustained attention task (before and during tDCS), which included probes recording subjective responses of mind-wandering. We assessed behavioural responses and employed dynamic functional network connectivity (dFNC) over regions of the default mode, salience and executive control networks to look at the effects of tDCS over behaviour and functional dynamics. Behavioural results provided substantial evidence in support of no effect of tDCS on task performance nor mind-wandering. dFNC analysis showed no effect of tDCS on frequency (how often) or dwell time (time spent) in underlying brain states. Overall, our results suggest that DLPFC-tDCS is unable to modulate mind-wandering propensity or influence underlying functional connectivity. This expands previous replication failures in indicating that tDCS is unlikely to lead to even subtle changes in mind-wandering related brain activity.

## Temporal Binding in Multi-Step Action-Event Sequences

Felicitas V. Muth, Robert Wirth, Wilfried Kunde

Actions producing effects are perceived to have happened later, while those effects are perceived to have happened earlier, compared to either happening in isolation. This perceived compression of the interval between action and effect is termed temporal binding and serves as an implicit measure for sense of agency. In everyday life, oftentimes multiple actions are required for goal attainment, i.e., a multi-step sequence of actions has to be performed before the desired effect happens. However, present-day research mainly assesses the sense of agency for single actions and effects, and preliminary work on the sense of agency in longer action-effect sequences is inconclusive. To fill this gap, the line of research presented studies temporal binding in multi-step action-event sequences. We employed a temporal binding paradigm in which participants had to press two keys to evoke corresponding effects, once in a forced choice (Experiment 1) and once in a free choice paradigm (Experiment 2). Overall compression of the interval between actions and effects was driven by strong effect binding for both effects, while there was no action binding in either of the experiments. These observations might inform the design of human-machine interfaces as they emphasize on the temporal alteration of effect perception.



Studying P-without-A experimentally: a novel paradigm for isolating phenomenal and access consciousness.

Yoni amir, Yaniv Assaf, Yossi Yovel, Liad Mudrik

Does phenomenal consciousness exist in the absence of any access? The dissociation between phenomenal (P) and access consciousness (A) is a matter of ongoing debate. Perhaps most challenging is the apparent inability to experimentally demonstrate the existence of P-without-A; once subjects report having a P-experience, by definition it is also A-conscious. Although overflow studies tried to tease A-consciousness and P-consciousness apart, an online access to the stimuli during these procedures cannot be denied. Therefore, a more direct demonstration of P-without-A would have to entail (a) lack of access during the stimulation; (b) some indication that this stimulus was still experienced phenomenally; and (c) evidence that the stimulus was not simply unconsciously processed. Here, we meet all these challenges by presenting a novel paradigm for probing P-without-A. Subjects are presented with overlapping sounds that are sometimes accompanied by an ongoing, continuous pink noise. They are probed about this noise both in real-time and in retrospect. Then, they perform a discrimination task to determine which of two different pink noises was presented. The combination between online, real-time reporting and post-stimulus one accordingly allows us to uniquely experimentally separate P-consciousness from A-consciousness and tease the two apart.

Retro-perception at a cocktail party: can retrospective attention bring to consciousness words that were initially ignored during dichotic listening?

Axel Garnier-Allain, Daniel Pressnitzer, Claire Sergent

How temporarily linked are conscious perception and sensory processing of a stimulus? Different accounts propose that consciousness arises either time-locked to the stimulus, or to the moment of attention allocation toward it. Recent work suggested that conscious perception could be retrospectively triggered by an attentional cue displayed after an unseen stimulus, challenging the first of these two views. Most studies investigating this flexibility in the timing of conscious perception have done so in the visual modality. But retro-perception should also be at play in other modalities. We expect it to be especially important for audition where the fleeting status of sounds makes it particularly critical to be able to re-inspect previously unconscious stimuli. In a series of experiments using dichotic listening, we investigated the effect of a cue on the perception of an unattended auditory target word. We observed both pre-cueing and retro-cueing effects on target identification. Crucially, these cues also improved both subjective and objective report of the target, suggesting a genuine retro-perception effect rather than a memory effect. These results, decoupling the initial sensory processing of a stimulus from its conscious access, are in line with conscious perception being time-locked to attention allocation rather than stimulus onset per-se.

How the bodily self-interacts with the remembered self: Episodic autobiographical memory for virtual scenes is modulated by different levels of bodily self-consciousness during encoding

N.H. Meyer\*, B. Gauthier\*, E. Franc, F. Lance, J. Potheegadoo, O. Blanke

Episodic autobiographical memories (EAM) are contextual memories of self-related events and depend on different processes during encoding, storage, and retrieval. Recent work using virtual reality showed that the strength of EAM during retrieval depends on the perspective at encoding, with richer EAM when the event was encoded from a first-person perspective (1PP) with own body view compared to a third-person perspective or without body view. Interestingly, 1PP and body view are important aspects of bodily self-consciousness (BSC), a form of self-consciousness based on multisensory and sensorimotor bodily mechanisms. Here, we hypothesize that the experimental modulation of BSC during EAM encoding modulates and improves EAM recognition. We designed immersive virtual environments coupled with upper limb motion tracking to modulate BSC through visuomotor synchrony during encoding. One hour after, we tested participants with a recognition task and report that they were significantly better in detecting changes in scenes encoded during conditions with elevated BSC. These empirical data show that BSC contributes to EAM by demonstrating that an enhancement of BSC based on online sensorimotor stimulation boosts EAM recognition. We discuss how the brain mechanisms of the bodily self (BSC) interact with those of encoding and retrieval of the remembered self (EAM).

Can we use introspective reports of intention and movement to diagnose psychopathology?

Tomáš Dominik, Roman Procházka

Over the past 20 years, findings in the literature consistently suggested that certain mental disorders lead to abnormal subjective timings of intention to move or movement itself. Our study explored whether such timings could be used to distinguish between selected groups of psychiatric patients and a sample of healthy population. Specifically, we expected later intention reports in individuals with addiction, neurotic disorders, or psychotic disorders, and later movement reports in individuals with neurotic disorders. We examined 58 patients and 51 control participants in face-to-face sessions. We asked the subjects to perform voluntary uncued button presses while watching a rapidly revolving clock and subsequently report the clock position in the moment they first felt the intention to move (W reports) or the finger movement itself (M reports). The valid results of 47 patients and 40 controls did not support our expectation of later M reports associated with neurosis, nor our expectation of later W reports associated with addiction, neurosis, or psychosis. In fact, in addiction and neurosis, we found a significant effect in the opposite direction. Supplementary analyses suggested that this inconsistency with the previously reported results might be due to the effect of specific medication rather than the diagnoses themselves.

## Steady-state evoked potentials differentiate between exteroceptive and interoceptive attention

L Kritzman, M Eidelman-Rothman, D Freche, A Keil, G Sheppes, N Levit-Binnun

Interoception is the sense of the physiological condition of the body. Developing objective measures of interoception is important for understanding its role in consciousness and metacognition. Here we demonstrate the use of steady-state evoked potentials (ssEPs) as means to measure differences between exteroceptive and interoceptive attention. ssEPs are relatively narrow band oscillations that have the same frequency peak as a driving sensory stimulus and are characterized by an excellent signal-to-noise ratio. While studied in various exteroceptive attention paradigms, it is not clear whether ssEPs are sensitive to interoceptive attention. To address this, 43 healthy participants performed a ssEP task, which included the presentation of flickering dots along with an attention task. Participants were instructed to look at the dots presented on the screen and to either count their heartbeats (interoceptive attention) or to count visual targets (exteroceptive attention). ssEPs amplitude and phase stability, as well as alpha activity and the heartbeat evoked potential, were extracted. Our findings indicate that relative to exteroceptive attention, interoceptive attention reduced ssEPs amplitude and phase stability, increased alpha activity and the amplitude of the heartbeat evoked potential. These results provide initial evidence that ssEPs can be harnessed to study interoceptive processes.

## Interpreting neural measures of consciousness in disorders of consciousness: a role for a comparative, inductive approach?

Jasmine Walter

Disorders of consciousness (DOC) pose a significant clinical and ethical challenge because they allow for complex forms of conscious experience in patients where intentional behaviour and communication are limited. There has been an ongoing research effort to develop neural measures to assess consciousness in DOC. However, we face an epistemic challenge in validating these measures because we have no ground truth about the presence or nature of consciousness in many DOC patients. Neural measures of conscious “level” also raise an ontological question, as there is a growing view that consciousness is a multidimensional phenomenon that cannot be fully described by a unidimensional measure. One alternative to traditional clinical validation for neural measures in DOC is to consider independent evidence drawn from studies where these measures have been applied in other states and populations where more is known about conscious experience. This information can support inductive inferences about which dimensions of consciousness are most correlated with these neural measures in general. Though these inferences cannot provide conclusive evidence about DOC consciousness, I argue that this comparative, inductive approach can provide valuable guidance in the development of a precise, multidimensional framework for interpreting the results of neural measures of consciousness in DOC patients.

Pupil dilation modulations in response to different degrees of visual awareness and different threatening body signals

Marta Poyo Solanas, Minye Zhan, Beatrice de Gelder

Substantial evidence has been gathered over the years about emotional image processing outside awareness in both blindsight patients and healthy participants. However, these findings are often currently criticized for being artefacts of the tasks used to assess awareness. Here, we investigate the processing of threatening body expressions in healthy participants by means of a continuous flash suppression paradigm (CFS) while accounting for the continuous and subjective nature of perceptual awareness by using four different response alternatives: (1) “no experience”, (2) “brief glimpse”, (3) “almost clear experience” and (4) “clear experience”. Participants showed a significantly higher recognition sensitivity for fearful bodies than for angry ones in all visual awareness conditions except during no experience of the stimulus. In addition, perceiving fearful and neutral body expressions elicited a significant larger pupil size in comparison to angry body expressions. Larger pupil sizes were also observed as the visual experience of the body expression became clearer. In conclusion, this study shows pupil dilation modulations in response to different degrees of visual awareness and emotional signals and suggests that fearful and angry body expressions may be processed differently despite both stimuli signaling threat.

Prior exposure to supportive contexts improves implicit learning of phrase structure grammars

Lu Zhao, Qingyun Zhang, Xiaoli Ling

The perception and processing of phrase structure grammars characterized by structural hierarchies is a core human linguistic competence, with no known equivalent in animal communication systems. Previous studies have revealed that these grammars can be detected and learned implicitly, but appear to be subject to some constraints using artificial grammar learning paradigms in the lab. Three experiments were conducted to investigate that prior exposure syntax in simple contexts can highlight similar structures in subsequent input, facilitating the implicit acquisition of more difficult phrase structure grammars. Experiment 2 and Experiment 3 consisted of a two-part memory task (Pre-Exposure Phase and Exposure Phase). To establish a learning baseline, Experiment 1 has no Pre-Exposure Phase) in which participants were asked to listen to and memorize grammatical strings, followed by a classification task. Results showed that exposure to learnable structures associations can boost participants' ability to unconsciously learn complex phrase structure grammars relation. These findings demonstrated that improvement of implicit learning in complex language structures can be based on prior exposure in supportive contexts.

## Body representations in self-referential related brain regions

Inbal Linchevski, Noa Zeharia, Or Yizhar, Keinan Poradosu, Yulia Golland, Amir Amedi, Nava Levit-Binnun

The default mode network (DMN) is a large-scale brain network activated by intrinsic, self-referential tasks and deactivated by externally-directed, attention demanding tasks. A central component of self-related processing is information associated with one's body. Conversely, movement is a key way by which the self-executes externally-directed tasks. In this study, we investigated whether body movements are represented as external or internal tasks, inducing negative or positive blood oxygenation level-dependent (BOLD) functional Magnetic Resonance Imaging (fMRI) activity, respectively. We also examined whether differential activation patterns resulted from movement of different body parts. Results show modulation of brain regions concerned with self-referential activity by simple body movement and set apart the face from other body parts in relation with activity in these regions. Specifically, body-parts' movement, overall, led to deactivation in several DMN nodes, namely the temporal poles, hippocampus, medial prefrontal cortex (mPFC) and posterior cingulate cortex. Facial movement induced an inverted and selective positive BOLD pattern in the temporal poles, hippocampus and mPFC. Face movement selective areas in the temporal poles showed functional connectivity with the hippocampus, mPFC and the nucleus accumbens. These findings suggest that conceptual and embodied self-related processes may be mapped onto shared brain networks.

## The role of metacognition in monitoring performance and regulating learning in early readers

Ioanna Taouki, Marie Lallier, David Soto

Metacognition refers to the capacity to reflect upon our own cognitive processes. Although there is an ongoing discussion in the literature on the role of metacognition in learning and academic achievement, little is known about its neurodevelopmental trajectories in early childhood, when children begin to receive formal education in reading. In the present talk, we will present the results of a longitudinal behavioral study carried out in a cohort of children aged between 6 and 7 ( $N=60$ ), for which we evaluated their metacognitive efficiency ( $\text{meta-}d'/d'$ ) in linguistic (lexical decision, visual attention span) and non-linguistic contexts (emotion recognition), and related this to the children's performance in general standardized tests of cognitive abilities. We show that a) there is no evidence of associations between metacognitive ability (i.e. how confidence ratings track accuracy in the task) and students' performance in standardized tests of reading ability and general cognitive skills in this early stage of reading acquisition, b) domain-specific resources are more likely to support metacognition at this age and c) metacognitive efficiency is a significant predictor of longitudinal learning in both a linguistic and a non-linguistic task context, which highlights its importance as a tool in life long learning.

## Attention modulates information format and information content of intracortical auditory predictions

Tara Tahseen, Simon Houtman, Laura Imperatori, Alejandro Blenkmann, Robin Ince, Tristan Bekinschtein, Andres Canales-Johnson

Detection of novel sensory information enables predictive interaction with the surrounding environment. Neural mechanisms of prediction error are typically studied by presenting a series of “standard” stimuli with intermittently occurring deviant stimuli, also called “oddballs”, and by contrasting brain responses between these stimuli categories. The most widely studied deviance ERP is the auditory mismatch negativity (MMN) – a negative deflection of electrical event-related potential recorded using intracranial electrodes. However, the effects of attention on the MMN response and their underlying cortical mechanisms are not well understood. Using intracortical EEG (iEEG) during a global/local paradigm, we investigate the effects of attention on the MMN response in five human participants with electrodes located in the auditory, frontal and parietal cortices. Using a novel approach combining multivariate pattern analysis (MVPA) and information theoretic analyses based on information decomposition, we show that attention modulates MMN information both in format and content. Specifically, our results show that attention not only enhances the cross-time decoding patterns (information format) between standard and deviant tones, but also the type of information (information content) of those same MVPA patterns within and between cortical regions, and across global and local condition.

## Awareness is required for Autonomic Performance Monitoring in Instrumental Learning: Evidence from Cardiac Activity

Lina I. Skora, James J. A. Livermore, Federica Nisinia, Ryan B. Scott

Cardiac deceleration in response to feedback has been extensively studied in the context of learning and decision-making. Deceleration after error-related negative feedback is reliably observed and precedes explicit awareness of the stimulus-outcome contingency. It is reasonable to infer that this form of autonomic performance monitoring may support learning in the absence of conscious awareness. Cardiac deceleration is consistently seen in instrumental conditioning when stimuli are consciously perceived, and in simpler learning tasks even when stimuli are absent from awareness. However, recent failures to replicate unconscious instrumental conditioning raises a key question as to whether such autonomic performance monitoring can occur in this paradigm when stimuli are not consciously perceived. Here, we employed an instrumental conditioning task, requiring approach or avoid responses to visually masked stimuli predictive of reward and punishment, paired with continuous ECG assessing cardiac activity. The imperfect masking process permitted us to contrast learning and cardiac deceleration for trials with, versus without, conscious stimulus awareness. Our results revealed that while learning was not significant in either condition, there was reliable evidence for error-related cardiac deceleration in trials when stimuli were consciously perceived, and reliable evidence for its absence in trials where stimuli were outside of conscious awareness.

What could patients teach us about the limits of cognitive-motor dissociation?

Perrine Séguin, Emmanuel Maby, Fabien Perrin, Alessandro Farnè, Jérémie Mattout

Despite recent improvements in the assessment of patients with disorders of consciousness, it is still a critical issue to detect covert cognition behind total paralysis. This motivated the use of non-motor paradigms to assess consciousness. However, the effectiveness of these tools for detecting consciousness in the face of motor disability remains questionable. Recent studies reveal that electrophysiological parameters conventionally used to detect consciousness, such as the P300, are disturbed in conscious but almost totally paralyzed patients, like patients with locked-in syndrome (LIS) due to a brainstem injury or amyotrophic lateral sclerosis. In this talk, we will critically review the literature related to patients with LIS, which highlights this difficulty to detect their covert response to command. Specifically, we'll underline that electrophysiological paradigms based on mental tasks are also impacted by motor impairments. We hypothesize that selective attentional processes are likely to be altered, concomitantly with, or as a result of motor disorders, especially oculomotor ones. Interestingly, this hypothesis appears to be in line with cognitive and computational theories of brain functions that tightly couple perception and action. Drawing from these theories, we will discuss key dimensions that are under-investigated in these patients, such as volition, interoception, or peri-personal space processing.

Time and the search for physical properties of consciousness

John Sanfey

There are no known physical properties of consciousness. Here I show that the conscious experience of time, the now, is reflected in scientific methodology by equivalent, abstract systems. This functional equivalence forms a bridge between consciousness and science, and it makes empirically testable predictions for the behaviour of neural correlates of consciousness in the brain. The analysis begins in the fundamentals of science. All scientific models use a variety of abstract tools such as calculus and field theory that describe and analyse change that humans experience during the interval of time we call now. Such abstract systems create virtual now-ness in a manner equivalent to the device that generates perception in the first place. The concept of functional equivalence means that the properties of these abstract systems also describe the mechanics of human perception.

## Influence of affective valence on perceptual filling-in

Nils Kraus, Guido Hesselmann

Predictive coding models of human cognition conceive perceptual and affective processes to be closely interconnected. It is yet still an open question, whether the link of both processes is limited to the unidirectional influence of perceptual prediction errors on emotion or whether emotional status also can in turn alter low-level perceptual processing. In order to elucidate this question, in this preregistered study 50 participants listened to either harmonic instrumental music or stressful acoustic noise, inducing positive and negative affect. They were then asked to report onset times in a visual illusion task (uniformity illusion). The uniformity illusion consists of a visual pattern in which central and peripheral contents differ from another but where central fixation leads to the extrapolation of foveal contents to extrafoveal areas of the visual field. The results are showing a significant reduction of the time for this perceptual filling-in to take effect (difference in response times of illusionary and control trials) when induced affect in participants was positive compared to negative. These findings suggest an influential role of emotional states in low-level perceptual processing, furthering our understanding of emotion-perception interactions.

## Perception of one's own body within an immersive realistic environment enhances accuracy and re-experiencing during memory retrieval

Heather Iriye, H. Henrik Ehrsson

Our bodies provide a necessary scaffold for memories of past events. Yet, we are just beginning to understand how feelings of one's own body during the encoding of realistic events shape memory. Participants formed memories for lifelike events by watching pre-recorded 3D videos that involved a first-person view of a mannequin's body through head mounted displays. We manipulated feelings of body ownership over the mannequin using a perceptual full-body illusion. Participants saw an object touch the mannequin and simultaneously felt touches on the corresponding location of their real body, which created an illusory sense of ownership over the mannequin. As a control condition, we disrupted the illusion by delivering seen and felt touches in an alternating pattern in half of the videos. Participants completed cued recall questions and subjective ratings (i.e. degree of reliving, emotional intensity, vividness, and belief in memory accuracy) for each video immediately following encoding and one week later. Sensing the mannequin's body as one's own during encoding enhanced memory accuracy across testing points, immediate reliving, and delayed emotional intensity, vividness, and belief in memory accuracy. These findings demonstrate that a basic sense of bodily selfhood provides a crucial foundation for the accurate reliving of the past.



