

The First SAS Interoception Preconference: Body-Brain Interactions, Wellbeing, and Society

Date & Time: [March 30, 2022, 10am-3:30pm EST \(fully virtual\)](#)

Chair: [Vera Vine, Ph.D., Queen's University](#)

Interoception, the perception of peripheral physiological activity by the brain, is fundamental to survival and theorized to underlie much of human experience. Discovery has accelerated about basic mechanisms of interoception and its role in psychological processes, like cognition and emotion. This preconference capitalizes on these gains to begin extending interoception science into increasingly socially useful realms. It brings together scholars across levels of training to explore how interoception science can help us understand real-world problems, including those involving mental health, adversity, and social behavior.

PRECONFERENCE SCHEDULE (All times in EST)

- 10:00am EST** **Brief Welcome & Keynote Speeches**
Professor Sarah Garfinkel
Professor Manos Tsakiris
- 11:45am EST** **Body Break**
- 12:00pm EST** **Spotlight Symposium**
Laura Barca, Ph.D. (Invited Speaker)
Andy J. Arnold, M.A. (Spotlight Award Winner)
Giada Dirupo, Ph.D. (Invited Speaker)
Bridget Callaghan, Ph.D. (Invited Speaker)
Mariana von Mohr, Ph.D. (Spotlight Award Winner)
- 1:20pm EST** **Body Break**
- 1:30pm EST** **Flash Talks – Group 1**
Charles Verdonk, M.D., Ph.D.
Liron Rozenkrantz, Ph.D.
Alejandro Galvez-Pol, Ph.D.
Hannah Raila, Ph.D.
- 1:55pm EST** **Mini Body Break**
- 2:00pm EST** **Poster Session**
- 3:00pm EST** **Mini Body Break**
- 3:05pm EST** **Flash Talks – Group 2**
Laura Crucianelli, Ph.D.
Adam Robert Teed, Ph.D.
Azure Reid-Russell, M.A.
Ian Kleckner, Ph.D., M.P.H.

INVITED PRESENTATIONS

Professor Sarah Garfinkel (Keynote Speaker), *Institute of Cognitive Neuroscience, University College London*

Dimensions of Interoception in Clinical Conditions

Professor Manos Tsakiris (Keynote Speaker), *Royal Holloway & Centre for the Politics of Feelings, University of London*

Feeling the Body Politic: Interoception and the Political Life of Embodied Minds

Laura Barca, Ph.D. (Invited Speaker), *Italian National Research Council*

Keep Your Interoceptive Streams Under Control: An Active Inference Perspective on Anorexia Nervosa

Giada Dirupo, Ph.D. (Invited Speaker), *Lausanne University Hospital & University of Lausanne*

The Role of Interoception in Understanding Others' Affect: Dissociation between Superficial and Detailed Appraisal of Facial Expressions

Bridget Callaghan, Ph.D. (Invited Speaker), *University of California Los Angeles*

Connecting Experiences of Adversity with Physical and Mental Health Outcomes: Pathways through the Brain-Gut-Microbiome Axis

ABSTRACTS FOR SUBMITTED PRESENTATIONS

SPOTLIGHT SYMPOSIUM/AWARD WINNERS

ANDY J. ARNOLD, M.A., *University of California San Diego*

Some Body to Trust: A Meta-Analysis Revealing Diminished Interoceptive Body Trust in Loneliness. Social connection is a vital homeostatic need for humans, and loneliness—perceived social isolation—results when this need is not adequately fulfilled. Loneliness, pervasive and dangerous, is subjectively defined and reflects dysregulation of physiology, affect, and behavior. As a core condition underlying psychosocial health, loneliness carries significant morbidity and mortality risk throughout the lifespan. Interoception—the process of sensing, regulating, and perceiving bodily states—is critical for assessing an organism’s needs and (ideally) motivating behavior to fulfill those needs. Interoception is thus dysregulated in loneliness. We present robust evidence of aberrant interoceptive sensibility—measured by self-report MAIA scales—in loneliness. Across 17 samples and 4,292 participants, diminished Body Trust (BT) emerged as the key interoceptive feature of loneliness: $r(4290) = -.42$. BT remained significant in stepwise regression when controlling for other constructs related to loneliness and interoception—depression, alexithymia, gratitude, and self-compassion. We demonstrate differential impacts of these constructs on dissociable dimensions of social connection. This meta-analysis replicates previous findings on correlates of loneliness, compares their strength, and adds BT as a key integrative mechanism for psychosocial health. We discuss the meaning of BT in the context of its growing clinical relevance and explore how interoception may represent intrapersonal connection which impacts interpersonal connection. BT may facilitate embodied, quality social connection by conferring (self and other) emotional clarity. An intrapersonal focus on BT, integrating selfhood and affect, can empower all (and underprivileged) individuals to mobilize their own conceptions of well-being, connection, and social change. Our research can inform health initiatives to help people achieve quality social connection, a requirement for optimal health and human functioning. **Coauthor: Karen Dobkins**