## On Intrinsically Valenced Perception

Hilla Jacobson

Common philosophical wisdom still identifies the phenomenal characters of perceptual experiences with their sensory aspects. Against this backdrop, it has recently been argued that perceptual experiences have another significant phenomenal aspect. Perceptual experiences – from pains to supposedly “neutral” visual experiences – are standardly valenced: what it's like to undergo them is pleasant/unpleasant, it feels good/bad to some degree. My first goal is to support a close relation between valence and perceptual experiences, focusing on empirical evidence suggesting that the valences associated with perceptual experiences are not post-perceptual. My second goal is to elucidate the notion of intrinsically valenced perception (IVP) and defend its coherence. What is required for perception to be intrinsically valenced? Specifically, if perception itself is valenced, what should be the relations between its valenced and its sensory aspects? I will identify various constraints that IVP should meet. I will then defend a principle that aims to capture IVP and best accommodates the previously identified constraints. Finally, I will defend the coherence of this principle by offering a more specific model of the relations between sensory and valenced aspects, according to which valence is a determination-dimension along which the phenomenal characters of experiences with specific sensory aspects vary.

## Expectation in Perception

Rebecca Keller

This project gives a characterization of perceptual expectation as a kind of objective perceptual representation, representing perceptual attributives unattached to singular perceptual tokens. Perceptual expectations are a distinct subset of what neuroscience and psychology generally calls expectations, which likewise function in the production of perceptions, in that perceptual expectations are unique in their memory-based etiology, genuinely perceptual content, and future-facing function. They function to represent some way that the world will be, but that it is not presently observed to be. Critically, however, the perceptual expectation account makes no commitment to this being implemented as induction, differentiating it and making it preferable to strong predictive coding accounts. In fact, the perceptual expectation account is entirely implementation-neutral. I review extant empirical evidence from neuroscience and psychology that supports the existence of perceptual expectations. I argue that perceptual expectations contribute perceptual representational content to perception, and that they function to produce accurate perceptions under suboptimal perceptual conditions.

## How Hypnosis Experiments Question the Plausibility of Counterfactualist Mental Causation

Ben Whittington

The predominant method of explaining mental causation from a thoroughly physicalist perspective is via a counterfactualist model of causation (i.e., Barry Loewer, Karen Bennett, Peter Menzies, Christian List, Adina Roskies, and Derk Pereboom). These models in particular rely heavily on the notion that phenomenal conscious properties and events and their neural correlates are non-separable. However, the recent Wegnerian experiments with hypnosis raise serious questions for this assumption. This talk will examine the potential implications for these hypnotic experiments on agency for counterfactualist models of mental causation. I shall argue that these experiments provide evidence that, even if counterfactualist mental causal models were plausible, physicalist mental causation in the actual world still would not be plausible.

## Evaluating type 1 error rates of traditional and hierarchical measures of metacognitive accuracy

Manuel Rausch, Michael Zehetleitner

A key aspect of metacognition is metacognitive accuracy, i.e., the degree to which confidence judgments differentiate between correct and incorrect trials. To measure metacognitive accuracy, researchers are faced with a plethora of established and novel options. We investigated type 1 error rates associated with different measures of metacognitive accuracy by hierarchical resampling from the confidence database, a large online collection of confidence data sets, in order to accurately represent the statistical properties underlying confidence judgements. All measures that require the traditional first-level analysis separately for each participant and a subsequent group-level analysis using coefficients computed during the first level analysis performed fine in terms of type 1 error rates, including gamma correlations, confidence slopes, meta- $d'$ , meta- $d'/d'$ , and type 2 ROC curves. In contrast, measures based on a hierarchical analysis did not perform equally well: Hierarchical meta- $d$  was associated with a type 1 error rate slightly above the nominal alpha level. Logistic mixed model regression was associated with dramatically inflated type 1 error rates when random slopes were omitted from model specification. Overall, it is argued that newly proposed hierarchical measures of metacognitions should not be trusted unless they are accompanied by a rigorous examination of type 1 error rates.

## Performance and the development of explicit knowledge in implicit sequence learning

Clarissa Lustig, Sarah Esser, Hilde Haider

Recent studies in implicit learning investigate how implicit acquired knowledge becomes consciously aware. For the serial reaction time task (SRTT), Haider and Frensch (2005) propose that an unexpected change in one's own behavior can trigger search processes, whose content might become aware. A consistent empirical finding is that participants who gain explicit knowledge show a sudden decrease in reaction times. This so called RT-drop might show the point in time when explicit knowledge occurs (Haider & Rose, 2007). Here, we investigated whether the RT-drop is necessary for the development of explicit knowledge. To answer this question, we manipulated the timing of long and short response stimulus intervals (RSI). In the blocked-RSI condition, the RSIs were presented in blocks, which should facilitate the expression of a RT-drop. In the random-RSI condition, the RSIs changed randomly. For this condition, the expression of a RT-drop should be hampered. We found that more participants of the blocked-RSI condition than of the random-RSI condition showed an RT-drop. The amount of explicit knowledge did not differ between these two conditions. The findings suggest that the RT-drops accompany the development of explicit knowledge and do not seem to be a necessary presupposition for explicit sequence knowledge.

## The First Prior - from Co-Embodiment to Co-Homeostasis in Early Life

Anna Ciaunica, Axel Constant, Hubert Preissl, Katerina Fotopoulou

The idea that our perceptions in the here and now are influenced by prior events and experiences has recently received substantial support and attention from the proponents of the Predictive Processing (PP) and Active Inference framework in philosophy and computational neuroscience. In this paper we look at how perceptual experiences get off the ground from the outset, in utero. One basic yet overlooked aspect of current PP approaches is that human organisms first develop within another human body. Crucially, while not all humans will have the experience of being pregnant or carrying a baby, the experience of being carried and growing within another person's body is universal. Specifically, we focus on the development of minimal selfhood in utero as a process co-embodiment and co-homeostasis, and highlight their close relationship. We conclude with some implications on several critical questions fuelling current debates on the nature of conscious experiences, minimal self and social cognition.

## Anomalous Self- and World-Experiences in Depersonalisation Traits - a Qualitative Study

Anna Ciaunica, Elisabeth Pienkos, Estelle Nakul, Luis Madeira, Harry Farmer

This paper proposes a qualitative study exploring anomalous self and world-experiences in individuals with high levels of depersonalization traits. Depersonalization (DP) is a condition characterized by distressing feelings of being a detached, neutral and disembodied onlooker of one's mental and bodily processes or even of reality itself ('derealization'). Feelings of depersonalization are extremely common in the general population, yet under-acknowledged and under-examined. Our findings indicate the presence of a wide range of anomalous experiences traditionally understood to be core features of depersonalization, such as disembodiment and disrupted self-awareness. However, our results also indicate experiential features that are less highlighted in previous work, such as faster time perception and blurriness of the self/other boundaries which may play a key role in altering one's sense of self and sense of presence in the world. Our qualitative study provides an in-depth examination of self-reported disturbances of one's relatedness to one's self and the world, thereby shedding further light on the nature of altered subjective experiences in DP. In doing so, this paper draws attention to key aspects yet overlooked that may prove valuable for potential diagnosis and therapy. We conclude by highlighting limitations of this study and a number of open questions that further work needs to address in the future, in order to better understand this condition and to improve the quality of life of those experiencing depersonalization.

## Neural correlates of the DMT experience determined via simultaneous fMRI and EEG

Christopher Timmermann, Leor Roseman, Fernando Rosas, Lisa Luan, Hannes Kettner, Sharad Haridas, David Erritzoe, Enzo Tagliazucchi, Carla Pallavacini, David Nutt, Robin Carhart-Harris

DMT is a psychedelic that induces immersive phenomenology associated with experiencing 'alternate realms' and communication with sensed presences or 'entities', in a state of partial disconnection from the external environment. In this study we sought to determine the effects of DMT using simultaneous EEG-fMRI. Twenty participants were enrolled in a single blind, placebo-controlled, counter-balanced study, and underwent 2 placebo and 2 DMT EEG-fMRI sessions. fMRI results revealed significant decreases in network integrity in canonical resting state networks (RSNs), while global functional connectivity was increased under DMT compared to placebo, and associated with 5-HT<sub>2A</sub> receptor density. EEG findings revealed strong decreases in alpha oscillations and increases in low-frequency power and spontaneous signal diversity. Widespread increases in global connectivity were associated with increases in delta and decreases in alpha power. Our results indicate that the immersive psychedelic state induced by DMT is associated to reduced modularity, increased global integration, and higher repertoire of brain states. Importantly, increased low-frequency power (a signature commonly attributed to reduced levels of awareness) was significantly associated with fMRI measures of global connectivity), suggesting that low frequency power might signal disconnection from the external environment but not reduced levels of conscious experience.

## Where is my voice from? Spatial judgment of self- and other-voice

Wen Wen, Yuta Okon, Atsushi Yamashita, and Hajime Asama

Processing of self-voice has attracted widespread attention in psychology and psychiatry, because of the importance of self-voice in self-recognition, as well as the link between self-voice recognition and auditory hallucination, which is a major feature of many psychoses. We investigated people's distance perception of their own voice when the voice was heard from external locations. After speaking a short vowel, participants heard their own voice from one of four speakers that were placed either 90 or 180 cm from their sitting position. They then indicated which speaker they heard the voice from. Their voices were either pitch-shifted by  $\pm 4$  semitones (other-voice condition) or not altered (self-voice condition). The results showed that self-voice from closer speakers was misattributed to further speakers to a significantly higher extent than other-voices. Structural equation modeling using participants' schizotypal scores showed that the effect of self-voice on distance perception was significantly associated with the score of delusional thoughts and distorted body image in the active speaking session but not in the replay session. The findings of the present study provide important insights for understanding how people process self-related stimuli when there is a small distortion and how this may be linked to the risk of psychosis.

## Metacognitive training: the devil is in the confidence scale

Martin Rouy\*, Vincent de Gardelle, Gabriel Reyes, Jérôme Sackur, Jean Christophe Vergnaud, Elisa Filevich\*, Nathan Faivre\*

Metacognitive training consists in improving the capacity to monitor one's own thoughts. Recently, Carpenter and colleagues (2019) reported that metacognitive performance can be improved through adaptive training: healthy participants performed a perceptual discrimination task, and subsequently indicated the confidence in their response. Metacognitive performance defined as the adequacy between task performance and confidence was found to increase when participants received monetary rewards based on their confidence judgments, while remaining constant in a control group rewarded on the accuracy of their perceptual judgments. Furthermore, metacognitive performance was found to increase in an untrained cognitive domain, advocating for the domain-generalty of this training procedure. We will discuss two possible confounds that might have led to an artificial inflation of metacognitive performance, namely the absence of incentives in the baseline condition and an inconsistency between the reward scheme and the instructions about the confidence scale. We will also report the results of a pre-registered conceptual replication where no metacognitive training occurs when incentives are constant and instructions are consistent with the reward scheme. In light of these results, we will discuss alternative strategies to effectively train metacognition, in view of remediating metacognitive deficits in clinical populations.

## On Pure Consciousness of Autopoietic Machines

Julio Alcántara

This research project will experiment with the simplest form of conscious experience humans are capable of or minimal phenomenal experience (MPE), firstly, to prove its empirical existence, secondly, to disentangle its core causal factors, and thirdly, to attest its content-properties. Deleting and maximizing the unit of identification (UI) are the two channels to analyze empirically the MPE within the model of the Ascending Reticular Activation System (ARAS), the minimal form of phenomenal experience and the minimal phenomenal selfhood (MPS), mainly the thresholds of electrical frequencies of the brain during the analyzed states, their correlations and simulations, and subjective reports. Does it exist an all pervading form of conscious experience? Which phenomenal characteristics does pure consciousness (PC) entail? And based on this, can a minimal model for conscious experience as such be developed? This research tries to overcome ideological contaminations by knowing the metaphysical implications of its propositions and their relation to a wider scientific context based on intuition-free experimental philosophy, in which two experiments are proposed in order to study consciousness as such, firstly, the confirmation of MPE during lucid deep sleep through listening to different musical patterns, and secondly, a controlled hallucination in Virtual Reality (VR) with the maximization of the UI.

## Beyond imagination: Hypnotic visual hallucination induces greater lateralised brain activity than visual imagery

Renzo Lanfranco, Alvaro Rivera-Rei, David Huepe, Agustín Ibañez, Andrés Canales-Johnson

Hypnotic suggestions can produce a broad range of perceptual experiences, including hallucinations. Visual hypnotic hallucinations differ in many ways from regular mental images. For example, they are usually experienced as automatic, vivid, and real images, typically compromising the sense of reality. While both hypnotic hallucination and mental imagery are believed to mainly rely on the activation of the visual cortex via top-down mechanisms, it is unknown how they differ in the neural processes they engage. We have used an adaptation paradigm to test and compare top-down processing between hypnotic hallucination, mental imagery, and visual perception in very highly hypnotisable individuals whose ability to hallucinate was assessed. By measuring the N170/VPP event-related complex and using multivariate decoding analysis, we found that hypnotic hallucination of faces involves greater top-down activation of sensory processing through lateralised mechanisms in the right hemisphere compared to mental imagery. Our findings suggest that the neural signatures that distinguish hypnotically hallucinated faces from imagined faces lie in the right brain hemisphere.

The minimal exposure duration required for neural processing of faces and emotional expressions

Renzo Lanfranco, Andrés Canales-Johnson, Axel Cleeremans, Hugh Rabagliati, David Carmel

Faces convey a great deal of information. Previous studies have suggested a processing advantage for upright over inverted faces, and for emotional over neutral faces. Do orientation and emotion affect the minimal required exposure of face discrimination? Due to hardware limitations, visual studies typically present stimuli for suprathreshold durations, disrupting processing with masks. Here, we used a tachistoscope that enables sub-millisecond presentations. Participants discriminated the location of a face from that of a scrambled face, in unmasked presentations. Above-chance discrimination required ~2.5ms of stimulation. An advantage for upright over inverted faces arose by 4.4ms, for both perceptual and metacognitive sensitivity. We found no effect of emotion on either. EEG-ERP and decoding analyses found evidence of face processing and conscious access at 4.3ms, but only revealed differential emotion processing at the longest presentations, once participants could reliably perceive faces. Finally, whilst decoding analysis found evidence of face and emotion processing at shorter durations than ERPs, it could not decode either factor with shorter durations than 4.3ms, suggesting that conscious access is required for emotional face processing. These findings clarify the minimal exposure required for face perception, emotion processing, and conscious access, suggesting that holistic processing provides advantages in perception and awareness.

Computational theories of consciousness are incompatible with rationalism

Yair Pinto

Rationalism entails that humans can know that the rational approach, i.e. rational thinking and careful empirical observations, generates more reliable knowledge than completely random approaches, such as reading Tarot cards. In this talk I will argue that rationalism and computational theories of consciousness are incompatible. The reasoning is as follows. Computational theories of consciousness imply that all aspects of human consciousness, including conscious comprehension (rational thinking) and conscious sensory experiences (empirical observations), are algorithmic. Thus, if a human employs the rational approach to solve a problem, then she is actually employing an algorithm. It is well known from computability theory that a formal system (which is equivalent to an algorithm) is either inconsistent, or the formal system cannot prove its own consistency. Moreover, inconsistent formal systems are completely unreliable, since any statement can be proven in such systems. Therefore, if the rational approach is algorithmic, then either it is completely unreliable, or humans cannot know that it is reliable. Thus, either one can adhere to the notion that humans can know that the scientific approach is more reliable than reading Tarot cards, or one can adhere to a computational theory of consciousness, but not both.



## Neural Representation of the Relational Self from Infancy to Adulthood

Adi Ulmer Yaniv, Shani Waidergoren, Ariel Shaked, Roy Salomon, Ruth Feldman

The self is a central construct of human consciousness. Investigations into the cognitive and neural underpinnings of the "self" highlight its multidimensionality and indicate that various "Self models" are sustained by different neural systems. Here, we focused on the Relational Self, a dimension denoting the self-within-attachment relationships that taps the continuity of attachment across development and affiliative bonds. Mothers and children dyads were followed across two decades and videotaped in naturalistic interactions at infancy, childhood, and adulthood. During fMRI scanning, participants were exposed to videos of their own mother-child interactions from the three ages and matched unfamiliar interactions. Relational Self-stimuli elicited greater activations across preregistered regions, including thalamus, amygdala, hippocampus, ACC and insula. Critically, Relational Self-stimuli were age-invariant in most regions of interest despite large variability of stimuli across multiple self-related features, such as similarity, temporal distance, affect, or mentalization, and Bayesian analysis indicated strong evidence for lack of age-related differences. PPI analysis demonstrated that Relational Self-stimuli elicited tighter connectivity between the ACC and insula. Findings suggest that the Relational Self may be sustained by integration of exteroceptive and interoceptive self-related signals, supporting perspectives on the continuity of self within attachment across development.

## Intracranial recordings reveal unique shape and timing of responses in human visual cortex during illusory visual events

Maartje Cathelijne de Jong, Mariska Vansteensel, Raymond van Ee, Frans S. S. Leijten, Nick F. Ramsey, Chris Dijkerman, Serge O. Dumoulin, Tomas Knapen

During binocular rivalry perception spontaneously changes without any alteration to the visual stimulus. What neural events bring about this illusion that a constant stimulus is changing? We recorded from intracranial electrodes placed on the occipital and posterior temporal cortex of two patients with epilepsy, while they experienced illusory changes of a face-house binocular-rivalry stimulus, or observed a control stimulus that physically changed. We performed within-patient comparisons of broadband high-frequency responses, focusing on single epochs recorded along the ventral processing stream. We found transient face- and house-selective responses localized to the same electrodes for illusory and physical changes, but the temporal characteristics of these responses markedly differed. In comparison with physical changes, responses to illusory changes were longer-lasting, in particular exhibiting a characteristic slow rise. Furthermore, the temporal order of responses across the visual hierarchy was reversed for illusory as compared to physical changes: for illusory changes higher-order fusiform and parahippocampal regions responded before lower-order occipital regions. Our tentative interpretation of these findings is that two stages underlie the initiation of illusory changes: a destabilization stage in which activity associated with the impending change gradually accumulates across the visual hierarchy, ultimately graduating in a top-down cascade of activity that may stabilize the new perceptual interpretation of the stimulus.

Zero-shot search termination reveals a dissociation between implicit and explicit metacognitive knowledge

Matan Mazor, Stephen M. Fleming

In order to infer that a target item is missing from a display, subjects must know that they would have detected it if it was present. This form of counterfactual reasoning critically relies on metacognitive knowledge about spatial attention and visual search behaviour. Previous work on visual search established that this knowledge is constructed and expanded based on task experience. Here we show that some metacognitive knowledge is also available to participants in the first few trials of the task, and that this knowledge can be used to guide decisions about search termination even if it is not available for explicit report.

Human sleep impairs top-down auditory processing despite extensive spiking responses: an intracranial iEEG/LFP/single-unit study

Hanna Hayat, Amit Marmelshtein, Aaron J. Krom, Yaniv Sela, Ariel Tankus, Ido Strauss, Firas Fahoum, Itzhak Fried, Yuval Nir

Sleep entails reduced behavioral responsiveness and changes in consciousness, providing a powerful approach to better understand the neural correlates of conscious. However, the extent of responses along cortical sensory pathways during sleep remains unclear. Here we recorded polysomnography, iEEG, microwire LFPs, and neuronal spiking activity in epilepsy patients (n=14 sessions) implanted with clinical depth electrodes, while presenting auditory stimuli (e.g. click-trains, words, music) during wakefulness and sleep. We found robust spiking (n=315 responses from 55 clusters) and induced high-gamma (80-200Hz) power responses (n=876 from 129 iEEG/LFP channels) during both NREM and REM sleep across the lateral temporal lobe whose magnitude was only moderately attenuated, most notably for late responses beyond early auditory cortex. Nonetheless, sleep responses maintained their tight locking with soundwave envelopes and their information content was minimally affected. By contrast, alpha-beta (10-30Hz) power decrease was prevalent in wakefulness but significantly disrupted in sleep (n=432 responses from 86 iEEG/LFP channels). Entrainment to 40Hz click-trains was comparable across REM sleep and wakefulness but reduced in NREM sleep. Together, our results establish robust auditory responses during sleep while alpha-beta power decrease, likely reflecting top-down processes, is deficient. More broadly, they point to feedback signaling as key in conscious sensory processing.

## Structural constraints on NCCs

Sascha Benjamin Fink, Holger Lyre, Lukas Kob

One primary goal in the neuroscience of consciousness is to find the neural correlates of consciousness (NCCs). At its heart, correlation is a statistical notion such that even strong correlations need not indicate any meaningful connection between the correlates. Pearson (1897) called these „spurious correlations“. This raises a worry: If strong correlations between phenomenal and neural goings-on can be found without any meaningful connection, how can we ensure that NCC research contributes to finding the neural substrate of consciousness? Here, additional constraints become attractive if they allow us to reject mere statistical correlates as "NCCs-proper", where the correlation is indicative of a metaphysical connection like causation, supervenience, identity, etc. Inspired by the prominence of structural relations in both phenomenology and psychophysics, we motivate a structural constraint on NCCs-proper. Various phenomenal experiences relate to each other in various degrees of similarity and difference. These complex relations are used to identify and individuate experiences: We get to know which experience a person is having by getting to know the structures it stands in. Theoretical considerations and evidence suggest that these intra-phenomenal structures will be mirrored in their neural substrate. An NCCs-proper therefore must preserve the structure governing the associated experiences. Then, any neural structures that fail to preserve phenomenal structures are less likely to be NCCs-proper. We illustrate this with a study by Brouwer & Heeger (2009), which can be interpreted as ruling out V1 or MT+ as NCCs of color experiences. In an outlook, we hint at the metaphysical implications of this constraint."

## The problem of epistemic indirectness in consciousness science

Ali Yasar

The reliance on markers and proxies has been claimed to ground a fundamental epistemic deficit for scientific approaches to consciousness. One of the key reasons is that such reliance makes detection procedures epistemically indirect in contrast to the knowledge a subject has about her own conscious experiences qua introspecting that is supposed to be epistemically direct. Since it is assumed that direct knowledge comes with epistemic benefits, approaches that are unavoidably indirect, will suffer from fundamental deficits. In this talk, I will argue that not indirectness, but the possibility of intervention and their methodological realizations make a real epistemic difference that actually affects the ambitions in the scientific study of consciousness. I focus on two challenges: First, I address the theoretical challenge of intervention, consisting in the question whether differences in the ability to intervene actually make an epistemic difference for some paradigmatic cases of conscious experience. Second, I address the methodological challenge, consisting in the question to what extent the required steps of intervention can be empirically realized. I show that indirectness does not ground an epistemic deficit, but even enables scientific approaches to be epistemically better suited than the introspecting subject, although some methodological shortcomings remain.

## The Effects of mindfulness practice on the association between autonomic interoceptive signals and emotion regulation selection

Ziv Ardi, Yulia Golland, Roni Shafir, Gal Sheppes, Nava Levit-Binnun

Recently, we showed that Mindfulness-Based Stress Reduction (MBSR) effects regulatory selections. We hypothesized that this is enabled via an MBSR-induced increase in sensitivity to interoceptive signals associated with the emotional stimuli. To test this, N=84 participants were randomized to either a MBSR program or a waitlist control. Before and after the MBSR program, they were connected to autonomic sensors and tested on a task examining their regulatory selections when confronted with low or high negative intensity images. They also completed a battery of mindfulness, interoception and wellbeing self-report measures. We found that participants assigned to the MBSR were overall more likely to choose reappraisal than distraction after the program. Crucially, interoceptive signals in response to negative images predicted regulatory selections in this group. Specifically, lower cardiac reactivity predicted the choice to reappraise whereas higher cardiac reactivity predicted the choice to distract. Greater differences in cardiac reactivity between states that prompt reappraisal and states that prompt distraction were associated with higher wellbeing. Our findings suggest that mindfulness increases the sensitivity of regulatory selections to interoceptive signals, and this is associated with subjective wellbeing. This may be a central pathway through which MBIs exert their positive effects on mental health and resilience.

## When seeing is not believing: a mechanistic basis for predictive divergence

Chiara Caporuscio, Sascha B. Fink, Philip Sterzer, Joshua M. Martin

Visual illusions provide a compelling case for the idea that predictions regarding causes in the world may differ at the level of perception and belief. This discrepancy is easily explained by theories that argue that perception and cognition are processed in discrete modules that are informationally encapsulated from one another, but it is not straightforwardly accommodated by Predictive Processing, that takes perceptual and cognitive predictions to derive from the same underlying processing hierarchy. Recent insights concerning the neural implementation of prior information may shed light on this question. Specifically, prior information is proposed to be implemented in both the top-down and bottom-up streams of information processing. While the former is context-varying and flexible in updating, the latter is context-independent and difficult to revise. We propose that predictive divergence may emerge when flexible prior information at higher hierarchical levels determining belief, contradicts inflexible prior predictive information at lower levels determining perception. This allows Predictive Processing to account for conflicting percepts and beliefs while still maintaining its core assumptions.

## Useful Misrepresentation: Perception as Embodied Proactive Inference

Joshua M. Martin, Mark Solms, Philipp Sterzer

According to the predictive processing framework, perception is geared to represent the environment in terms of embodied action-opportunities, as opposed to objective truth. Here, we argue that such an optimisation is reflected by biases in expectations (i.e. prior predictive information) that facilitate “useful” inferences of external sensory causes. To support this, we highlight a body of literature suggesting that perception is systematically biased away from accurate estimates under conditions where utility and accuracy are conflicting. We interpret this to reflect the brain’s attempt to adjudicate between conflicting sources of prediction error, as external accuracy is sacrificed in order to facilitate actions that proactively avoid physiologically surprising outcomes. This carries important theoretical implications and offers new insights into psychopathology.

## Scene-object processing with and without awareness

Inbal Gur Arie, Itai Linzen, Alyssa Truman, Liad Mudrik

The role of conscious perception in processing real-life object-scene relations has been the focus of recent studies, yielding conflicting results. Here, we used EEG and masking to pinpoint the neural processes involved in object-scene integration and in object identification, both when the stimuli were consciously perceived and when they were not. In three experiments, we accordingly focused on the N300 and N400 components, held to represent identification and integration processes, respectively. Intact and scrambled objects, presented in isolation or embedded in congruent and incongruent scenes were presented. During conscious processing, evidence for both the N300 and N400 components were found, while during unconscious processing, only N300 effects emerged, differentiating intact from scrambled objects (irrespective of congruency). This suggests first that object identification procedures can take place without awareness – even when objects are embedded in complex scenes. However, deciphering the relations between objects and the scenes in which they appear does seem to require conscious processing.

## Why do some scientists say they study consciousness?

Matan Mazor

Consciousness is a philosophically loaded term that does not map to a specific cognitive function or behaviour. Describing research as the scientific study of consciousness must serve a purpose, otherwise a more informative label would have been used (Grice, 1975; Goodman & Frank, 2016). Here I ask what this added information value may be. Based on recent uses of the word consciousness in high-profile scientific outlets (Nieder et al., 2020; Ben-Haim et al., 2021) I suggest that this additional information value is unlikely to be in the relation to experiential properties of cognition and behaviour, nor in a historical link to a tradition of consciousness research. I consider the possibility that in some contexts the word consciousness carries information to non-academic consumers of scientific output, such as funding agencies and policy-makers: it implies that research output from this scientific project is relevant to ethics and morality.

## Meditation-induced flexibility in networks supporting the embodied-self: A neurophenomenological MEG study

Yoav Schweitzer, Fynn-Mathis Trautwein, Yair Dor-Ziderman, Ohad Nave, Stephen Fulder, Yochai Ataria & Aviva Berkovich-Ohana

The nature of self-experience and its function in health and disease are of great concern to philosophers, psychologists and neuroscientists. A fundamental aspect of self-experience regards the embodied-self, a pre-reflective foundational level of selfhood tied with the sense of agency and body ownership and establishing a self-word distinction. Pilot results showed proficient meditators were able to volitionally induce such embodied-self alterations in the magnetoencephalography (MEG) lab, and that these were marked by decreases in beta-band power over medial and lateral parietal regions. Building on these proof-of-concept studies, we initiated a large-scale neurophenomenological study of the embodied self, combining neural measures (MEG), behavioral tasks and phenomenological interviews. Forty-six long-term meditators received a 3-weeks training enhancing their abilities to volitionally alter their embodied-self, and specifically their self-boundaries, while their brain was scanned in the MEG. Importantly, we were able to confirm beta-band reductions to be a neural signature of flexible and reduced self-boundaries. The results both confirm and extend previous findings, demonstrating the flexibility and malleability of the embodied-self, which bares implications for various psychopathologies.

## Perceptual awareness of optic flows paced optimally and non-optimally to walking speed

Paweł Motyka, Zuzanna Kozłowska, Piotr Litwin

Previous research suggests that visual processing depends strongly on locomotor activity and is tuned to optic flows consistent with self-motion speed. Here, we used a binocular rivalry paradigm to investigate whether perceptual access to optic flows depends on their optimality in relation to walking velocity. Participants walked at two different speeds on a treadmill while viewing discrepant visualizations of a virtual tunnel in each eye. We hypothesized that visualizations paced appropriately to the walking speeds will be perceived longer than non-optimal (too fast/slow) ones. The presented optic flow speeds were predetermined individually in a task based on matching visual speed to both walking velocities. Additionally, perceptual preference for optimal optic flows was expected to increase with proprioceptive ability to detect threshold-level changes in walking speed. Whereas faster (more familiar) optic flows showed enhanced access to awareness during faster compared to slower walking conditions, for slower visual flows only a non-significant tendency for the analogous effect was observed. These effects were not dependent on individual proprioceptive sensitivity. Our findings concur with the emerging view that the velocity of one's locomotion is used to calibrate visual perception of self-motion and extend the scope of reported action effects on visual awareness.

Evidence synthesis indicates contentless experiences in meditation are neither truly contentless nor identical

Toby Woods, Olivia Carter, Jennifer Windt

Contentless experience involves an absence of mental content such as thoughts, perceptions, and mental images. In academic work it has been traditionally treated as including states like those aimed for in Shamatha, Transcendental, and Stillness Meditation. In this talk, findings will be presented from evidence synthesis with respect to 135 expert texts from the three practices. From the expert texts, 65 features of the contentless experiences in the practices were identified. It was found that there are broad similarities in the experiences across the practices, but that there are differences for four features and possible differences for another 47. Numerous forms of content including wakefulness, naturalness, calm, bliss/joy, and freedom were found to be present in the experiences. The findings indicate that meditation experiences described as contentless in the academic literature can in fact involve considerable variation, and that in many and perhaps most cases these experiences are not truly contentless. This challenges traditional understandings in academic research that in these so-called contentless experiences all content is absent, and that the experiences are therefore an identical state of pure consciousness or consciousness itself.

Threat extinction without awareness: evidence from masking and continuous flash suppression

Shani Bachar-Avnieli, Liad Mudrik, Daniela Shchiller, Gideon E. Anholt

Anxiety disorders are the most common mental disorders. The typical treatment for these disorders is exposure to the anxiety inducer. However, many patients are reluctant to confront feared objects or situations, and therefore don't receive proper treatment for their distress. Accordingly, previous studies explored the possibility to unconsciously expose subjects to aversive or frightening stimuli as an alternative, less aversive form of alleviating anxiety. The goal of the present study is to test whether extinction of lab-induced fear is attainable while controlling for limitations in methodology in prior research, using two common methodologies: Continuous Flash Suppression (CSF) and Visual Masking (VM). In each experiment participants were first threat-conditioned, and later randomly divided into three groups: (1) clearly visible exposure; (2) unconscious exposure; and (3) No-Extinction. We found effective extinction and successful extinction retention (indexed by a skin conductance response) under both conscious and unconscious exposure conditions only under VM, while in CFS the results are inconclusive and call for further investigation. These results demonstrate the effectiveness of unconscious extinction, even when strict measures of awareness are taken. Our findings bear theoretical implications for the understanding of exposure therapy and may pave a path for the potential clinical utility of unconscious extinction.



## Controlling (for) first-order task performance in studies on metacognition: cons & cons

Borysław Paulewicz, Marta Siedlecka

It is widely believed that when effects in measures of metacognition are accompanied by effects in measures of first-order task performance, something has to be done about it. In such cases, controlling performance either statistically or by means of interventions (calibration, staircase) is perceived as a good way of dealing with what is often described as a confounding (“of metacognition by first-order performance”) problem. However, in many such cases the term “confounding” is used in a way that shows a lack of understanding of what confounding is. We argue that this kind of attempts to “deconfound metacognition” results from (often implicitly) equating first-order task processing with first-order task performance and from ignoring the regulatory function of metacognition. Using basic causal inference principles, we formally show that controlling for first-order task performance is in general not a good idea, and we illustrate the asymptotic bias that may result from such practices using simple simulations.

## Population activity structure rather than response magnitude underlies perceptual stability in the human brain

Rotem Broday-Dvir, Yitzhak Norman, Rafael Malach

In searching for a neuronal signature of perceptual awareness a ubiquitous principle is the role of response magnitude in crossing the perceptual awareness threshold. However, a major challenge to such magnitude-dependency is the striking phenomena of rapid-adaptation, in which the magnitude of neuronal responses rapidly declines by 40-50% within 450-500 msec of exposure to a fixed stimulus. Here we examined the hypothesis that what determines the appearance of the visual percept is not the magnitude of the response, but rather the activation pattern elicited across multiple neurons. Visual images of familiar faces and places were presented for 1.5 seconds to 13 patients implanted with intra cranial electrodes over high order visual cortex for clinical purposes. Responses from 43 face-selective electrodes showed strong, ignition-like, activations to face images that rapidly declined despite the persistent stimulus. By contrast, examining the activation patterns across multiple electrodes revealed that aspects of these patterns remain stable and show high correlations across the entire stimulus presentation period. Furthermore, the stimuli pair-wise activation distances also persisted largely unchanged across time. Our results support the notion that visual perceptual content is reflected in the multi-site pattern of neuronal activations –i.e. its location within the relevant activation space geometry.

Iggy and Ziggy on consciousness. Reconsidering Chalmers' hard, easy, and meta-problems of consciousness

Tobias Schlicht

I present an argument against Chalmers' distinction between easy and hard problems in form of a reductio, showing a development from his early to his later writings. The distinction plays a central role in his conception of a Zombie, a physical-functional/psychological doppelgänger of a human being who lacks phenomenal consciousness and is supposed to support Chalmers' dualism.

Consider Iggy and his Zombie-twin Ziggy:

1. If the easy/hard distinction holds, then Iggy & Ziggy are identical in all physical, functional, and psychological respects. (Chalmers 1996, p84)
2. Iggy & Ziggy make the same judgments about their conscious experiences. (1) (Chalmers 2018, 1996, p162)
3. Judgments about conscious experiences contain phenomenal concepts. (Chalmers 1996, ch.5)
4. Iggy's phenomenal concepts are partly constituted by phenomenal qualities. (Chalmers 2010)
5. Ziggy's phenomenal concepts are not (cannot be) partly constituted by phenomenal qualities. (Chalmers 1996, ch.5)
6. Therefore, Iggy's & Ziggy's judgments differ conceptually. (3,4,5)
7. Therefore, Iggy & Ziggy are not identical in all physical, functional, and psychological respects. (5,6)
8. This results in a reductio, since premise 1 and premise 7 contradict each other. (1,7)
9. Therefore, the easy/hard distinction must be rejected.

I discuss various moves against premises 2, 3, 4, and 5 which are unavailable to Chalmers. The only way Chalmers can escape the reductio is by rejecting premise (1) which makes most easy problems hard by accepting phenomenal intentionality.

Could a digitally simulated agent have conscious experiences, and could we know this?

Owen Holland

While biological organisms are currently the source of all our knowledge about consciousness, we are in danger of mistakenly taking various attributes and constraints associated with biological consciousness as being fundamental to an agent's consciousness when they may be merely contingent in the broader spectrum of consciousness itself. Examples include but are not limited to the necessity of biological support, the involvement of metabolic control, the physicality of the agent and/or the physicality of the world in which the agent is embedded, the continuity and/or granularity of the underlying informational or computational substrate of the agent, and the privacy or inaccessibility of conscious experience. Building on the recent paper "Forget the bat" (Holland, 2020, <https://doi.org/10.1142/S2705078520500058>), the talk will argue that there is no clear evidence that a digitally simulated agent in a digitally simulated world could not support conscious experiences, and will explore the leveraging of the intrinsic properties of digital systems in enabling complete access to all events in the simulated system to facilitate the identification of putatively conscious experiences within the agent.

UnReal? The psychophysics of the Sense of Reality

Gadi Drori, Paz Bar-Tal, Yair Zvilichovsky, Roy Salomon

In everyday life, we have an ability for differentiating normal from aberrant perceptual phenomena, a Sense of Reality (SoR). In neuropsychiatric disorders such aberrations often manifest as hallucinations or illusions, making SoR a vital criterion in clinical assessments. Despite its relevance to mental health the neuropsychological mechanisms of SoR are not well understood. It is, therefore, essential to explain the cognitive and neural processes underlying SoR. In this pilot study, we operationalized artificial alterations of reality as objective psychophysical measures in a virtual reality (VR) environment. Within this environment, participants experienced systematically manipulated parameters (e.g. time/gravity/color) compared to an unaltered VR environment and were subsequently asked to report if the environments were identical. Participant ratings were then used to calculate a - just noticeable difference (JND) for each manipulated parameter, describing the estimated ratios by which reality manipulations were detected. Preliminary results indicate consistent and replicable JNDs within each parameter, allowing an experimentally controllable psychophysical approach to investigating SoR. Importantly, employing such a psychophysical approach enables the comparison of different reality manipulations, providing a foundation for modeling SoR.

## Nonconscious chaining of events to form holistic fear memories in the human brain

Aurelio Cortese, Ryu Ohata, Norimichi Kitagawa, Hiroshi Imamizu, Ai Koizumi

In rich real-life contexts, one may experience a threat, such as a car crash, after serially perceiving a passing bicycle, a changing traffic light, and a ringing cell phone. Discriminating when and when not to expect threat enhances survival and psychological health in humans. Despite this, it remains unclear how humans learn to anticipate threats based on higher-order configurations of cues (i.e., temporal sequences), and whether such learning requires consciousness. Here, using fMRI, we show that participants develop fear-like responses to a specific sequence of cues, above and beyond their responses to the subcomponent cues alone. Interestingly, most volunteers failed to explicitly report the association between the cue sequences and threat, indicating that episodic threat association memories can form below consciousness. Applying multivoxel pattern analyses, we found that the hippocampus coding of sequence information during threat association learning was disrupted by the threat cue (resulting in chance-level decoding accuracy). The dorsolateral prefrontal cortex instead maintained the sequence information throughout. Our results suggest a new route for threat learning relying on higher-order brain regions, when learning operates on complex information rather than individual cues (as commonly studied). These mechanisms and their failure may explain overgeneralization of fear in trauma-related disorders.