MARIANA VON MOHR, Ph.D., *Royal Holloway, University of London*

Interacting Hearts: The Role of Interoception on Social Decision-Making and Social Influence. Social decisions, i.e. decisions we take together with others, are at the core of human social behaviour. These collective decisions range from mundane choices, such as where to have dinner or what movie to watch on Netflix, to important ones, such as who to vote for in the next elections. Critically, such decisions are often influenced by others’ views and opinions. Yet, little is known about the role of interoception on how much influence we take from others. Indeed, we all have ‘gut feelings’, commonly known as a feeling or intuition about something, with little to no explanation. These gut feelings often guide our decisions, but they might also determine the amount of influence we take from others when making a decision. Thus, across two studies (total N=118), we used an experimental technique capitalizing on the phasic discharge of aortic baroreceptors to examine how ‘gut feelings’, coupled with trait-like levels of interoceptive accuracy, modulate the degree to

which participants change their mind about the perceived trustworthiness of faces following feedback from others. While ‘gut feelings’ did not shape participants’ change of mind, we found an attenuation of change of mind specific to interoceptive accuracy. In particular, individuals with higher interoceptive accuracy showed less change of mind when provided with discrepant social feedback, both in terms of several hundreds of others (study 1) as well as when provided by one other person (study 2). This is the first study to show that individuals with higher interoceptive accuracy are less suggestible to other people’s judgements and provides evidence about the important role of interoception in societal issues. [Coauthors: Gianluca Finotti, Bahador Bahrami, Manos Tsakiris](#)

FLASH TALKS – Group 1

CHARLES VERDONK M.D., Ph.D., *Laureate Institute for Brain Research & French Armed Forces Biomedical Research Institute*

Neural Responses to Heartbeats during Peripheral Adrenergic Stimulation: An Initial Investigation. Interoception is critical for health and well-being in humans as it facilitates the maintenance of homeostasis and optimizes allostatic regulation over various timescales. Yet, evidence is still lacking to decipher the neurophysiological mechanisms driving interoception, at both bottom-up and top-down levels of information processing. The current analysis tested the influence of peripheral adrenergic perturbation on the Heartbeat Evoked Potential (HEP), a neural marker of brain activity in response to heartbeats. HEP data was collected from 32 healthy participants under a resting state condition (baseline), and during intravenous bolus infusion of isoproterenol (2µg), a rapidly acting peripheral beta-adrenergic agonist akin to adrenaline resulting in increased cardiovascular signals. We minimized cardiac-related artifacts contaminating EEG signal by using a combination of the optimal basis set approach and independent component analysis. HEP data was subjected to cluster-based permutation statistical testing. We observed that adrenergic stimulation substantially modulates HEP amplitude. Specifically, compared to the baseline condition, the infusion condition (isoproterenol 2µg), which was characterized by elevated heart rate and heightened interoceptive awareness, was associated with larger HEP amplitudes at fronto-central locations in the latency range of 176–284ms after the cardiac R-wave event ($t(31) = -2.33, p < .001$). These preliminary results are of key importance to a physiologically informed understanding of the neural mechanisms underpinning the HEP, and raise the possibility that the HEP dynamically reflects shifts in peripheral cardiovascular status. If confirmed in a larger sample, it will support future investigations focused on probing the interoceptive pathophysiology of psychiatric disorders. [Coauthor: Sahib S. Khalsa](#)

LIRON ROZENKRANTZ, Ph.D., *Massachusetts Institute of Technology & Harvard Medical School*

Perception of One’s Immunity as a Basis to Experience Psychophysiological Symptoms. Beyond the clear challenges that the COVID-19 pandemic has posed, like health-related, financial, and psychosocial challenges, it has arguably provided the most fruitful grounds to develop psychophysiological symptoms. Indeed, studies performed during COVID-19 have identified an increase in psychosomatic complaints, and associated these experiences with anxiety regarding COVID-19. It is unclear, though, what specific set of beliefs is associated with COVID-related psychosomatic complaints, and whether they can predict the experience of such symptoms. In two studies that included over 300 participants approached at two time-points, we identified a particular set of beliefs as a leading predictor of the experience of psychosomatic symptoms weeks later. These were people’s beliefs regarding their symptoms’ severity, were they to get infected with COVID, which we termed “estimated symptoms’ severity”. These results persisted after controlling for objective risk for severe symptoms, state anxiety and demographics, implying an internal relation between body perception and health symptoms. We next pre-registered and replicated these results in a separate cohort of participants. We further found that a construct of “perception of body’s immunity” has contributed to mediating the effect of estimated symptoms severity on later experience of symptoms. These findings suggest that perception of one’s immunity may in fact be linked with actual physical health. They further contribute to the understanding of the development of psychosomatic symptoms. Finally, identifying a particular set of beliefs leading this effect opens the door for an intervention to mitigate their effects. [Coauthors: Tobias Kube, Michael Bernstein, John D. E. Gabrieli](#)

ALEJANDRO GALVEZ-POL, Ph.D., *University of the Balearic Islands*

Active Sensing is Coupled to Heartbeats. Cognition varies with phasic bodily signals such as heartbeat. Yet, these results have been shown by locking the brief presentation of stimuli to distinct cardiac phases. However, in everyday life, information is not presented in such a phase-locked and passive manner, but actively sensed at one’s pace. In this context, whether active sensing is modulated by the cardiac cycle remains largely unknown. Here, in two different experiments, we instructed participants to freely initiate, sense, and end the processing of visual, and tactile stimuli at their own pace. Next, we examined whether the participants processed these stimuli in a particular phase of the cardiac cycle. Respectively, in the free visual task ($n = 32$) we found a significant coupling of saccades and fixations with the cardiac cycle ($p < 0.001$). More eye movements were generated during the systolic phase of the cardiac cycle, which has been reported as the period of maximal effect of the baroreceptors upon cognition. Conversely, more visual fixations were found during the quiescent diastole phase. Likewise, in the free tactile task ($n = 46$) we found that participants started to touch the tactile stimulus

(gratings) during systole and held their touch to sense these during diastole. Moreover, the results show that the duration of participants' touch varied as a function of the phase of the cardiac cycle in which they initiated the touch. When participants initiated touching in the systolic phase, they significantly held for longer periods of time (vs. touches initiated in diastole; $p < 0.001$). Overall, we believe that since several physiological changes occur during systole (e.g., baroreceptors firing), we believe that people might intuitively optimize the processing of sensory inputs by sensing the external environment during quiescent periods of the organism. **Coauthors:** [Pavandeep Virdee](#), [James M. Kilner](#)