## Retrospective Behavioral Sampling: A dynamic sampling approach to contents of perceptual and memory awareness

Talia Brandman, Rafael Malach, Erez Simony

A central challenge in linking neuronal states and the contents of conscious awareness centers on tracing dynamic changes in the stream of conscious content. A major difficulty here is to disentangle the multitude of simultaneous cognitive processes, without altering the natural experience itself. Here, we present a novel method, retrospective behavioral sampling (RBS), which models distinct dimensions of cognition along the time-course of naturalistic perception, without manipulating, simplifying or interfering with real-time content. Twenty-eight participants viewed movies and listened to a story, and subsequently recalled their experience of over 50 discrete events from the stimuli, rating memory, surprise, emotion, perceived importance, and introspective states. Results reveal highly-reliable, and informative, temporal patterns of change in each measure, exhibiting effective variability across events while maintaining consistency across individuals. Remarkably, memory ratings that were collected again more than a week later, resulted in an almost identical time-course of mean memorability (across subjects) as memory ratings collected immediately following stimulation ( $R=0.9$ ). Altogether, these findings validate the effectiveness of RBS in tracking dynamic changes in conscious content throughout naturalistic stimulation, reliably across individuals and stably across measurements. We further demonstrate how RBS can be used to link the stream of conscious content with neuronal responses.

## Neural Synchrony modulates Sense of Agency during Joint Action

Nicolas Coucke, Nicolas Bourguignon, Salvatore Lo Bue, Axel Cleeremans, Emilie Caspar

During successful joint action, individuals must keep track of each other's actions and adjust their own actions accordingly. Here, we aimed to investigate the relationship between interpersonal coupling and action awareness by analyzing the influence of neural synchrony on the sense of agency. To do so, we developed a novel behavioral task that requires two participants to coordinate and synchronize their movements whilst completing a trajectory through an obstacle course using their fingers on a touchscreen. Participants succeeded in a trial when they completed the trajectory in a synchronized manner; they failed when they were not synchronized or when either of them crossed an obstacle. During the task, the EEG signals of both participants were simultaneously recorded in a hyperscanning setup. We calculated neural synchrony for different frequency bands in the EEG channels and assessed sense of agency by means of questionnaires and through the ERPs associated with failed trials. Our results indicate a positive correlation between neural synchrony and sense of agency when a participant was leading the joint action. These findings hint at the importance of self-other integration in the processing of an individual's sense of agency.

## Dissociating conscious perception from decision

N. Sanchez-Fuenzalida, S. van Gaal, S. Fleming, J.M. Haaf, J.J. Fahrenfort

In consciousness research, a popular method is to create experimental conditions based on responses given by participants (e.g. 'seen'/ 'not-seen'). However, it is not often clear whether biases in observers' responses stem from a shift in conscious perception, or whether they arise from post-perceptual shifts in response criterion. To dissociate perception from decision we developed a task where observers either categorize a line as shorter/longer than a reference or reproduce its length. Crucially, participants do not know yet which task they will perform while viewing the target line. We reasoned that a manipulation is perceptual when observers are biased in both tasks, whereas we conclude that the manipulation is post-perceptual, when observers are selectively biased in the categorization task but not in the reproduction task. We manipulated observers' responses using the Müller-Lyer illusion, a pay-off scheme, and an asymmetrical base-rate. A Bayesian ordinal model comparison analysis suggests that while all manipulations result in a strong bias in the categorization task, only the Müller-Lyer illusion results in a bias in both the categorization and the reproduction task. This shows that only the Müller-Lyer illusion reflects a true perceptual shift.

## Brain's reconfiguration to anesthesia predicts recovery of consciousness in unresponsive patients

Catherine Duclos, Yacine Mahdid, Charlotte Maschke, Danielle Nadin, Alexander Rokos, Caroline Arbour, Mohamed Badawy, Justin Létourneau, Adrian M. Owen, Gilles Plourde, Stefanie Blain-Moraes

**Introduction:** Current techniques to predict recovery from a disorder of consciousness (DOC) are limited by their reliance on a patient's ability and willingness to respond to commands/stimuli or the requirement of expensive medical equipment that is difficult to access at bedside. Here, we introduce a novel, electroencephalography (EEG)-based measure of brain adaptability to predict recovery of consciousness in behaviourally unresponsive individuals: the Adaptive Reconfiguration Index (ARI). **Methods:** The ARI is calculated by (i) perturbing the brain with a targeted dose of propofol anesthesia and (ii) contrasting high-density EEG network properties — alpha network hubs and directed phase-based functional connectivity — before, during and after exposure to anesthesia. We tested the prognostic value of the ARI in a case series of 12 individuals with a disorder of consciousness (DOC). **Results:** The ARI was significantly higher in patients who later recovered full consciousness ( $p=0.003$ ), achieving prognostic accuracy of 100% in predicting recovery of consciousness within 90 days. **Conclusions:** Unresponsive individuals with the capacity to recover full consciousness show specific brain network alterations in response to propofol anesthesia. EEG and propofol anesthesia can be administered at bedside with no patient distress or contraindications, affording the ARI tremendous translational potential for acute clinical settings.

## Deviation from criticality in disorders of consciousness and its restoration with anesthesia

Catherine Duclos, Hyoungkyu Kim, George A. Mashour, Uncheol Lee, Stefanie Blain-Moraes

**Introduction:** The healthy brain's functional network is thought to operate in a critical state, optimally configured for information transmission, integration and storage. This study investigated the criticality properties of the brain networks of individuals in a disorder of consciousness (DOC), with and without anesthesia. **Methods:** We measured the network susceptibility and spatial coherence with the pair correlation function (PCF) and the order parameter (OP), respectively, in the theta and alpha frequency bands (4-13 Hz) from 3.5-min segments of high-density EEG data recorded before and during anesthesia in 12 DOC patients and 9 healthy individuals. We compared states (baseline vs. anesthesia) and groups using Mann-Whitney U-tests. **Results:** DOC patients had significantly lower PCF and OP than both healthy awake and healthy anesthetized subjects ( $p<0.05$ ). Whereas anesthesia induced a non-significant decrease of  $10.4\pm 19.3\%$  in OP in healthy subjects ( $p=0.095$ ), anesthesia improved criticality in the DOC group by significantly increasing PCF by  $16.1\pm 15.5\%$  and OP by  $20.1\pm 23.1\%$  ( $p<0.05$ ). **Conclusions:** This study suggests that the DOC brain network operates in a subcritical state, with lower PCF and OP than both responsive and unresponsive healthy individuals. Importantly, our results suggest that anesthesia may increase network criticality in the DOC brain.

## Influence of monitoring motor performance on metacognitive control of behavior

Polina Arbuzova, Elisa Filevich

Metacognition, or the ability to monitor and control our own cognitive processes, has been mostly studied using perceptual tasks where participants have no influence over the stimuli presented to them. An exception to this are tasks where participants are given the option to accumulate further evidence, which they often use when their confidence in a decision about a stimulus is low. This suggests a causal role for confidence in decision making. To further explore this notion, we studied the interplay between performance monitoring in a motor task, and motor performance itself. On each trial, participants first threw a virtual ball (zero-order task), identified it (first-order task) either based on the trajectory of the ball (indirect parameter) or elbow angle at the point of ball release (direct parameter), and finally reported their confidence in their own identification decision (second-order task). Participants' movement profiles varied with the aspect of the movement that was to be monitored, suggesting a causal role of metacognition on behaviour. Further, when participants monitored direct, but not indirect, aspects of their movements, motor performance correlated with motor metacognitive ability. Based on the differences between tasks, we discuss these findings as metacognitive control of behaviour.

## A dissociation between conscious state and EEG oscillations in Angelman syndrome

Joel Frohlich, Lynne M. Bird, Joerg F. Hipp, Catherine Chu, Martin M. Monti

Children with Angelman syndrome (AS) display high-voltage, delta (1- 4 Hz) frequency EEG activity while awake and conscious. This paradoxical EEG signature, which more closely resembles EEG activity typically seen in unconscious states (e.g., slow wave sleep or coma), presents a mystery: what EEG features, if not delta power, reliably indicate that a person is unconscious? AS EEG thus has potential use as a testbed for biomarkers of consciousness. Recently, we demonstrated that EEG signal complexity tracks conscious state better than EEG spectral power in children with AS (Frohlich et al. 2020 *Neuroscience of Consciousness*; for a review of similar findings, see Frohlich et al. 2021 *Brain*). Our newest work compares several candidate EEG markers of consciousness in AS and age-matched typically developing control children. Using Lempel-Ziv complexity and 1 – 2 Hz relative power as classification features, we trained regularized logistic regression to discriminate abnormal wake and sleep EEGs from children with AS ( $n = 35$ , 78.6% accuracy) and then showed that the results generalize to a validation set of healthy children with normal EEGs ( $n = 41$ , 95.1% accuracy). Our results identify features that may be useful for detecting consciousness even under circumstances of abnormal cortical dynamics.

## The Power of Uniqueness: Sham Treatment Personalisation Affects Pain Perception

Dasha A. Sandra, Jay A. Olson, Mathieu Roy

Personalised health, where individuals receive interventions targeted to their individual biological and behavioural characteristics, have shown early success by drastically improving treatment outcomes. However, it is yet unclear what effects psychological factors such as positive expectations and beliefs associated with receiving personalised (as opposed to standard) interventions have on the response to these interventions. Here, we tested this hypothesis in the context of pain perception. In a pilot study, we recruited 17 healthy participants (14 women) to complete various sham genetic and physiological tests, presented as either required to tailor an analgesic treatment to their biological characteristics (experimental) or as a separate procedure (control). Participants then completed a pain perception task while ostensibly receiving stimulations from a (placebo) electric analgesic machine. We found that participants receiving the pseudo-tailored treatment reported experiencing lower pain intensity (standardized  $b = .6$ ) and lower pain unpleasantness ( $b = .6$ ). We will confirm our findings in a pre-registered randomised controlled trial of 120 participants. This is the first study of whether receiving personalised information improves individual expectations and leads to a stronger placebo effect.

## Modelling Pathological and Psychedelic Visual Hallucinations using Deep Neural Networks

Keisuke Suzuki, David J. Schwartzman, Anil K. Seth

Visual hallucinations (VHs) are perceptions in the absence of the sensory information that would normally support such perceptions. While there are broad similarities between aetiologically distinct VHs there are also substantial phenomenological differences. The mechanistic factors underlying these differences remain poorly understood. We address this challenge using a method we call computational neurophenomenology: the application of computational models, interpretable in terms of neural mechanisms, to account for phenomenological properties of perceptual experience. Specifically, we use a combination of a Deep Convolutional Neural Network and a Deep Generator Network to simulate the computational pathologies underlying VHs of both neuropathological and psychedelic origin. Our model is able to generate detailed visualisations of VHs that vary systematically in their veridicality spontaneity, and complexity. We verify the validity of these synthetic VHs by directly comparing them to subjective reports of VHs arising from clinical pathology or psychedelic compounds. The parameterisations of our model that lead to these distinct phenomenologies - in terms of different contributions of discriminative and generative networks - therefore serve as neurally-interpretable hypotheses for the computational pathologies underlying distinct VHs. Altogether, our study showcases how neural network models can shed light on potential neural mechanisms underpinning aberrant perceptual phenomenology.



An academic survey on theoretical foundations, common assumptions and the current state of the field of consciousness science

Jolien C. Francken, Lola Beerendonk, Dylan Molenaar, Johannes J. Fahrenfort, Julian D. Kiverstein, Anil K. Seth, Simon van Gaal

We report the results of an academic survey into the theoretical and methodological foundations, common assumptions and the current state of the field of consciousness science. The survey consisted of 22 questions, was distributed online and at two different occasions of the ASSC annual meeting (2018/2019), targeting active scientists in the field only. 232 consciousness scientists with different backgrounds (e.g., philosophy, neuroscience, psychology, computer science) and in various stages of their careers (e.g., junior/senior faculty, graduate/undergraduate students) filled out the questionnaire. Results reveal that while respondents answer related questions quite consistently, there is (still) considerable discussion and debate between researchers about the definition of consciousness and the way it should be studied. To highlight a few observations, respondents believe that machines could have consciousness, that consciousness is a gradual phenomenon in the animal kingdom and that unconscious processing encompasses high-level cognitive functions. Further, we show which theories of consciousness are considered most promising, how supposedly different theories cluster together and which neural measures are the most likely signatures of consciousness. These findings provide us with a 'snapshot' of the current, dominant views of professional researchers in the field and may help to prioritise research and theoretical approaches to foster progress.

Spatial uncertainty does not boost unconscious processing under CFS

Fenja Benthien, Guido Hesselmann

Previous research suggests that selective spatial attention is a determining factor for unconscious processing under continuous flash suppression (CFS), and specifically, that inattention toward a stimulus location facilitates the unconscious processing of this stimulus by reducing the depth of CFS (Eo, Cha, Chong, & Kang, 2016). The aim of our study was to further examine this modulation-by-attention model of CFS using a number priming paradigm. Participants (N=26) performed a number comparison task on a visible target number ("compare target to five"). Prime-target pairs were either congruent (both smaller, or both larger than five) or incongruent. Spatial attention toward the primes was varied by manipulating uncertainty of the primes' location. Based on the modulation-by-attention model, we hypothesized: In trials in which the location of the primes was uncertain, reaction times (RTs) for congruent prime-target pairs should be faster than for incongruent ones. The Bayes Factor analysis of our data shows no effect of location uncertainty on unconscious priming under CFS. We discuss our findings in the context of recent unpublished MVPA-fMRI data from our lab and argue that spatial inattention is likely not the key factor that may reconcile the divergent CFS results.

## Difficulty in an incidental decision disrupts instrumental learning

Nura Sidarus, Martina Kavanova, Adrien Kerebel, Vincent Valton, Jonathan Roiser

Depression has been associated with alterations in decision-making and reinforcement learning, and with biases in metacognition, such as low confidence. However, interactions between these aspects of cognition remain under-investigated. In healthy participants, difficulties during decision-making have been shown to reduce perceived control over action outcomes and disrupt learning. We investigated whether difficulty in incidental, irrelevant decisions can impact learning, and whether that effect is related to depressive symptoms. In an online pilot study in the general population (N=173), participants performed a probabilistic value-based learning task, within which was embedded an orthogonal perceptual decision-making task. Perceptual difficulty was manipulated by presenting easy- vs. difficult-to-discriminate stimuli (titrated per subject), and participants judged their perceptual confidence on each trial (which they were instructed did not affect value-based outcomes). Participants also completed a battery of mental health questionnaires. As expected, perceptual performance and confidence were lower in the difficult than the easy perceptual condition. Notably, performance on the value-based learning task was also impaired in the difficult vs easy perceptual conditions, and there was a preference for cues associated with the easy condition. Preliminary analyses did not reveal any correlations with depressive symptoms. Difficulty in an irrelevant decision disrupts value-based learning, consistent with reports of effort discounting or of a misattribution of metacognitive signals (confidence) to learning."

## Concurrent implicit learning of multiple visual sequences

M. Sc. Sarah Wilts, Prof. Dr. Hilde Haider

The Global Workspace Theory of Consciousness states that information is processed in a massive, distributed set of specialized and parallel working modules. The processing within such modules is assumed to be unconscious and encapsulated. However, the exact representational content of these modules is still under debate. On the one hand, the modules might refer to modalities (e.g., visual, auditory perception). On the other hand, according to the Theory of Event Coding, the modules might even be specialized in the processing of distinct features (e.g., color and shape within the visual modality). Both notions differ regarding their predictions of multiple implicit sequence learning. Our research contributes to this debate by testing whether two independent regularities instantiated by different features within the visual modality can be learned concurrently. In Experiment 1 (n=42), we replicated an artificial grammar learning experiment that provides evidence for the concurrent learning of two visual grammars, a color and a shape grammar. In Experiment 2 (n=62), we tested the generality of these findings with a serial reaction time task. Here, the participants concurrently learned uncorrelated color and shape sequences. Overall, the findings converge to the assumption that implicit learning is based on abstract features rather than on modalities.

## Stimuli Presented on the Fringe of Awareness Evade Proactive Interference

Alberto Aviles, Howard Bowman

Can episodic memory operate outside consciousness? Since Potter (1976), many experiments have shown that stimuli presented in Rapid Serial Visual Presentation (RSVP) are poorly recognized or recalled (Bowman et al., in preparation) in a later test. These failures of reportability are consistent with the view that many RSVP stimuli are not consciously perceived. However, failing at report does not necessarily imply failing at encoding. In the current experiment, we explore whether stimuli presented in RSVP could interfere with the retrieval of items presented later, i.e. there could be proactive interference. In a series of RSVP trials, participants were presented with streams of words and asked to make an Old-vs-New judgement on a single probe at the end of each trial. Trials vary on the number of words presented (long = 36 items, short = 12 items). Additionally, we manipulated the Stimulus Onset Asynchrony: 83, 100, and 350ms. We analysed reaction times and fitted a Hierarchical Drift Diffusion Model. The results showed that RTs and the threshold parameter “a” of the model were modulated by the length of the streams, but only for the slowest presentation rate. We conclude that the memory traces for stimuli presented in RSVP (at fast presentation rates) were absent or too fragile to interfere with the retrieval of subsequent stimuli. The results agree with the view that conscious perception plays a key role in the memory encoding process.

## Machine learning approach to study kinematic aspects of Sense of Agency

Asaf Applebaum, Amit Regev Krugwasser, Yonatan Stern, Roy Salomon

Sense of Agency (SoA) is the feeling of control over bodily motor actions. SoA arises, according to contemporary theories, from both implicit sensorimotor integration processes as well as higher-level explicit judgments. Despite extensive research on motor processing, little is known about the relation between motor kinematics and implicit and explicit processing of SoA. Here we examined, using a data-driven machine learning approach, whether unconscious sensorimotor incongruency over a viewed motion is related to the motion kinematics in a virtual hand (VH) task. Participants (N=57) performed an unseen finger movement and viewed a virtual hand making a movement that could either be synchronous with their action or include a parametric temporal or spatial incongruence. We trained a hybrid CNN-RNN deep neural network model to predict, based on the participant finger kinematics, whether the VH movement was synchronous or altered. Preliminary results suggest that the model distinguishes between synchronous and altered trials, even when participants were unaware of the conflict. This finding indicates that ML can uncover the kinematics underlying how sensorimotor conflicts alter the behavior of the motor system in the absence of conscious awareness, perhaps allowing a new implicit measure of SoA.

## Predicting lapses of attention with sleep-like slow waves

Thomas Andrillon, Angus Burns, Teigane MacKay, Jennifer Windt & Naotsugu Tsuchiya

Attentional lapses are ubiquitous and can negatively impact performance. They correlate with mind wandering, or thoughts that are unrelated to ongoing tasks and environmental demands. In other cases, the stream of consciousness itself comes to a halt and the mind goes blank. What is happening in the brain that leads to these mental states? To understand the neural mechanisms underlying attentional lapses, we cross-analysed the behaviour, subjective experience and neural activity of healthy participants performing a task. Random interruptions prompted participants to indicate their mental states as task-focused, mind-wandering or mind-blanking. High-density electroencephalography revealed the occurrence of spatially and temporally localized slow waves, a pattern of neural activity characteristic of the transition toward sleep. These slow waves accompanied behavioural markers of lapses and preceded reports of mind wandering and mind blanking. Furthermore, the location of slow waves distinguished sluggish versus impulsive behaviours, mind wandering versus mind blanking. Our results suggest attentional lapses share a common physiological origin: the emergence of local sleep-like activity within the awake brain.

## Falsification and Consciousness

Johannes Kleiner, Erik Hoel

The search for a scientific theory of consciousness should result in theories that are falsifiable. However, here we show that falsification is especially problematic for theories of consciousness. We formally describe the standard experimental setup for testing these theories. Based on a theory's application to some physical system, such as the brain, testing requires comparing a theory's predicted experience (given some internal observables of the system like brain imaging data) with an inferred experience (using report or behavior). If there is a mismatch between inference and prediction, a theory is falsified. We show that if inference and prediction are independent, it follows that any minimally informative theory of consciousness is automatically falsified. This is deeply problematic since the field's reliance on report or behavior to infer conscious experiences implies such independence, so this fragility affects many contemporary theories of consciousness. Furthermore, we show that if inference and prediction are strictly dependent, it follows that a theory is unfalsifiable. This affects theories which claim consciousness to be determined by report or behavior. Finally, we explore possible ways out of this dilemma.

## Time Course of Conscious and Unconscious Semantic Processing

Nitzan Micher, Dominique Lamy, Maayan Avneon, Shai Fisher

Can conscious perception be dissociated from unconscious perception? One contentious issue between researchers is whether conscious and unconscious processing are qualitatively different from each other or whether all differences between them merely constitute quantitative differences. One proposed distinction between conscious and unconscious processing is their time course. A previous study found that while conscious semantic processing maintained its magnitude along the RT distribution, unconscious semantic processing decreased as RT increased. We raised two accounts of this finding. The first is that unconscious, but not conscious, processing decays over time. The second is that fast and slow RTs correspond to fast-intuitive and slow-rational processing modes and only the fast-intuitive mode is sensitive to unconscious information. We tested our hypotheses by using a response priming task with varying time intervals between prime and target (SOA) on each trial. The first account predicted that as SOA increase unconscious processing would decrease while the second predicted that unconscious processing would stay the same. We conducted two experiments and both showed that as SOA increased, conscious processing either increased or stayed the same while unconscious processing decreased. These findings unequivocally support the decay hypothesis and also show a qualitative difference between conscious and unconscious processing.

What do illusionists mean when they talk about 'what-it-is-likeness' of conscious experience?

Krzysztof Dolega

Illusionism is a popular approach to the metaphysics of consciousness, according to which phenomenal consciousness is illusory and experiences don't really have qualitative properties (Dennett, 1991; Frankish, 2016). However, illusionists relentlessly continue to define consciousness by appealing to 'what-it-is-likeness' of experience. This is problematic because, on their view, it isn't even clear what the phrase is supposed to refer to. An illusionist's typical response — that the illusion of subjective character of experience stems from the cognitive system misrepresenting itself — merely exchanges the problem of explaining the nature of phenomenal properties for the problem of answering how misrepresenting such properties can explain the subjective nature of experience. This paper outlines a novel version of illusionism called 'virtualism'. This view begins with a detailed analysis of the concept of 'what-it-is-likeness' and the fact that originally it was introduced to denote the subjective perspective of a whole organism. I propose that this property is a \_virtual\_ property of the whole cognitive system, but not of any of its parts. This approach not only explains what illusionist mean when they talk about subjective experience, but it also points out to how the view can account for the 'explanatory gap' between subjective and objective properties.

## The brain bases of responsiveness variability under moderate anaesthesia

Feng Deng, Nicola Taylor, Adrian M. Owen, Rhodri Cusack, Lorina Naci

The effects of anaesthesia vary substantially between individuals, in some cases with devastating consequences for individuals who become accidentally aware during surgical interventions. We investigated the neural bases of this inter-individual effect variability, and asked what they reveal about the breakdown of conscious cognition under anaesthesia? Healthy participants (N=17) underwent moderate propofol anaesthesia inside the MRI scanner during a narrative condition, and behavioural responsiveness was measured with a target detection task. In a second group of non-anesthetized participants (N=25) we qualified the attention demands of narrative understanding. Critically, we found that 30% of anaesthetized healthy participants were unaffected in their response times, thus thwarting one of anaesthesia's key aims — the suppression of behavioural responsiveness. Individuals with larger grey matter volume in frontal regions and stronger functional connectivity within the executive control network, were more resilient to anaesthesia, than those with lower values. These results show that responsiveness variability during propofol anaesthesia relates to inherent differences in brain function and structure within the executive control network, which can be predicted prior to sedation. These results shed light on the brain bases of responsiveness differences and highlight novel markers that may help to improve the accuracy of awareness monitoring during clinical anaesthesia.

## Evidence for perceptual insight in a virtual psychophysics experiment

Marianne Broeker, Andra Mihali, Guillermo Horga

An agent's ability to recognize the extent to which their subjective perceptual experience corresponds to actual states of the world is a form of insight. We developed a psychophysics task that uses a motion after effect (MAE) illusion to quantify the strength as well as the compensation of the distorted percept due to the illusion. We quantify insight as the extent to which perceptual reports shifted by the illusion are corrected to compensate for perceptual distortion when individuals have explicit knowledge about the illusory nature of the MAE. 57 healthy controls participated in the online version of this task. Participants were asked to report their beliefs about the actual direction of motion of a spiral stimulus, in addition to their perceived (illusory) direction of motion. Participants were able to compensate for distorted perception: When reporting their beliefs under the MAE illusion, participants's bias shifted from negative ( $M = -0.04$ ,  $SD = 0.057$ ) back towards 0 ( $M = -0.0198$ ,  $SD = 0.038$ ) ( $t(56) = -2.579$ ,  $p = 0.0126$ ). Overall, we operationalised a complex form of metacognition, perceptual insight, implement it in an online task and showed that participants compensated for their distorted percepts when they had knowledge of their illusory nature.

Where does metacognitive inefficiency come from?

Dobromir Rahnev, Medha Shekhar

Confidence judgments are usually less informative about one's accuracy than they could be; a phenomenon known as "metacognitive inefficiency." Here we discuss the reasons for this inefficiency, focusing on two critical issues. First, metacognitive inefficiency is often assumed to stem from a noisy signal. However, no empirical evidence to date directly supports this view. Instead, we argue that metacognitive inefficiency may be almost entirely due to imperfect computations. Second, the inefficiency is usually thought to be due to random, nonsystematic noise. Again, no empirical evidence to date supports this view. Instead, metacognitive inefficiency may be mostly driven by systematic errors in computation. We explore the implications of these considerations to theories of metacognition and especially to claims for domain-specific metacognition.

What is the feeling of effort about?

Juan Pablo Bermúdez

There has been significant progress in understanding the feeling of mental effort and the feeling of bodily effort, but this progress has not translated into a general theory of the feeling of effort, and the two research programs remain largely disconnected. To advance toward such general theory, I defend the \*single-feeling view\*, which holds that there is only one feeling of effort for both mental and bodily actions. This feeling represents the expected costs, both mental and physical, of performing a given action. Expected-cost theories have been proposed for the feeling of mental effort, so here I focus on arguing that the feeling of bodily effort should also be explained in those terms. This feeling does not simply represent bodily exertions, but rather their expected costs as calculated via subpersonal processes. I finish by discussing the single-feeling view's implications for action guidance, the sense of agency, and the definition of efforts.

Awareness is needed for scene-based contextual effects on perception of ambiguous objects

May Sar-Salom, Tzahi Kravitz, Dan Biderman, Liad Mudrik

Perception is typically held to rely on both bottom-up information and top-down processes. Previous work suggested some top-down processes can take place without awareness, by showing that subliminally contextual inducers bias perception of an ambiguous symbol. Here, we extend this line and examine whether such effects can be found for real-life objects in scenes. In three studies, we presented an ambiguous visible object embedded in consciously or unconsciously perceived scenes. In experiment 1, object was presented together with scene. While scene biased object categorization when consciously perceived, no effect was found for invisible scenes. In experiment 2, we examined if this result from the simultaneous presentation of object and scene, attracting subjects' attention towards the former. Accordingly, scene was presented before the object, yet same effect was found. Finally, in Experiment 3, the object was presented prior to its being simultaneously presented with the invisible scene, allowing sufficient time generating predictions about object identity. Here too, invisible context did not bias object classification. These findings provide substantial evidence against invisible scenes ability to disambiguate visible objects and bias classification. This suggests that consciousness might play an essential role in top-down contextual effects and in integrating objects onto rich, complex scenes.

3D LIVE Streaming Full-body Illusions: a new perspective on Bodily Self-Consciousness

Debbie M.L. de Boer, Patrick J. Johnston, Graham Kerr, Marcus Meinzer, Axel Cleeremans

Inspired by recent technological advances in the gaming industry, we used capture cards to create and LIVE-stream high quality 3D-images. With this novel technique, we developed a real-life stereoscopic 3D Full-body Illusion paradigm (a 3D-projection). Unlike previous versions of the Full-body Illusion that rely upon unwieldy head-mounted displays, this paradigm enables the unobstructed investigation of such illusions with neuroscience methods (e.g., tDCS, TMS, EEG & NIRS) and to examine their neural underpinnings. Neuroscience methods typically require free and unobstructed access to the head and skull. The present study reports a well-controlled experiment that for the first time systematically investigated a Full-body Illusion paradigm with brain stimulation (HD-tDCS). Whilst controlling for susceptibility factors, the study aimed to specifically characterize the link between abnormal right angular gyrus function and unusual self-location: (embodied) perspective-taking. In support, we report clear causal evidence that right angular gyrus stimulation enhances out-of-body projection; while specifically sense-of-agency and perspective-taking are hampered (i.e., self-other discrimination). These findings present novel insights into the mind-body relationship and offer important future directions for neurorehabilitation programs and treatment of psychosis symptoms. The brain's ability to locate itself might be the key mechanism for self-identification and to discriminate oneself from the environment.



## Brain Glucose Hypo-metabolism in Patients with Disorders of Consciousness: A Meta-analysis

Baris Kaan Ok, Arianna Sala, Jitka Annen, Aurore Thibaut, Steven Laureys

The present study aims to synthesize existing studies on cerebral hypo-metabolism in patients with disorders of consciousness (DOC). A systematic review and meta-analysis were conducted in February 2021. Two independent assessors searched PubMed for voxel-wise, whole-brain, resting-state [18F]FDG-PET studies involving >16years-old patients with prolonged DOC. Coordinate-based meta-analysis was performed via activation likelihood estimation in GingerALE (statistical threshold:  $p < 0.001$ , voxel-level;  $p < 0.05$  FWE-corrected, cluster-level). Distribution of hypometabolism was compared to the topography of neurocognitive and sensorimotor resting-state networks, based on the FINDlab atlas. Of the resulting 265 studies, 12 met inclusion criteria, with 245 patients (Unresponsive Wakefulness Syndrome (UWS),  $n=107$ ; Minimally Conscious State (MCS),  $n=138$ ); and 259 healthy controls. Meta-analysis revealed hypo-metabolism in DOC patients in precuneus, posterior/middle cingulate gyrus, angular gyrus, inferior/superior parietal lobule, precentral gyrus, middle frontal gyrus, thalamus and caudatum. Hypo-metabolism was found preferentially in the default mode (40% of the assigned voxels), the executive control (27%) and the basal ganglia/thalamus (24%) networks. Separate meta-analysis of UWS and MCS subgroups revealed hypometabolism in superior parietal lobule uniquely in UWS patients, and hypometabolism in the caudatum uniquely in MCS patients. Cerebral hypo-metabolism in patients with DOC preferentially affects regions belonging to the default mode, executive and basal ganglia/thalamus networks.

## Onset times of the referral-of-touch and ownership sensation in the rubber hand illusion

Anantha Krishna Sivasubramaniam, Rachel Pye, Andreas Kalckert

The rubber hand illusion (RHI) is a perceptual illusion characterised by the experience of referral-of-touch (RoT), i.e., the perceptual binding of the seen and felt touch, and ownership, i.e., feeling the rubber hand belongs to one's body. Previous studies have shown that both sensations show different patterns in specific experimental situations, thus suggesting these may represent different facets or stages of the RHI. Thus, the exact nature of the relationship between RoT and ownership is unclear. In the following experiment we measured the respective onset times of RoT and ownership. Amongst participants that experienced both RoT and ownership, RoT (17.8 sec) preceded ownership (28.2 sec). Interestingly, a subset of participants experience only RoT without ownership and these participants' RoT onset time (17.0 sec) is similar to participants that experience both ownership and RoT. We also observed that a small subset of participants experience ownership before experiencing RoT. These results provide further evidence that RoT and ownership represent distinct experiences within the RHI. Overall, our results are consistent with theoretical assumptions that the RoT drives the experience of ownership. However, the presence of participants experiencing ownership before RoT suggests the presence of an alternate route to the experience of ownership.

"Demystified" consciousness? Not so fast.

Łukasz Kurowski

Feinberg and Mallat (2018, 2019) claim that they have “demystified” subjectivity because, based on evolutionary and neurobiological analyses, consciousness with its various features follows naturally. Hence, there is no need to posit any explanatory gap between brain states and subjective states because consciousness follows naturally from biology, just as life follows from specific biological mechanisms. However, features such as qualia and unity of consciousness do not naturally follow from neurobiological features, mainly because Feinberg and Mallat do not state them. Hence, the explanatory gap persists and the project of “demystification” fails.

Brain connectivity profiles associated with perceptual task performance

Johan Nakuci, Jiwon Yeon, Ji-Hyun Kim, Sung-Phil Kim, Dobromir Rahnev

Over the last several decades, extensive research has uncovered the brain areas supporting many perceptual tasks. However, surprisingly little is known about how the brain connectivity profile during task execution is related to task performance. Here utilized fMRI data from 50 human subjects performing a simple perceptual task with confidence, and investigated how the brain functional connectivity profile is related to behavioral performance. We found that higher accuracy is associated with increased modularity, but was unrelated to reaction time (RT), confidence, or metacognitive efficiency. Further, we examined how these behavioral variables were related to the connectivity between large brain networks. The results revealed that subjects who exhibited faster response times had stronger connectivity between the dorsal and the ventral attentional network. In addition, confidence was associated with the strength of connectivity between the somatomotor and both the default mode and dorsal attention networks, consistent with theories of action-related influences on confidence. Surprisingly, global brain connectivity was not related to metacognitive efficiency, suggesting that the quality of one’s metacognition may not depend on global brain dynamics. These results demonstrate that different components of task performance depend on different brain connectivity profiles and provide insight into the mechanisms behind simple perceptual tasks.

## Sleeping brain dynamics: a window to study meditation effects on consciousness

Bindu M. Kuty

Meditation practice induces state and trait changes in brain activities and modulate cognition and consciousness. We studied the effect of vipassana meditation (long term vipassana meditation practitioners, age group between 35-65 years, both sexes) on sleeping brain dynamics in response to presentation of auditory stimulation during sleep. Sleep-specific brain responses like event-related potentials (ERPs) and K-complexes (eKCs) in response to auditory stimuli has been studied. Both meditators and non-mediator groups showed comparable slow-wave propensity and spectral profile. However, Vipassana meditators showed lower spindle propensity, larger ERPs (N550 and P900) and longer eKCs during N2-stages. Meditators also showed higher wide-spectrum activity in default mode network (DMN) and increased bilateral DMN-insula connectivity in theta band, and the connectivity showed strong correlation with ERPs and eKCs. The present study highlights the effect of Vipassana meditation practice in modulating consciousness during sleep. Such approaches help us to assess the cognitive flexibility of neural networks and its wider range cognitive possibilities.

## Perceptual incoherence and causal bias of altered consciousness in Schizophrenia

Dr Arun Sasidharan, Dr Ravindra P. N., Dr Ramajayam G., Dr Bindu M. Kuty

Scientific study of consciousness benefits greatly from research in mental disorders like Schizophrenia. Growing evidence suggests no common underlying neural patterns for perceptual impairments and self-disturbances (including causal bias) in such disorders, and they show a great deal of diversity in terms of affected brain regions and functions. Moreover, many of the disturbances in conscious access or interpretation of information seen in these patients, could be explained from different combinations of abnormal automatic or unconscious processes (aberrant neural synchrony). Taken together, the altered perceptual consciousness seen in disorders like schizophrenia warrants a search for subject-specific abnormalities that may show up in different brain regions and perceptual or cognitive functions, from a predictive coding framework. In this talk, I will share some insights based on our EEG dynamics data from schizophrenia patients' performance in a perceptually rich cognitive paradigm.

## How do humans give confidence? Comparing 12 popular process models

Medha Shekhar, Dobromir Rahnev

Humans have the metacognitive ability to assess the likelihood of their decisions being correct via confidence estimates. Several theories have attempted to model the computational mechanisms that generate confidence. Yet, due to little work directly comparing these models using the same data, there is no consensus among these theories. In this study, we compare twelve popular process models by fitting them to large datasets from two experiments coming from a perceptual task with confidence ratings. Quantitative comparisons showed that the best fitting model postulates a single system for generating both choice and confidence, where confidence is additionally corrupted by signal-dependent noise. These results contradict the dual processing notion that confidence and choice arise from distinct systems. Model evidence also failed to support popular notions that confidence is derived from post-decisional evidence, decision-congruent evidence, or posterior probability computations. Further, qualitative analyses showed that the worst performing models were characterized by relatively poor abilities to predict primary task performance and metacognitive ability. With these analyses, we establish a general framework for model selection that also provides qualitative insights into their successes and failures. Most importantly, these results, by confirming and falsifying theories about confidence, begin to reveal the nature of metacognitive computations.

## Maladaptive Perceptual Consciousness in Chronic Pain

Dr Vrinda M, Dr Geetha Desai, Dr Bindu M Kutty

Chronic pain is a complex, agonizing, and major global health issue, having a severe impact on individuals and the country's health care system, and economy. Current treatment strategies fail to give any sort of relief in the pain patients. From acute pain to chronic pain myriad changes (plasticity) occur in our body and brain which leads to aberrant top-down pain modulation. Majority of these occur subconsciously and this results in altered conscious perception of pain. In addition to aberrant pain perception, they also suffer from other co-morbidities like anxiety, depression, cognitive deficits, emotional instability, and aberrant sensory perception. So, the development of a cognitive model with a wider framework is imperative in treating pain. This model should encompass both subjective and objective assessment of perceptual (sensory gating, self-monitoring, image perception, auditory perception, motor readiness), emotional and cognitive (congruency detection, attention and memory, error monitoring, spatial attention). This comprehensive investigation facilitates in developing a treatment strategy (combining pharmacological and non-pharmacological) which would help in addressing the issue at multiple levels and thereby restoration of normal perceptual consciousness. In this talk, I will be presenting this cognitive model based on our current work.

## Slow ramping in spiking neurons; a LIF network model of spontaneous actions

Jake Gavenas, Ueli Rutishauser, Aaron Schurger, Uri Maoz

Stochastic accumulation explains many facets of spontaneous actions and related brain activity, including why neural signals such as the Readiness Potential (RP) seem to “ramp up” before self-initiated movement. Crucially, accumulator models predict that accumulating activity with less autocorrelation would have shorter pre-threshold ramping averaged signals. However, the opposite pattern emerges for individual neurons: spike trains have short autocorrelation timescales (sub-second; Cavanagh et al., 2016), but some neurons begin ramping their firing rates several seconds before movement (Fried et al., 2011). It is unclear how such ramping could emerge at the single-neuron level in an accumulator framework. Thus, it is also unclear whether stochastic accumulation correctly describes neural dynamics before spontaneous actions. We simulated spiking neural networks and studied the effects of network architecture and synaptic dynamics on autocorrelation and ramping patterns. We developed a network model in which neurons ramp their firing rates before spontaneous threshold crossings. Networks exhibited accumulator dynamics while also qualitatively matching single-neuron findings. Furthermore, ramping was usually accompanied by a negative trend in an approximate EEG signal, reminiscent of the RP. This model thus gives a potential neural mechanism for self-initiated action and, possibly, for other models of spontaneous consciousness, such as spontaneous ignition.