HANNAH RAILA, Ph.D., *University of California Santa Cruz*

Listen to Your Heart: A Pseudo-Interoceptive Heartbeat Increases Self-Focus. Awareness of and attention to internal bodily sensations (e.g., one's heartbeat, blushing) may make people more self-focused, which in turn may interfere with their ability to perform external tasks that require cognitive effort (e.g., holding a conversation). Researchers and clinicians have long noted this as a hallmark of disorders like social anxiety, but experimental paradigms that test it are lacking. Here, we developed a novel manipulation in which participants ($n = 95$) wore headphones and were randomly assigned to believe they were listening to their internal heartbeat vs. an external sound. We then measured their performance on a task demanding external attention (an n-back task) as well as their self-focus (preference for self-focused pronouns in a sentence completion task). These effects were measured both with and without assignment to an stress induction (anticipation of giving a speech). Analyses found that the heartbeat cue did increase self-focus, but only for those in the stress induction ($p = .048$, $\eta^2 = .052$). In the heartbeat group, there was a negative association between self-focus and performance on the n-back ($r = -.45$, $p = .002$), such that higher self-focus after listening to the heartbeat was associated with poorer performance. This novel, effective auditory manipulation may be useful to researchers who wish to alter self-focused attention during cognitive tasks. These findings suggest that attention to internal bodily sensations can, when people are under stress, increase self-focus; and that those who become highly self-focused may struggle with external tasks that require cognitive effort. **Coauthors:** [Victoria Lawlor](#), [Ashley Leon](#), [Jutta Joormann](#)

FLASH TALKS – Group 2

LAURA CRUCIANELLI, Ph.D., *Karolinska Institutet*

An Interoceptive Take on Touch and Thermoception. In the past two decades, a plethora of studies adopted the perception of cardiac signals as a proxy for interoception, but recent findings have cast doubt to the methodological and intrinsic validity of the tasks used thus far. Therefore, there is an ongoing effort to improve the existing cardiac interoceptive tasks and to identify novel channels to target the perception of the physiological state of the body. Amid such scientific abundance, one could question whether the field has been partially neglecting one of our widest organs in terms of dimensions and functions, the skin. According to some views grounded on anatomical and physiological evidence, skin-mediated signals such as affective touch, pain, and temperature have been re-defined as interoceptive. Nevertheless, there is no agreement at this regard. Here, we describe a novel interoceptive task, the thermal matching task, where participants ($N = 62$) have to match a previously perceived moving thermal stimulus to a range of colder/warmer stimuli. We compared thermoception on forearm and palm, to target the potential involvement of C-Tactile fibres, which are part of an afferent homeostatic system found mainly on hairy skin. The perception of dynamic temperature was superior on hairy skin ($F(1, 61) = 5.00$, $p = 0.029$, $\eta^2 = 0.084$), and it was related to pain perception only on non-hairy skin ($r = 0.34$; $p = 0.042$). No other significant relationships among the performance at the thermal matching task and cardiac, affective touch, and pain detection were found. Thus, dynamic thermoception might offer a promising avenue for the development of somatosensory methods to measure interoception. Overall, our results provide further support to the scientific and clinical study of interoception by means of skin-mediated signals and confirm the idea that interoception might be better conceptualised as a modular construct with relatively independent processing in parallel streams. **Coauthor:** [H. Henrik Ehrsson](#)

ADAM ROBERT TEED, Ph.D., *Laureate Institute for Brain Research*

Association between Neural Activity, Interoceptive Awareness, and Meal Anxiety during Peripheral Adrenergic Stimulation in Anorexia Nervosa. Background: Interoceptive dysfunction has been linked to the negative feeding behaviors and disrupted body perception in anorexia nervosa (AN). However, due to the inherent difficulty in isolating interoceptive signals, the neural mechanisms of interoceptive processing in AN, remain unclear. Methods: Females with AN ($n=28$) and female healthy comparisons (HC, $n=28$) matched for age and BMI received randomized double-blinded bolus infusions of isoproterenol (ISO; 0.5, 2 μg), an adrenaline analog, and saline during fMRI scanning prior to consumption of a 1 kCal meal. Blood oxygen level-dependent (BOLD) signal change, heart rate (HR), and self-reported cardiorespiratory sensation were measured during infusions. Using whole-brain fMRI analysis and linear mixed-effects models, we assessed the effects of dose and group during physiologically relevant a priori periods of the ISO time-course. BOLD signal change from