## The Consciousness Theories Studies (ConTraSt) database: analyzing and comparing empirical studies of consciousness theories

Itay Yaron, Lucia Melloni, Michael Pitts, Liad Mudrik

In the last decade, several theories of consciousness have been proposed. Those theories associate consciousness with specific but different neural substrates and processes and are supported by different empirical studies. To date, overviews in the field were typically written from the standpoint of one theory, relying mostly on qualitative interpretations of the results. A systemic, quantitative and theory-free overview of studies is necessary to characterize the state of the field with respect to these theories. Here, we present a comprehensive quantitative analysis of all studies (365 papers reporting 412 experiments) interpreted as supporting/challenging one of four leading theories of consciousness: Global Neuronal Workspace, Integrated Information Theory, Recurrent Processing Theory and Higher Order Theory. Three major outcomes will be presented: First, a highly-detailed description of the current state of the field across variables such as the paradigms, measures, and findings of those studies. Second, an analysis of the differential distributions of these variables in papers supporting/challenging each theory, used to identify trends towards specific methods that might predict support of a specific theory. Third, a unique online and open database with interactive plotting tools, enabling researchers to answer meta-questions about the field of consciousness studies and the probed theories.

## Unconscious processing and regression to the mean: an attempt to improve common practices

Itay Yaron, Yoav Zeevi, Uri Korisky, William Marshall, Liad Mudrik

The scope of unconscious processing has been debated for decades. While some claim that any cognitive function can be carried out unconsciously, others hold that unconscious processing is negligible or completely driven by methodological shortcomings. One prominent criticism targets the common practice of excluding participants based on an awareness assessment, claiming that this post-hoc data selection leads to false effects driven by regression to the mean (RTTM). Here, we examined this criticism using both simulations and data from 16 studies probing unconscious processing (36 experiments overall). We confirmed that the reliability of awareness measures in the field is concerningly low, in line with the original criticism. Yet, using simulations we showed that reliability measures may be unsuitable for estimating error in awareness measures. Furthermore, we found that the suggested way to assess whether an effect is genuine or reflects RTTM is flawed, largely reflecting the linearity of the data rather than separating RTTM-driven effects from genuine ones. Thus, we examined alternative ways to assess the possible contribution of RTTM to the reported effects. Together, our findings emphasize the need to account for unreliable awareness measures, in order to minimize the contribution of measurement error to effects of unconscious processing.

## Motor possibilities and expectations about depth interact in promoting real objects' conscious detection

Uri Korisky, Yael Solar-Priel, Niv Cohen, Mor Farjun, Noa Kaner, Liad Mudrik

Real, 3D objects, are processed differently than 2D pictures. In previous work, we showed that real objects are more readily detected than their photographs, but only when these objects are meaningful. This was done using a variant of Continuous Flash Suppression, “real-life” CFS, which allows suppressing real-life stimuli in the natural environment. What drives this facilitated detection? One possible explanation is that motor plans evoked by real, familiar objects, endow these objects with a perceptual advantage. Another explanation holds that we are more used to seeing objects in 3D, and that this familiarity is what drives the effect. In two experiments, this was tested by presenting objects as well as stimuli that are more typically seen in 2D (e.g., letters or commercial logos). Both types were presented in 2D and 3D. In the first experiment, each stimulus type was more readily perceived when presented in its typical form (i.e., letters were more readily detected when appearing in 2D, and objects – in 3D). Preliminary results from the second experiment suggest that no effect is found for logos while objects still emerge faster to awareness. Taken together, the evidence suggest that motor plans and experience-based expectations about dimensionality might interact in facilitating detection of real objects.

## Top-down and Bottom-up Interaction as a Behavioural Marker of Access Consciousness

Zefan Zheng, Shuyue Huang, Yongchun Cai

Global Neuronal Workspace theory postulates that the dynamic and simultaneous interaction between top-down network and bottom-up network is disabled during unconscious processing. However, such a hypothesis has been rarely directly tested in the field. To fill this gap, current study is focused on testing this theoretical postulate using three behavioural experiments which employed continuous flash suppression (Experiment 1 and 2) or backward masking (Experiment 3, a secondary analysis on an existing dataset) to manipulate access consciousness indexed by both discrimination accuracy and subjective report of consciousness. As it was well documented that in a conventional semantic priming paradigm, both the incongruity between BU prime representation, what the prime originally is, and the target, and the incongruity between TD prime representation, what subjects think the prime is, and the target could delay target response time (RT). Our Results showed that TD congruency and BU congruency produced additive RT effects in invisible conditions of prime perception, which suggests the independent nature of top-down and bottom-up processes during unconscious information processing. Reversely, an under-additive interactive pattern was shown when higher objective performance was achieved or subjective visibility was reported, which is a signature of informational interaction between two neural networks.

## Can we solve arithmetic equations non-consciously? A pre-registered replication.

Surya Gayet, Myrthel Dogge, Marius V. Peelen

Historically, consciousness has been deemed necessary for performing effortful and complex cognitive processes, whilst only reflexive and elemental feature processing was thought to be possible in its absence. One of the most famous counter-examples is a study showing that human observers were able to solve arithmetic equations that were not consciously perceived (Sklar et al., 2012). In this study, masked equations (e.g., “9 - 2 - 4 =”) were immediately followed by Arabic numerals that participants were required to read out loud. In two experiments (as well as in a subsequent replication study), Arabic numerals were reported faster when they happened to be the correct solution to the preceding equation, compared to when they were not. This implies that observers solved equations that they did not consciously perceive. Due to its huge implications for theories of consciousness, this finding was subjected to peer scrutiny, and several re-analyses were subsequently published that casted doubts on the original findings. Here, we conducted a high-powered pre-registered replication study, with an optional Bayesian stopping rule, and an analysis approach tackling key issues brought up in the reanalysis studies. TLDR: We found no evidence that observers can solve arithmetic equations that were not consciously perceived.

## Noradrenergic activity modulates effect of spatial predictions on visual perception

Stijn Nuiten, Jan-Willem de Gee, Johannes Fahrenfort, Simon van Gaal

To make sense of the world, our brain combines predictions about future sensory input with current incoming sensory information. Valid predictions result in faster and more accurate choice behavior, which is likely the result of more precise encoding of sensory information. The exact neural mechanisms underlying this effect are still debated, although evidence suggests that predictions induce changes in the input/output relationship of neuronal networks, resulting in sharpening of representations (“gain modulation”). Neuromodulators, such as noradrenaline and acetylcholine, have been proposed to play a pivotal role in controlling neural gain by regulating cortical excitability. Thus, sharpening of sensory representations by valid predictions is the result of (I) top-down signals from parietal/frontal regions and (II) neuromodulatory signals into sensory regions. We tested these alternatives by pharmacologically increasing activity of noradrenaline and acetylcholine in human participants performing a visual orientation discrimination task, on which the spatial locations of targets were predicted or not, while we measured EEG. Our preliminary data suggests that noradrenergic, not cholinergic, activity enhances the effect of spatial predictions on the accumulation rate of sensory information through alterations in pre-stimulus cortical excitability. These findings accentuate the important role of internal states of the brain in perceiving the external world.

## A mechanistic perspective on the harder problem of consciousness

Andy Mckilliam

Suppose we encounter or build a system that shares all of our consciousness-related capacities but does not share our neural mechanisms. Would it have subjective experiences? Answering this question is the harder problem of consciousness (HPC). According to Block (2002) we have no rational grounds for deciding either way: I agree. However, from a mechanistic perspective a number of things look different. First, the problem is considerably broader than Block suggests – dualists and illusionists must face it also. Second, the source of the problem can be identified in our inductive practices rather than in metaphysical intuitions. Third, the lesson to learn from the HPC is not that there is a “deep tension” in consciousness science, but rather that a mechanistic science of consciousness will not be universally generalizable. Given that mechanistic models are not universally generalizable, this should come as no surprise.



## Differences in cortical working memory coding of biological motion of oneself and others

Mateusz Woźniak, Timo Torsten Schmidt, Yuan-hao Wu, Felix Blankenburg, Jakob Hohwy

Establishing arbitrary associations between the self and a diverse range of stimuli leads to facilitated cognitive processing of these stimuli. However, little is known about how creating such abstract self-associations influences various aspects of the bodily self. In order to investigate this issue we conducted an fMRI study in which participants were told to hold in their working memory patterns of full-body biological motion (displayed by point-light walkers) arbitrarily labelled as either one's own movement, or as movement performed by someone else (one of two stranger-identities). After conducting MVPA we were able to decode whether a memorized movement was associated with the self or a stranger from the left inferior frontal gyrus (pars opercularis), and the left middle frontal gyrus. These two areas are frequently reported as involved in action understanding, and there is evidence suggesting that they form part of the human mirror neurons system. At the same time, presentation of self-associated abstract cues (colours) led to increased BOLD activity in the ventral medial prefrontal cortex, an area frequently associated with processing of abstract self-related information. Our results show that different brain systems are involved in processing of bodily and conceptual arbitrarily self-associated information.

## Dreams, Sleep and Emotions: Survey findings during Covid-19 pandemic

Dr. Gulshan Kumar, Dr. Ravi Yadav, Dr. Ravindra P. N., Dr. Bindu M. Kutty

Dreaming is a phenomenon, presumed to be experienced by every human. It's a process of experiencing perceptions, thoughts and emotions in NREM as well REM sleep. Substantial individual differences were seen in dream recall frequency and this was correlated with personality, behaviour and attitude towards dreaming. Studies have also found that participants who woke up frequently at night (more disturbed sleep) have high dream recall frequency. There are also gender differences, with females experiencing more vivid dreams and nightmares than males. In a study during Covid-19 pandemic, we hypothesised that there would be changes in dream content, subjective sleep quality and their mood across gender and dream recallers (low and high). In the total 941 participants, we found that females had more aggressive or cruel characters in their dreams than that of males. Females also reported more negative mood and sleep disturbances during Covid-19 pandemic period. In high dream recallers, sleep quality was compromised and they experienced negative dream and mood during sleep and wake, respectively. Overall, our findings suggest that poor sleep quality and emotional disturbances are correlated with dream recall frequency and dream contents.

## Consciousness from Yoga perspective

Dr. Ramajayam Govindaraj, Dr Arun Sasidharan, Dr Ravindra P. N., Dr Bindu M. Kutty

Consciousness is understood in diverse terms from phenomenological, neuroscience and spiritual perspective. From eastern perspective, philosophy of Yoga is rich in literature related to consciousness, though less studied. Despite Yoga being used widely for therapeutic purpose, yet the advantages are only a small proportion of its potential benefits. The entire rubric of Yoga including lifestyle modifications and advanced practices like samadhi has vast implications which are totally unexplored from a consciousness perspective. Tapping the full potential of Yoga in its entirety needs a new paradigm shift in our understanding about consciousness. Though studying neural correlates of consciousness from phenomenological and neuroscience perspective has advanced our understanding towards consciousness, the hard problem of consciousness remains untouched. To complement the existing findings and understandings of consciousness, it is important to study about consciousness from Yogic perspective, which in addition to phenomenal consciousness, also describes about contentless consciousness ('Turiya') Experiential wisdom of this contentless consciousness is spread across Yogic scriptures and is unique to Yoga philosophy. Scientific investigation can be fine-tuned if definitions and methods are guided by first-person contemplative experience of this contentless consciousness from Yogic perspective. Accordingly, I propose a new Yoga-based methodology to study consciousness.

## Subcortical neuronal correlates of perceptual consciousness

Michael Pereira, Nathan Faivre, Fosco Bernasconi, Jacob Suffridge, Shuo Wang, Victor Finomore, Nicholas Brandmeir, Ali Rezai, Olaf Blanke

Subcortical brain structures such as the basal ganglia or the thalamus are involved in regulating motor and cognitive behavior. However, their contribution to perceptual consciousness is still unclear, due to the inherent difficulties of recording subcortical neuronal activity in humans. Here, we asked neurological patients undergoing surgery for deep brain stimulation to detect weak vibrotactile stimuli applied on their hand while recording single neuron activity from the tip of a microelectrode. We isolated 29 putative single neurons in the subthalamic nucleus (STN) and 20 in the motor and sensory thalamus. A significant proportion of neurons (STN: 31%; thalamus: 25%;  $p < 0.05$ , permutation test) modulated their activity while participants were expecting a stimulus. We isolated a subset of neurons (STN: 22; thalamus: 17) for which we had sufficiently good behavior to contrast neuronal activity between detected (hit) and undetected (miss) stimuli. We found that the firing rate of 32% ( $p = 0.012$ ) of STN neurons differed between hits and misses, suggesting a possible role of these neurons for perceptual consciousness. We found only one (6%; n.s.) such neuron in the thalamus. We will discuss subthalamic correlates of consciousness in light of a recent proposal linking conscious access with evidence accumulation.

A theoretical approach to develop a working model to understand cognition and consciousness by integrating Ancient Indian knowledge system and Affective Neuroscience

Dr. Ravindra P. N., Dr Ramajayam G., Dr Arun Sasidharan, Dr Bindu M. Kutty

Indian knowledge system provides a theoretical cognitive construct that explains human experience and behavior comprehensively. Components of cognitive apparatus - Manas (thoughts), Buddhi (intelligence/discriminative-faculty) and Ahamkara ('I'-ness/ego) - contributes to experience. However, individual's phenomenological experience is shaped by 'tri-guna' (three qualities) which modulates the cognitive apparatus. Tri-guna are psycho-physiological in nature (potentially quantifiable) consisting of Sattva (balance and stability), Rajas (activity and imbalance) and Tamas (inertia and dullness). Tri-guna consists of state-trait components, where the 'trait' account for personality type and 'state' for dynamic core. The unique pattern that emerges from the interaction of the three qualities determines the nature of first-person experience. This explains the phenomenological aspects of cognition (perception), emotion, well-being and consciousness. On this basis, Yoga/meditation practice adopt a method of non-attachment to develop a unique pattern predominated by sattva (qualities of goodness, positivity, peacefulness, virtuous, etc.). Emotional styles in affective neuroscience and the underlying neural mechanisms are well-studied. Moreover, these emotional styles are dynamic and can be modulated by meditation training to develop a healthy emotional pattern. Thus, both Indian theoretical construct and affective neuroscience shares over-lapping principles. This theoretical integrated construct would be substantiated with data from a pilot study.

Frontal midline theta neurofeedback training as a potential intervention for adolescent depression

Suma Bhaskar, Dr Ravindra P. N., Dr Arun Sasidharan, Dr Ramajayam G., Dr Bindu M. Kutty

Underdeveloped fronto-limbic connections in adolescents lead to improper emotional regulation, impulse control, impaired insight, and capacity for planning. All of this may contribute to increased risk of developing depression in adolescents. Depressed adolescents have a reduced resilience, improper affect labelling – where they are not able to recognize interoceptive sensations (physiological and emotional) and wrongly interpret them as depression. Increasing attention by focusing on breath (with real time frontal mid-line  $\theta$  or fm $\theta$  Neurofeedback) can target Default Mode Network (DMN) to reduce its activity, thereby reducing rumination. It is known that fm $\theta$  power increases in focused attention tasks. Even though attention is considered as a component of cognitive ability, it is also an aspect of emotional style, both of which are affected in depression. Selective attention allows an individual to successfully screen out sensory or emotional distractions and focus on a particular task. Therefore, higher ability to screen out distractions and staying focused leads to higher emotional balance and well-being. Training depressed adolescents to increase attention through focused breathing will increase their fm $\theta$  by real time adaptive neurofeedback technique. This may help to reinterpret interoceptive sensations and to reappraise their cognitive state.

## Affective touch and the rubber hand illusion – a meta-analysis

Jesper Anell, Andreas Kalckert

In the rubber hand illusion (RHI) participants experience a fake hand as part of their own body. This illusion relies on tactile stimulation of the participant's hand. Affective touch is a specific form of tactile stimulation which entails an affective component, recruiting additional neurophysiological and psychological mechanisms. Previous studies have suggested an effect of affective touch on the RHI. However, the magnitude of this effect was inconsistent across studies. In the following we present a synthesis of studies examining the effect of affective touch in the RHI (as measured by proprioceptive drift and questionnaire ratings). Our systematic review identified 11 comparisons between affective touch and regular discriminative touch in five experiments from four different experimental studies. These studies showed that affective touch has a small but significant effect on the subjective experience of the illusion (Cohen's  $D = 0.20$ , 95%CI 0,05-0,35), and a medium effect on the proprioceptive drift (Cohen's  $D = 0.56$ , 95%CI 0,12-1,01). However, we observed a large heterogeneity in the proprioceptive drift measure ( $I^2 = 88\%$ ), potentially reflecting differences in the experimental setup and procedures. These results support the conclusion that affective touch increases the experience of ownership in the RHI.

## Metacognitive bias and optimal criteria for confidence judgments

Lucie Charles, Brian Maniscalco

Signal detection theory has long provided the field of psychology with a simple but powerful model of how observers make decisions under uncertainty, distinguishing their sensitivity from their response bias. Signal Detection theory has recently been extended to confidence judgments, providing a framework to measure precisely metacognitive sensitivity. While recent research has focussed on quantifying metacognitive efficiency across individuals and tasks, almost no study has explored metacognitive bias. In particular, second order signal detection theory proposes that high confidence reports are produced when accumulated perceptual information exceeds a certain level. However, we lack empirical evidence and a theoretical account of how such confidence criteria are positioned. In this talk, I will present a formal description of different strategies that can be used to determine the position of such confidence criteria. In particular, I will compare how optimizing different outcome measures, from confidence accuracy to second-order reward contingencies, can lead to radically distinct predictions on the optimal way to set one's confidence criterion. I will illustrate how such a formal approach can be applied to characterize precisely whether an observer is over- or under-confident, therefore providing important evidence to characterize humans' ability to introspect their own thoughts and actions.

## The Dynamics of Affect Across the Wake-Sleep Cycle: From Waking Mind-Wandering to Night-Time Dreaming

Pilleriin Sikka, Katja Valli, Antti Revonsuo, Jarno Tuominen

Affective experiences occur across the wake-sleep cycle—from active wakefulness to resting wakefulness (i.e., mind-wandering) to sleep (i.e., dreaming). Yet, we know little about the dynamics of affective experiences across these states. Here, we investigated the within-person fluctuations in the prevalence and valence of affect experienced during mind-wandering and night-time dreaming. We compared the affective ratings of 328 mind-wandering and 529 dream episodes from 32 healthy adults. In a sub-sample, we additionally analysed the affective ratings of 548 waking episodes from 15 participants. Results showed that mind-wandering was more positively valenced than dreaming, and that both mind-wandering and dreaming were more negatively valenced than active wakefulness. We also compared participants' self-ratings of affect with external ratings of affect (i.e., analysis of verbal reports regarding the same episodes). With self-ratings all the episodes were predominated by positive affect. However, the affective valence of verbal reports changed from positively valenced waking reports to affectively balanced mind-wandering reports to negatively valenced dream reports. Together, the findings show that (1) the positivity bias characteristic to waking experiences decreases across the wake-sleep continuum, and (2) conclusions regarding the affective nature of subjective experiences depend on whether self-ratings or the verbal reports describing these experiences are analysed. These findings contribute to our understanding of the nature and possible function of affective experiences across different states of consciousness.