significant clusters were then correlated with premeal anxiety ratings. Results: AN patients reported higher cardiorespiratory intensity ratings than did HCs during both peak response and recovery for both doses of ISO. During the recovery period at 2 μ g (b=7.36, 95% CI [0.38 14.33]) we observed significantly increased activation of the ventromedial prefrontal cortex (vmPFC) (cluster size=1030 voxels, < 0.05 false positive rate cluster corrected), which was correlated with premeal anxiety (rho=0.52, 95% CI [0.28 0.69]). Peripheral stimulation did not yield group differences in HR response, nor did groups significantly differ in brain activation during the saline or the 0.5 μ g conditions. Conclusions: Increased activation of the vmPFC in AN was associated with heightened cardiorespiratory sensations and meal related anxiety prior to eating a large meal. Thus, vmPFC dysfunction may contribute to the discrepancy between afferent signaling and interoceptive experience in AN and may be a potential treatment target for meal-related anxiety. **Coauthors: Justin S. Feinstein, Rachel C. Lapidus, Valerie Upshaw, Walter Kaye, Martin P. Paulus, Sahib S. Khalsa**

AZURE REID-RUSSELL, M.A., *Harvard University*

The Body Location, Description, Appraisals, and Interpretations of Interoceptive Stimuli and Self-Injurious Thoughts. Objective: Suicide is the self-destruction of one's own body, yet surprisingly little research has examined differences in how people with suicidal thoughts and behaviors experience their bodies. Here we examine how the subjective experience of body sensations may differ for people with and without self-injurious thoughts. Method: A sample of 132 adults completed an online survey assessing self-injurious thoughts and behaviors, depression symptoms, and current and past interoceptive experiences. Results: People with recent suicidal ideation reported experiencing more negative ($\beta = -0.67$, $p = .001$, OR = 0.79) and more intense body sensations ($\beta = 0.42$, $p = .03$, OR = 1.28) but did not differ in the location of their body sensations ($D = 1.84$, $p = .064$), and the certainty ($\beta = 0.50$, $p = .171$, OR = 1.05) and confidence ($\beta = -0.35$, $p = .061$, OR = 0.86) of their interpretations of body sensations when compared to people without suicidal ideation. Qualitatively, people with and without recent suicidal ideation described their current body sensations using themes related to joint and stomach sensations, anxiety and stress, sweat, tension, soreness, legs and circulation, and aches. People with recent suicidal ideation also reported experiencing more negative ($\beta = -0.69$, $p < .001$, 95% CI [-0.96, -0.42]) and more intense body sensations ($\beta = 0.91$, $p < .001$, 95% CI [0.65, 1.18]) during recent suicidal ideation than during the time of study assessment and described body sensations during recent suicidal ideation in the following themes: tightness, weakness, numbness, pain, negative emotion words, heaviness, and emptiness. Conclusion: The intense, negative body sensations that occur during suicidal ideation and in people with recent suicidal ideation provide insight into the bodily states that may lead to suicidal thoughts and behaviors and offer new directions in the assessment and potential treatment of self-injurious thoughts and behaviors. **Coauthor: Matthew K. Nock**

IAN KLECKNER, Ph.D., M.P.H., *University of Maryland Baltimore*

Pilot Study on the Effects of Exercise on Chemotherapy-Induced Peripheral Neuropathy (CIPN) and the Interoceptive Brain System. Introduction: Chemotherapy-induced peripheral neuropathy (CIPN) is a common, severe, tough-to-treat, dose-limiting toxicity with enigmatic mechanisms. Symptoms include numbness, tingling, and pain in the hands and feet. To better treat CIPN we need to study promising interventions such as exercise and novel mechanisms, such as brain involvement. Aims: To explore (1) whether exercise during neurotoxic chemotherapy ameliorates CIPN and (2) the role of the interoceptive brain system in CIPN. Methods: Patients were randomized 1:1 to (a) home-based low-moderate intensity progressive walking and resistance exercise or (b) nutrition education (time and attention control) for 12 weeks at their first infusion of neurotoxic chemotherapy. We assessed CIPN symptoms (CIPN-20 questionnaire; 0, 6, and 12 weeks) and (2) task-free functional connectivity in the interoceptive brain system using fMRI (0 and 12 weeks). Results: Nineteen patients (65 \pm 11 years old, 52% women, 42% breast cancer, 32% gastrointestinal cancer) were randomized to exercise (N=9) or control (N=10). Exercise attenuated CIPN symptoms (effect size [ES]=0.7 and 0.5 at 6 and 12 weeks). CIPN severity was positively correlated with functional connectivity across the interoceptive brain system (posterior cingulate - thalamus and posterior insula - anterior insula; ES=0.3). Exercise reduced functional connectivity in the interoceptive brain system (posterior cingulate - posterior insula; ES=1.4). Conclusions: Exercise may reduce CIPN via changes in the interoceptive brain system. Future work should test for replication. **Coauthors: Jennifer S. Gewandter, Amber S. Kleckner, Eva Culakova, Nimish A. Mohile, Michelle C. Janelins, Karen M. Mustian**

POSTERS

JOEY A. CHARBONNEAU, B.A. (POSTER 1), *University of California, Davis*

Rhesus Monkeys have an Interoceptive Sense of their Beating Hearts. The sensation of internal bodily signals, like when your stomach is contracting or your heart is beating, plays a critical role in broad biological and psychological functions, ranging from homeostasis to emotional experience and self-awareness. The evolutionary origins of this capacity and, thus, the extent to which it is present in nonhuman animals remains unclear. Here, we show that rhesus monkeys (*Macaca mulatta*, n=4) spend significantly more time viewing stimuli presented asynchronously, as compared to synchronously, with their heartbeats. This is consistent with evidence previously shown in human infants using a nearly identical experimental paradigm, suggesting that rhesus monkeys have a human-like capacity to integrate interoceptive signals from the heart with exteroceptive audiovisual information. As no prior work has demonstrated behavioral evidence of innate cardiac interoceptive ability in nonhuman animals, these results have important implications for our understanding of the evolution of this ability and for establishing rhesus monkeys as an animal model for human interoceptive function and dysfunction. We anticipate that establishing a monkey model of innate cardiac interoception will be critical to future psychiatric research, allowing for causal perturbations to interoceptive neurobiology towards a clearer understanding of the pathophysiology of psychiatric disorders. **Coauthors:** [Lara Maister](#), [Manos Tsakiris](#), [Eliza Bliss-Moreau](#)

MALLORY JEAN FELDMAN, M.A. (POSTER 2), *University of North Carolina at Chapel Hill*

An Ontology for Interoceptive Science. Interoception refers to the sensation and perception of the physiological body. Interoception is central to human survival, and consequently to both human physical and mental health. Despite over a hundred years of studying interoception, researchers lack a central scientific ontology that can guide induction. An ontology is a set of terms and their relationship to one another, optimized for internal consistency, flexibility, scalability, and problem solving within a given domain. Ontologies have proven useful in many fields, including within Affective Science, Neuroscience, Cognitive Science, and Genetics. These problems can be solved with an ontology that formally breaks down the biological and computational processes of interoception into its constituent parts. Using this ontology, researchers could target specific components-of-interest with a broader understanding for how those components might interact with others. In the present project, we propose an ontology of interoception derived from research on psychological constructionism, brain evolution, structural and functional neuroscience, and predictive models of sensation and perception. **Coauthor:** [Kristen A. Lindquist](#)

OLIVIA CARRUBBA, M.Sc. (POSTER 3), *University of Rome & IRCCS Fondazione Santa Lucia Research Hospital*

Towards Novel Measures of Gastric Interoception: The Water Load Test-III. Rationale: While interoception is receiving accruing scientific interest, most measures have focused on the cardiac and respiratory domains, neglecting the gastro-intestinal realm. The two-step Water Load Test (WLT-II) by Van Dyck et al. is a non-invasive task used to assess gastric interoception, GI. Here, we argue that WLT-II may present a momentous confound: GI is conceived as the ability to perceive the discrepancy between satiation, the comfort felt after one has eaten enough, and gastric fullness perceived when the stomach is entirely filled. We think that this discrepancy may not necessarily reflect GI, but different thresholds for perceiving satiation and fullness instead. Methods: Healthy, 3h fasted volunteers will be recruited to validate a multi-trial version of the WLT (the WLT-III). On each trial, participants ingest different, predetermined water amounts via multiple drinking modalities (e.g., drinking through a straw or glass). By focusing on gastric sensations, participants are asked to report how full, satiated, and thirsty they feel. The task ends when subjects report to have reached maximum gastric fullness. Thus, the number of trials will vary across participants. Intended Results: For each participant, GI will correspond to the mean of trial-by-trial differences between self-reported gastric fullness and actual gastric fullness (recalculated from the total amount of water ingested). Higher discrepancy indicates lower interoception. To characterize the feelings of fullness and satiation, we will compare the new measure of GI with the additional self-report measures. Implications: The multi-trial WLT-III will serve as a novel task to better quantify GI void of theoretical confounding factors. The task may have important clinical applications and will provide further evidence for the involvement of the stomach in interoception. **Coauthors:** [M. Scattolin](#), [G. Ponsi](#), [G. Porciello](#), [M. S. Panasiti](#)