## Self-boundary dissolution: a phenomenological investigation

Ohad Nave, Fynn-Mathis Trautwein, Aviva Berkovich-Ohana

A fundamental aspect of the sense of self is its pre-reflective dimension specifying the self as a bounded and embodied knower and agent. Being a constant and tacit feature structuring consciousness, it eludes robust empirical exploration. Recently, deep meditative states involving global dissolution of the sense of self have been suggested as a promising path for advancing such an investigation. To that end, we conducted a comprehensive phenomenological inquiry into meditative self-boundary alteration. The induced states were systematically characterized by changes in six experiential features including the sense of location, agency, first-person perspective, attention, body sensations and affective valence, in addition with employed meditative techniques and overall degrees of dissolution. Quantitative analyses of the relationships between these phenomenological categories highlighted a unitary dimension of boundary dissolution. Notably, passive meditative gestures of “letting go”, which reduce attentional engagement and sense of agency, emerged as driving the depth of dissolution. These findings set the stage for future phenomenologically informed analyses of neurophysiological data and highlight the utility of combining phenomenology and intense contemplative training for a scientific characterization of processes giving rise to the basic sense of being a bounded self.

Some perceptual illusions may be created by phenomenological control

Peter Lush, Ryan B. Scott, Anil K. Seth, Zoltan Dienes

‘Phenomenological control’ describes the top-down generation of subjective experience to meet contextual expectations arising from direct or implicit imaginative suggestion. It has been primarily studied in ‘hypnosis’, where suggestions for altered subjective experience drive striking experiential and physiological changes which, while voluntary, are experienced as involuntary. The ability to respond to imaginative suggestion in hypnosis is a normally distributed and stable trait. However it has long been known that hypnosis is not required for successful response to imaginative suggestion. Expectancies arising from demand characteristics (cues which communicate experimental aims to participants) may act similarly to expectancies arising from imaginative suggestions and therefore drive experiential changes in psychological experiments. We have previously reported substantial relationships between trait response to imaginative suggestion in a hypnotic context (hypnotisability) and three effects: the rubber hand illusion, mirror touch synaesthesia and vicarious pain. Here we present norms for the phenomenological control scale (PCS) – a measure of trait response to imaginative suggestion outside the context of hypnosis. We also report a substantial relationship between reports of visually evoked auditory response (vEAR) in which participants report auditory experience when watching silent video, and PCS scores. vEAR reports may reflect phenomenological control in response to demand characteristics.

Mind Blanking is Associated with Rigid Spatio-Temporal Brain Configurations in Typical Wakefulness

Sepehr Mortaheb, Manousos A. Klados, Laurens Van Calster, Paradeisios Alexandros Boulakis, Kleio Georgoula, Steve Majerus, and Athena Demertzi

During spontaneous thinking, our minds are sometimes empty of reportable contents, known as mind-blanking (MB). As MB challenges the view of a constantly thought-oriented mind, we here investigate its neurofunctional profile. Using an fMRI experience-sampling dataset, we show that MB is reported more scarcely and faster than thought-oriented mental states, and has low transitional dynamics that potentially serves as a transient mental relay. MB’s cerebral profile is linked to an overall positive connectivity pattern, bearing resemblance with neural configurations observed during local sleep. By estimating information exchange using graph-based transition probabilities, we found high segregation between the default mode (DMN) and other networks before MB reports; the DMN-salience network segregation was further able to classify MB from thought-oriented reports in smaller steps. Collectively, these results show MB as having a unique neurofunctional profile that, possibly, reflects neuronal silencing during waking periods allowing more mechanistic investigations of MB in the future.

Neural signatures of consciousness can be reactivated retrospectively.

François Stockart, Elisa Mossé, Claire Sergent

Is our perceptual experience of a stimulus entirely determined during the early buildup of sensory representation, or can later influences still determine whether we will perceive it consciously? Recent studies demonstrated that retro-cueing attention towards the location of a visual target after its disappearance can still improve detection. This effect has been interpreted as reflecting delayed conscious access to the target. In our magnetoencephalography (MEG) study, we test this interpretation by investigating whether neural signatures of conscious access can be activated retrospectively. Using a single visual stimulus at contrast threshold and symbolic auditory retro-cues, we manipulated retrospective endogenous attention and assessed its influence on target visibility and orientation discrimination. Behavioral data indicate that endogenous reorienting of visual attention improves target detection. Pilot MEG data show that, in valid trials, there is a cue-dependent, top-down reactivation in the source space corresponding to V1 ~250-300ms after cue presentation, and that this reactivation is associated with increased decoding of visibility responses in retro-cue trials. The reactivation is time-locked to the cue. Our results indicate that conscious access to a stimulus can be triggered by retrospective attention several hundred milliseconds after its onset, underlining temporal flexibility in conscious perception.

#### Interoceptive Attention to Bodily Sensations in Mindfulness

Dar, Omer\*; Hadash, Yuval; Veksler, Tanya; Oren-Schwartz, Romi; Levy-Kornbluth, Ma'ayan; Amir, Iftach; Goldstein, Pavel; Bernstein, Amit

Although cultivating internally-directed attention, such as interoceptive attention to bodily sensations, is theorized to function as an essential mechanism of mindfulness training, empirical evidence is limited and mixed. Using a novel body map measurement methodology, we are currently investigating the effect of one-week mindfulness meditation retreats (N~90), relative to matched controls (N~45), on interoceptive attention. Before and then after the retreat or control period, participants complete a body map task – reporting the location, intensity and hedonic tone of sensations – in response to hearing their own neutral- and negative- thoughts (Amir et al., 2020). In preliminary analyses (n = 28), retreat participants demonstrated elevations in relative frequency of pleasant sensations and reductions of unpleasant sensations at post- relative to pre-retreat, following neutral- (.12 vs. .27,  $p < .01$ ; .39 vs. .19,  $p < .01$ ) as well negative- thoughts (.06 vs. .22,  $p < .01$ ; .39 vs. .30,  $p = n.s.$ ). Second, the magnitude of the association between subjective emotion and unpleasant bodily sensations was strengthened following the retreat ( $r_{pre} = .24$  vs.  $r_{post} = .54$ ). Findings may contribute to insight into the effects of mindfulness training on interoceptive attention to bodily sensations.

## Perceptual consciousness and moral worth are strongly coupled

Matan Mazor, Arianna Risoli, Anna Eberhardt, Stephen M. Fleming

In a recent theoretical paper, Birsch, Schnell & Clayton (2020) introduced a multidimensional framework of animal consciousness. Here we adopted their classification system and asked which of these dimensions contribute most to moral concern for non-human beings. Participants placed moral value on mental attributes more than physical similarity to humans in biology, appearance, and size. Specifically, behavioural indications of rich and complex visual processing had strong effects on both consciousness ratings and moral concern, more so than indications of self-awareness. Furthermore, moral worth was highly correlated with consciousness ratings, across items and participants. We discuss our findings in light of the philosophical debate over the moral significance of functional aspects of consciousness (Carruthers, 2019; Danaher, 2020; Levy, 2014), and in relation to the relevance of the scientific study of consciousness to ethics.

## Electrophysiological correlates of awareness and task relevance in an inattentional deafness paradigm

Torge Dellert, Insa Schlossmacher, Maximilian Bruchmann, Thomas Straube

Several event-related potentials (ERPs) have been proposed as neural correlates of consciousness (NCC), including early negativities and late positivities. However, previous studies have primarily focused on vision, and awareness was often confounded with task relevance. To expand this research to the auditory modality, we presented spoken words in a sustained inattentional deafness paradigm. Electrophysiological responses were obtained in three physically identical experimental conditions with different instructions. Participants were 1) either left uninformed or informed about the presentation of spoken words and performed a demanding auditory distractor task (U/I condition), 2) all informed about the words while continuing the same task as before (I condition), or 3) requested to respond to the now task-relevant words (TR condition). After completion of the U/I condition, only informed participants reported awareness of the words, while uninformed participants experienced inattentional deafness. In ERPs, awareness of words was accompanied by an anterior auditory awareness negativity (AAN). Only task-relevant stimuli elicited late positivities. Taken together, these results indicate that early negativities but not late positivities index awareness across sensory modalities. Thus, they support a role of early sensory processing in conscious perception and highlight the importance of considering task relevance in the search for NCC.



## Neurophenomenology of Simple Sensory Experience: An fNIRS Study

Asger Lakkenborg, Esben Kran, Rebekah Baglini, Andreas Roepstorff, Daina Crafa

Neurophenomenology, the study of how experience is represented by the brain, has been called the “really hard problem” of consciousness due to the highly subjective and complex nature of lived experiences. To date, most neurophenomenological research studies rely on participants’ verbally-reported experiences, and potentially confounds these experience with their verbalization as well as with thoughts associated with reflecting on the experience while preparing to report it. Until recently, neuroimaging devices could not tolerate the motion artifacts caused by verbalization. The advent of functional near-infrared spectroscopy (fNIRS), which is highly tolerant of motion, has changed that. The present study disentangles sensation, pre-verbal reflections, and verbalization of simple auditory and visual stimuli using fNIRS. Preliminary findings revealed increased activation in several prefrontal and sensory brain regions and novel findings when reflecting upon an experience compared to sensing or reporting it. This project is the first in a series of three closely-related experiments and, to our knowledge, it is the first neurophenomenological study using fNIRS.

## Complex-structured tactile signals override visuo-proprioceptive divergence in the rubber hand illusion

Piotr Litwin, Paweł Motyka

Body ownership is continuously shaped by integration of cues from different senses. However, the debate continues on whether it results from mere accumulation of available multisensory evidence or rather prioritization of the most relevant sensory signals. In the talk, I will present results of our recent study, supporting the latter view. The rubber hand illusion (RHI) was elicited in different conditions varying in availability and spatiotemporal complexity of tactile stimulation (none, simple, or complex) and differing in terms of visuo-proprioceptive divergence (the distance between the real and fake hands). The subliminal hand displacement procedure was used to alleviate potential suggestibility effects. We found that RHI was attenuated at the farthest distance only when tactile information was absent or simplified, but the attenuation was effectively prevented by the use of complex tactile stimulation—in this case, RHI was comparably vivid at both distances. Additional analyses showed that the effects occurred mainly across lower ranges of RHI strength distribution (among “weak” and “moderate” RHI responders). Passive proprioceptive acuity – assessed via elbow joint position discrimination task – was not related to RHI strength. I will also discuss theoretical implications of our results, focusing on causal inference models of body ownership.

Lempel-Ziv complexity changes across states of consciousness are dominated by spectral effects  
Fernando Rosas, Adam Barrett, Daniel Bor

Recent work in neuroscience has shown the great promise of Lempel-Ziv (LZ) complexity to assess conscious level from neurophysiological data. An important open question, however, is to what extent the difference in LZ complexity between two conditions may simply reflect the known spectral changes between them -- e.g. slow oscillations in sleep, compared to wakeful rest. To address this challenge, we propose a new, mathematically-grounded, method to decompose the LZ difference between two conditions into spectral, phasic, and spectrum-phase interaction components. Our method reveals that LZ changes across conscious states, for instance between normal wakeful rest and the psychedelic state or non-REM sleep, are mostly driven by changes in spectral power. Furthermore, each of these components can have distinctive spatial topologies, and phasic and spectrum-phase interaction components can sometimes take the opposite sign to the predominantly spectral overall effect. The fact that LZ, a single scalar number, is capable of discriminating between such diverse states of consciousness suggests it is neatly distilling particularly relevant information from a large, multi-dimensional spectrum. This new understanding of LZ helps us understand the properties of brain dynamics of conscious and unconscious states in a more fine-grained way.

Agency and Body Ownership across typical, psychedelic and psychotic populations

Gabriella Panishev, Amir Harduf, Roy Salomon

The embodied sense of self, usually termed body consciousness, is comprised of two fundamental aspects, Body Ownership (BO), the experience of identifying with the body and the Sense of Agency (SoA), the experience of controlling our actions. Both BO and SoA are significantly altered when the self is disrupted, as in psychedelic and psychotic experiences. Indeed, psychedelics are known to produce significant disruptions of self-consciousness, known as ego-dissolution and are thought to induce long lasting changes in the sense of self. Similarly, psychosis includes changes in the sense of control over one's body and mind as in passivity symptoms or thought insertion, and is widely considered a disorder of self. Here, we aimed to test if such changes in self are related to multisensory integration processes. We used a novel adaptation of the Moving Rubber Hand Illusion in which participants experienced either congruent or conflicting visuo-motor or visuo-tactile stimulation, inducing illusory BO and SoA over a rubber hand. We investigated modulations of BO and SoA based on both visuotactile (VT) and visuomotor (VM) correspondences in three groups (N=75): neurotypical individuals, heavy psychedelic users and psychosis patients. The results showed that overall the three groups had comparable BO and SoA experiences. However, the psychosis patients didn't experience BO induced by visuo-motor correlations. We found a correlation between BO and SoA, but no correlation was found between positive or negative symptoms of psychosis and BO or SoA. The results suggest that reported changes in self-experience related to long term psychedelic use and psychosis are not manifest in bottom up multisensory processes of the bodily self.

## An Artificial Neural Network Agent Trained to Control Endogenous Visuo-spatial Attention: Support for the Attention Schema Theory

Isaac R. Christian, Andrew I. Wilterson, Michael S. A. Graziano

Burgeoning behavioral evidence supports the hypothesis that the brain may construct a model of its own attention. The Attention schema theory posits that the brain's model of attention, or attention schema, is what we call awareness. When this model of attention is impaired, awareness and attentional control are compromised. To test whether a model of attention is functionally useful for control, we trained an artificial, deep Q-learning neural network agent on an analog of an endogenous visuospatial attention task. We tested how a descriptive model of spatial attention (the attention schema), added to the agent, might support two control functions: tracking a visual stimulus and inhibiting a distractor. We tested the agent's performance with and without the attention schema. With a schema present, the agent achieved near maximum task performance, but without access to a model of attention, the agent failed to correctly track a stimulus or inhibit attention to a distraction. These results suggest that the control of endogenous visual attention can be improved with a model of attention, and furthers the body of work investigating the possible benefit to the brain of building representations, not only of objects in the external world, but also of internal cognitive processes.

## UnReal? A cognitive approach to modeling the subjective Sense of Reality

Paz Bar-Tal, Gadi Drori, Yair Zvilichovsky, Roy Salomon

Consciousness mediates between our representation of the environment and the actual environment's characteristics. This correspondence is often termed 'reality' and our appraisal of its validity, the Sense of Reality (SoR). Aberrations of reality are often manifested as hallucinations (perception of non-existing objects) or illusions (perceptual experiences that are inconsistent with reality). Thus, SoR is an essential criterion in the assessment of neurological and psychiatric disorders. However, an understanding of the cognitive processes underlying SoR is still lacking. In this study, we employed a virtual reality approach to examine whether "virtual hallucinations" impact subjective judgments of reality. We used a novel VR environment (Unreal) in which we manipulate visual aspects of reality, mimicking the phenomenology of hallucinations found in psychedelic, psychotic and mystical states. In the Unreal environment, we parametrically manipulated laws of nature, perceptual effects, or aspects of the self, while participants rated how realistic the environment was. Preliminary results indicate significantly lower subjective reality judgments when reality alterations were introduced, and that these differed considerably between aspects. These results suggest that our novel VR approach can impact subjective judgment of reality in an experimentally controllable manner, allowing an empirical method to understand our implicit model of reality.

## Cardiac attribution to oneself is modulated by synchronous heartbeat biofeedback

Paradeisios Alexandros Boulakis, Federico Raimondo, Sepehr Mortaheb, Lionel Naccache, Athena Demertzi

The theoretical account of embodiment indicates that the synchronous presentation of interoceptive activity with an external object facilitates the external objects' attribution to oneself. Here, we used the synchronicity component to test the opposite possibility, whether synchronous interoceptive biofeedback would facilitate heartbeat attribution to oneself. During fMRI scanning, subjects were listening to auditory sounds presented either in synchrony or out of synchrony to their monitored heartbeats. After listening to a sequence of sounds, participants had to judge by button press whether the sequence was generated from their own heartbeat ("Mine") or it was artificially generated ("Other"). Behaviourally, subjects tended to respond faster during synchronous feedback, without any evidence for faster responses. At the brain level, the salience network and the insula seems to support interoceptive judgements, irrespective of mineness. However, an exploratory PPI analysis, using the areas more active during synchronous presentation, revealed increased connectivity of the thalamus with the anterior cingulate cortex, the right insula and the frontal gyrus, and the medial cingulate cortex with the amygdala. Our findings highlight the role of synchronous feedback on improving interoceptive attributions by increasing thalamo-cortical connectivity between regions highly associated with interoceptive error monitoring, resulting in more precise and accurate judgements.

## The entropic heart: effects of psychedelics on cardiac activity

Fernando Rosas, Pedro Mediano, Christopher Timmermann, Malin Uthaug, Andrea Luppi, Sarah Garfinkel, Daniel Bor, Robin Carhart-Harris

Modern investigations into altered states of consciousness induced by psychedelics have mainly focused on their effects on the brain; in contrast, their impact on the rest of the human nervous system has been far less explored. Inspired by the Entropic Brain Hypothesis, which posits that the rich psychological effects of psychedelics depend on a parallel enrichment of the underlying neural dynamics, we conjecture that an analogous phenomenon may take place in the autonomic nervous system, leading to an "Entropic Heart" effect. To test this conjecture, we developed a Bayesian method to estimate the entropy of heart-rate signals, and analysed the heart activity of healthy subjects under psychedelic doses of psilocybin, LSD, DMT, and ketamine. Results reveal a consistent increase of heart entropy across all the studied drugs, with these changes predictive of various aspects of the subjects' subjective reports. Furthermore, we find significant differences in low- and high-frequency heart-rate variability that may be associated with the emotional valence associated with psychedelic experiences. These findings help us expand our understanding of altered states of consciousness and their manifestation in the body, and may yield novel technologies that psychedelic psychotherapy could use to track the physiological state of patients.

## Social cognitive ability influences the strategy used for judging others' awareness

Branden J. Bio, Michael S. A. Graziano

Tracking the awareness of others is highly adaptive. Here we asked whether subjects use a variety of strategies to make judgements about others' awareness and tested how these different possible strategies might relate to general aptitude in social cognition. In our study, subjects performed an 'attribution-of-awareness' task adapted from Kelly et al. (2014) where they judged the extent to which an agent was aware of an object. K-means clustering was employed to agnostically sort subject strategies. Five unique response groups were found. Subjects' general aptitude for social cognition was measured using the Reading the Eyes in the Mind Task (RMET; Baron-Cohen et al., 1997; 2001a) and the Hinting Task (HT; Corcoran et al., 1995; Greig et al., 2004). We found that subjects with higher social cognition, as measured by the RMET and the HT, were more likely to use a strategy of relying on specific social cues to inform their judgments about the awareness of others. From these results it appears as though individuals more adept at social cognition are better at or at least more likely to incorporate more perceptual information from a social environment into their schema of another individual's awareness.

## What memory is for

Helge Malmgren

From a biological perspective, the primary function of our mechanisms for remembering is not to create and maintain an internal retrospective autobiography but to guide action in the present. Specifically, when memory takes the form of perceptual re-presentations, their function is to assist perception where external information is incomplete. Re-presentations are often evoked by external stimuli but can develop independently of them and guide actions over considerable periods of time. The mechanism for producing re-presentations is usually believed to be located in the hippocampus. This is implausible for several reasons. Perceptual re-presentations are evoked by almost any sense modality and have to interact quickly with perception and action. An exclusively hippocampal mechanism would mean a passage through a bottleneck – the entorhinal cortex – and a time-consuming round-about before reaching the effectors. Instead the re-presentations should be produced near the respective sensory or associative areas, should be able to direct action through the same pathways as these areas use, and should involve hippocampal memory mechanisms only in case there is a need for storage beyond the immediately perceived presence. The occurrences of re-presentations in hippocampus may instead be explained by part of the hippocampus being a perceptual rather than a mnemonic device.

## Functionalist and generalist approach to the sensory substitution devices (SSDs) design

Marta Łukowska, Michał Wierzchoń, Dominik Osiński, Weronika Kałwak

SSDs allow to study the emergence of new perceptual experience qualities. Proposed as assistive technology for the visually impaired, they have not become popular. The reason might be dominance of the generalist approach to SSDs design, where SSDs substitute lost visual functions. However, the functionalist approach suggests focusing on specific functions important for the user. Here, we discuss the issue based on the existing literature with various SSDs and our own studies advocating for the latter approach. In our longitudinal study with sighted, blindfolded participants, we found a predominance of action- over perception-oriented strategy when using Colorophone (v.1.0) - a colour-to-sound SSD. Participants who used the device to plan exploratory actions rather than focused on vision-related qualities, experienced greater progress throughout 72-days training. Moreover, in participants who progressed in training, we found greater activity in the regions specialised in motion processing. Together with the observed neuroplasticity in the dorsal visual stream, the results suggest that the SSD supported online action planning rather than visual-like phenomenal experience. We conclude by discussing the usefulness of the functionalist approach to SSD design and the consequences of the approach to debate on the nature of the phenomenal experience induced by SSDs.

## Dopaminergic modulation of reversal-learning and associated confidence in Parkinson's disease and heroin addiction

Vanessa Fleury, Damien Benis, Astrid Kibleur, Daniele Zullino, Paul Krack, Nathan Faivre

Metacognition is the capacity to monitor and control one's own mental activity, which is usually quantified as the capacity to adapt confidence ratings to the accuracy of one's responses during perceptual or cognitive tasks. While tremendous progress has been made to describe metacognitive processes at the behavioural and neural levels, the determining pharmacological factors of metacognition remain unclear. In particular, studies modulating dopaminergic activity through pharmacological (ant)agonists have brought mixed results. Here, we examined the role of dopamine on metacognition by collecting confidence judgments in a reversal-learning task among patients with Parkinson's disease ( $N = 19$ ), heroin addiction ( $N = 17$ ), under two treatment conditions (drug-on and drug-off) reflecting high versus low dopaminergic states. Patients were compared with 29 healthy controls. We will describe the effect of dopamine on reversal learning using a hierarchical Bayesian experience-weighted attraction model, and on metacognitive monitoring using second-order signal detection theory. Finally, we will examine the relationship between task performance and symptomatology with a focus on behavioural and substance addictions as well as neuropsychiatric fluctuations.

## Discriminating states of consciousness with responses to natural auditory texture stimulation

Urszula Górska, Andre Rupp, Yves Boubenec, Tansu Celikel, Bernhard Englitz

Background: Many naturalistic sounds, like rain or fire, while revealing highly dynamical local structure, could be well recognized by their statistical profile. Assessing such detection directly from neural activity would be particularly relevant for unresponsive patients with disorders of consciousness (DOC). Methods: We presented subjects with naturalistic sounds that changed their statistics at an unexpected point in time. Active listeners were reporting it, passive-aware performed an active task before and passive-naïve were not. Further, we added deep asleep unconscious participants, and DOC patients behaviorally classified as minimally conscious or unresponsive. We quantified evoked potentials and complexity of neural response at stimulus and change. Results: Change detection in natural acoustic textures was neurally reflected by the formation of parieto-occipital positivity potential that scaled with task engagement. While it was substantially reduced in the absence of response, it also failed to distinguish DOC patients. Alternatively, complexity analysis led to the separation of presumably conscious from unconscious participants. Conclusion: Overall, the process of evidence accumulation towards change detection could be interpreted as a violation of predictability. However, parietal potential revealed confounded by a task. Conversely, the combination of complex acoustic stimuli and dynamical complexity of the neural response appears promising towards DOC's diagnosis.

## A psychophysiological marker of the metacognitive component of conscious representation

Monika Derda, Michał Wierchoń

Shea and Frith (2019) have recently refined the Global Neuronal Workspace Theory proposing that conscious representation should not only be globally available but should also be characterized by a metacognitive component. It is, however, not clear what this component actually is and how it could be captured empirically. Here, we offer an extensive overview of the literature discussing the possible definitions of the metacognitive component and consider how it can be operationalized. In particular, we will focus on the question, whether the non-linear increase of the P3 amplitude, typically interpreted as an indication that a certain representation enters the global workspace, may also serve as an index of the metacognitive component of conscious representation. To answer that we have run a study using a visual masking task. Preliminary data shows that the changes in the P3 amplitude are in line with the evidence accumulation model (e.g. it scales with reaction time, differentiates between correct and erroneous responses). We discuss the resemblance between P3 and CPP component which was previously shown to correlate not only with accumulated sensory evidence but also confidence.

Physiologically implausible warmth, but not cold, suppresses the feeling of limb ownership in the somatic rubber hand illusion

Dominika Radziun, Laura Crucianelli, Henrik Ehrsson

Previous studies suggest that interoceptive signals contribute to the feeling of body ownership, yet the specific role of thermosensation is still poorly understood. Here, we investigated the contribution of thermal information in illusory self-touch, using a modified version of the somatic rubber hand illusion. We manipulated the temperature of the material of the rubber hand to physiologically implausible (11-16 °C) or plausible cold (17-22 °C), physiologically plausible (38-42 °C) or implausible warm (43-48 °C), and neutral (around 23 °C). We hypothesized that in the “implausible” conditions, the illusion of self-touch would be suppressed due to the significant incongruence in temperature between the participant’s left index finger and their right hand. Partially in line with our hypothesis, we found that the illusion was suppressed only when the rubber hand had a physiologically implausible warm temperature, as measured by means of subjective ratings. Interestingly, in all the other thermal conditions, the illusory experience was present and vivid, suggesting that one can experience ownership also over implausibly cold body parts. In conclusion, our findings highlight a potential role of thermal congruency in body ownership, but also suggest a substantial degree of flexibility in terms of specific cold and warm contributions to body representation.

The onset of subjective visual experience emerges within the P2/N2 range - evidence from a direct behavioral approach in combination with EEG

Renate Rutiku, Klaus-Peeter Ladvá, Michał Wierzchoń, Talis Bachmann, Chen Song

How long does it take to become conscious of a visual event? Evidence stretches over relatively early activity in visual cortices to prominent late events in a global network of frontoparietal regions. Yet a direct and precise connection with the dynamic build-up of subjective experience has proven difficult to establish. In a series of experiments, we demonstrate that by using continuously changing stimuli instead of brief, static events, a direct link between the onset of subjective experience and EEG activity can be established. Participants were instructed to wait for the sudden onset of a continuously changing stimulus and stop it in its tracks as soon as they noticed it. Next, the stimulus had to be changed back to the position where it was when participants first became aware of it. These subjective reports of stimulus onset were related to single-trial ERP estimates from concurrent EEG recordings. Across participants, EEG activity in the P2 and N2 range was most reliably correlated with direct reports of the onset of subjective experience. The results suggest that conscious perception of a visual event typically arises within 200 ms after its onset and precedes global activity in frontoparietal regions.



Context-induced modification of the reliance on internal or external information when forming metacognitive judgments

Stephan Goerttler, Gaia Corlazzoli, Nicolas Coucke, Axel Cleeremans, Wim Gevers

Metacognition, that is, insight into one's own cognitive processes, is a hallmark property of consciousness. Using a color discrimination task, we investigated to what extent humans base their metacognition, here operationalized by confidence judgments, on internal (e.g., reaction time) or external information (e.g., feedback on the performance of the previous trial). We further created differing performance contexts by adjusting the task performance to either 75% (correct condition) or 35% (error condition) correct responses, using a running staircase procedure. Not surprisingly, our results show that participants were more confident in the correct condition, that slower response times were associated with lower confidence, and that positive feedback on the previous trial was associated with higher confidence. A more interesting finding is that participants created their confidence judgments on different information depending on the context: In the correct condition, confidence judgments were based more strongly on the response time compared to the incorrect condition. On the other hand, positive feedback on the previous trial increased the confidence more strongly in the error condition than in the correct condition. In sum, we demonstrate that our metacognition relies more strongly on internal information with good performance, but more strongly on external information when performance is poor.

Interoceptive sentience as the affective, ubiquitous, homeostatic and most basic form of consciousness

Ignacio Cea, David Martinez-Pernia

In this article, we propose the concept of interoceptive sentience, as a unifying synthesis of key notions and empirical findings, from diverse authors that claim the existence of a phenomenologically ubiquitous, hedonically valenced, more/less aroused, pre-reflective, and objectless feeling of being alive, essentially linked to interoception and homeostatic regulation, that would constitute the most basic layer of consciousness, at least in humans. The talk will proceed as follows. First, we present the concepts of 'core affect' (Russell, 2003; Russell & Barrett, 1999), 'the feeling of being alive' (Fuchs 2012, 2018), 'background feelings' (Damasio 1994, 1999, 2018), 'interoceptive feelings' (de Vignemont 2019), and 'homeostatic sentience' (Craig 2015), and present our concept of 'interoceptive sentience' as a unifying synthesis of all those notions. Then, we relate interoceptive sentience to emotions and moods. In the third part, we compare our notion to other interoception-related scientific concepts, specifically to 'interoceptive awareness', 'interoceptive accuracy', 'interoceptive sensibility' and 'interoceptive sensitivity' (Barrett et al., 2004; Critchley et al., 2004; Garfinkel et al., 2015; Pollatos et al., 2007). We end up highlighting diverse areas of research that could benefit from incorporating our notion, and the future work that opens accordingly.

## An Integrated World Modeling Theory for Consciousness

Adam Safron, PhD

Using the Free Energy Principle and Active Inference framework as an overarching perspective, I have recently proposed a minimum unifying model for consciousness: Integrated World Modeling Theory (IWMT). From IWMT's point of view, Integrated Information Theory (IIT) and Global Neuronal Workspace Theory (GNWT) are partially reconciled by considering workspaces to be complexes with high  $\phi$  values (quantifying self-cause-effect-power), with the computational objects from both these theories having semantic content/grounding by considering their significance for iterated Bayesian model selection and discrete updating of generative models over the sensoriums of embodied-embedded agents. In this way, IWMT sidesteps many concerns with IIT, and also allows GNWT to begin to address the Hard problem. This synthesis further speaks to the ongoing debate and adversarial collaboration between these theories, suggesting that while the physical/computational substrates of consciousness may be centered on a "posterior hot zone" as suggested by IIT, conscious access may still depend on the establishment of effective connectivity between frontal and parietal regions as suggested by GNWT. Finally, IWMT may also inform the boundary problem of where consciousness begins in suggesting that phenomenality may require sufficiently deep hierarchies that joint marginals can be calculated via stimulus-decoupled synchronous complexes, or "self-organizing harmonic modes."

## REBUS and/or/as SEBUS: Both Strengthened and Relaxed Beliefs Under Psychedelics

Adam Safron, PhD

In introducing a model of "relaxed beliefs under psychedelics" (REBUS), Carhart-Harris and Friston (2019) have presented a compelling account of the effects of psychedelics on brain and mind. This model is contextualized within the Free Energy Principle (Friston et al., 2006; Friston, 2010), which may represent the first unified paradigm in the mind and life sciences. By this view, mental systems adaptively regulate their actions and interactions with the world via predictive models, whose dynamics are governed by a singular objective of minimizing prediction-error, or "free energy." According to REBUS, psychedelics flatten the depth of free energy landscapes, or the differential attracting forces associated with various (Bayesian) beliefs, so promoting flexibility in inference and learning. Here, I would like to propose an alternative account of the effects of psychedelics that is in many ways compatible with REBUS, albeit with some important differences. Based on considerations of the distributions of 5-HT<sub>2A</sub> receptors within cortical laminae and canonical microcircuits for predictive coding, I propose that 5-HT<sub>2A</sub> agonism may also involve a strengthening of beliefs, particularly at intermediate levels of abstraction associated with conscious experience (Safron, 2020).

## Mind body coherence

Hannah Biddell

Concordance between emotional and physiological states is predicted by theories of emotion, though direct evidence for this relationship is rare - largely it seems due to incorrect method of analysis. The current study utilises a within participants approach to mind-body coherence across multiple pre-existing datasets and finds evidence for individual differences in coherence. These differences are predicted by age and autonomic (cardiac vagal) flexibility. They also relate to differences in alexythymia, psychological well-being, and information processing/learning under conditions of uncertainty.

## Dimensionality reduction of EEG during exposure to propofol has prognostic value for unresponsive patients

Charlotte Maschke, Catherine Duclos, George A. Mashour, Stefanie Blain-Moraes

In a healthy brain, propofol anesthesia induces a strong functional reorganization, resulting in a decreased functional integration. Based on the assumption that only a sufficiently integrated system dynamically reacts to perturbations, we hypothesized that in disorders of consciousness (DOC), the brain's response to propofol reflects its capacity to support consciousness. We used a data-driven, time-resolved approach to quantify a DOC patient's potential to recover consciousness, based on the brain's dynamic response to propofol. High-density electroencephalographic data was recorded during resting state and propofol anesthesia (2.0  $\mu\text{g/mL}$ ) in 11 patients in a DOC and 9 healthy controls. For each 10-second window of EEG data, we estimated the strength and direction of functional connectivity based on the weighted and directed phase lag index, respectively. Using a Principal Component Analysis for dimensionality reduction, we extracted the principal component which best describes the brain's dynamic transition into propofol anesthesia. Whereas DOC patients who recovered full consciousness within three months post-recording showed dynamically adapting brain patterns along this component, a static non-altered brain response was indicative of the patient's inability to recover consciousness. We conclude that the brain's ability to dynamically respond to propofol reflects a patient's capacity to emerge and sustain consciousness.

## Tracking contingency unconsciously

Shao-Min (Sean) Hung, Daw-An Wu, Shinsuke Shimojo

Tracking contingencies among objects in the sensory world is crucial for survival. Given our limited processing capacity, it is unlikely that humans can track all the occurring contingencies consciously. Here we tested the possibility of unconscious contingency tracking in a series of experiments (each  $N \geq 10$ ). In each trial, an exogenous cue was sandwiched by a forward and a backward mask, and a Gabor patch appeared as a target subsequently. Both the cue and the target were presented in one of the two designated locations, and the contingency of the two was manipulated by changing the co-occurrence probability. Participants were asked to judge the orientation of the Gabor and the location of the masked cue. Cue invisibility was confirmed by both subjective report and chance performance on the location task. We first established that the cue prompted shorter reaction time on the target. Furthermore, training with particular cue-target contingencies had carryover impacts: Cuing effects in subsequent test phases could be modified in opposite directions depending on whether preceding training phases contained fully predictive vs. random cue-target contingencies. These results show unconscious contingency tracking and more importantly, how the implicit contingency affected the effectiveness of a future unconscious cue.

## The Yogic Theory of Mind and Consciousness

Vaibhav Tripathi, Pallavi Bharadwaj

Yoga as a philosophy and tradition has been followed for thousands of years and has a strong understanding of the nature of the mind and its various properties. In this talk, we'll present the Yogic perspective of mind and consciousness starting with how Yoga system classifies the different external states of the mind namely attention, mind wandering and memory as modulations of the mind. Such modulations affect perception and the consciousness of perception. We'll talk about the various internal states of pratyahara, dharana, dhyana and samadhi and discuss the different kinds of samadhi as listed by Patanjali in his Yoga sutras. As mentioned in the Yogic texts, these internal states are experienced by everyone, albeit for short durations. The practise of Yoga allows one to hold any state for longer. Such a classification can help us identify the different extrinsic and intrinsic modes of processing of the mind, and can allow a better understanding of the temporal dynamics of mental states. Inability to direct the flow of states has been attributed to various disorders. We propose that these states have specific biological correlates which can be found by neuroscientific experiments on experienced meditators who have practised controlling the flow of mind in each state. The comprehensive and cohesive framework provided by the Yogic theory can help improve experiment design for psychophysics studies and give us a complete description of various states of the mind and how it affects consciousness.

Posterior parietal cortex neurons distinguish memorized past from what is perceived as reality

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Humans can discriminate whether a piece of information is being held internally as memories or externally as coming from the outside world. The posterior parietal cortex (PPC), as an information accumulator for conscious perception, is hypothesized to monitor such distinction between the memorized and perceived information. We recorded electrophysiology data from the dorso-medial PPC on an adult monkey while it performed a temporal-order judgement (TOJ) task. Critically, in the delay/maintenance period of the TOJ task, we presented a congruent image in 1/4 of the trials (i.e., extracted from the video that they had just encoded), in another 1/4 of the trials with an incongruent image (i.e., extracted from other videos), and in 1/2 of the trials without any distractor as baseline (no-picture). We acquired single-unit spike data (121 neurons) from 14 daily sessions (940 trials in total). With receiver operating characteristic (ROC) analyses, we found around 7% of the neurons could exclusively discriminate congruent condition from the no-picture condition. These results indicate that primate PPC neurons are able to monitor the congruency of perceived external stimuli and evaluate them against the content in working memory.

Functional and cortical morphometric basis of metacognitive introspection in Old World monkeys (*Macaca mulatta*)

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Metacognition refers to the ability to be aware of one's own cognition. Ample evidence indicated that metacognition in the human primates is highly dissociable from cognition (Fleming et al., 2010 *Science*) and specialized across domains (Morales et al., 2018 *The Journal of Neuroscience*). However, such metacognitive sophistication is highly understudied in monkeys. Here we set out to make a thorough inquiry of the complexity in macaques' metacognition by combining a challenging behavioural paradigm (temporal wagering by macaque monkeys), computational modelling (hierarchical Bayesian meta-d'), focal neuromodulation (inhibitory transcranial magnetic stimulation), and longitudinal morphometric MRI (pre- vs. post- metacognitive training). We provided a comprehensive investigation of a high-level cognitive facility in a nonhuman primate species. At the behavioural level, we found that metacognition in macaques is highly domain-specific for memory vs. perception processes. At the neural level, we found a critical functional role of Area 46d in supporting metacognition without implicating their task performance. We were also able to specify the precise timing during which meta-evidence accumulation is computed along with but not after task decision. To add on all these, we further revealed that, longitudinally, the prefrontal cortices are highly plastic and showed rapid morphometric modification due to the intensive metacognitive training that the monkeys had received. Behavioral, functional, and morphometric evidence reveal sophisticated metacognitive introspection in macaque monkeys.

Draw the line - using temporal experience tracing to capturing subjective experience states

Barbara Jachs, Tristan Bekinschtein, Manuel Camino Garcia

A continual problem for the study of the neural correlates of naturalistic conscious experience states has been the lack of continuous measures for experiences. In this talk I present the findings from our meditation studies, where participants reported on twelve phenomenological dimensions using temporal experience tracing. The Temporal Experience Tracing method requires participants to retrospectively graph the intensity of an experience dimension over time. In this case, participants traced experience intensities over the duration of the meditation. We show these traces can be used to extract clusters of subjective experiences, which allows us to investigate their transition dynamics. Furthermore, we were able to classify unseen meditation sessions from known participants. Supporting the idea of inter-individual phenomenological similarity, the neural markers associated with high classification accuracies overlap between two separate meditation groups. We recommend the temporal experience method for the studying of the temporal dynamics of first-person experiences and their neural correlates."