AKANSHA NARAINDAS, M.Sc. (POSTER 4), *University College Dublin*

Investigating Body Based Mental Imagery and its Relationship to Body Image Disturbance and Interoceptive Awareness from Young to Late Adulthood. Body image disturbance (BID) is the distortion of perception, behaviour, or cognition related to weight or shape. There is significant variation in BID; with limited understanding of how body image evolves over time and the role that self-body imagery plays in this development. Body surveillance behaviours cause individuals to engage in 3rd person viewpoints of the self; leading to a prioritization of external signals (exteroception) at the cost of internal signals (interoception) (Riva, 2018). This study investigated levels of BID and interoceptive awareness from early-late adulthood and its relationship to own body mental imagery. A within-subjects cross sectional study was hosted online. 1000 female participants with 250 subjects per 4 target age groups: Young adults (18-24), Adults (25-

39), Middle aged adults (40-59), Older aged adults (60-75) took part. The study used a modified Own Body Transformation (OBT) task to measure own-body mental imagery through visual perspective manipulations. Interoceptive awareness was measured by The Multidimensional Assessment of Interoceptive Awareness (MAIA-2, Mehling et al, 2018) and components of BID (Body dissatisfaction, Body shame and Body Surveillance) were measured by questionnaires. There was a significant difference in interoceptive awareness scores between the age groups ($F(3,955) = 4.003, p=0.008$). Interoceptive awareness rises during young adulthood and steadily declines into older adulthood. There was a significant difference in time taken to perform the OBT task between the age groups ($F(3,955)=7.402, < 0.001$) and a strong negative correlation between BID scores and interoceptive awareness ($r = -.266, p < 0.001$) indicating that levels of BID decreased as interoceptive awareness increased. These results demonstrate the link between BID, own body mental imagery and interoceptive awareness across the female adult life-span and provide diagnostic insights for the manifestations of BIDs amongst the varied age groups. **Coauthor: Sarah Maeve**

EMILY M. ADAMIC, M.S. (POSTER 5), *Laureate Institute for Brain Research*

Hemispheric Divergence of Interoceptive Processing Across Psychiatric Disorders. Conscious perception of the inner body involves interactions between “top-down” attentional processes and “bottom-up” sensory input. The relative contributions of these information streams to interoceptive dysfunction in psychiatric disorders such as anxiety, depression, and/or eating disorders (ADE) are unknown. Given that the insula represents a cortical interface between these two processing streams, we hypothesized that the dysgranular subregion would show common activation across a whole-brain “convergence” of two fMRI tasks involving top-down or bottom-up interoception: voluntary attention towards cardiorespiratory sensations or peripheral perturbation of cardiorespiratory signals via intravenous isoproterenol infusion. 46 individuals with ADE and 46 healthy comparisons (HC) completed both tasks. We found the dysgranular mid-insula to be the primary region of convergence in both groups, but with hemispheric differences: relative to HC, the ADE group showed proportionally greater convergence within the left ($\chi^2 = 19.12, < 0.01$) and less within the right ($\chi^2 = 26.72, < 0.01$) dysgranular mid-insula. We then focused our analysis on the dysgranular insula, and found that across groups, the spatial patterns of convergence within the left dysgranular insula were less similar than those within the right (Dice coefficients of 0.58 and 0.78, respectively). These findings provide evidence of hemispheric asymmetry in interoceptive processing in ADE and add to an emerging body of work suggesting that the left dysgranular mid-insula may be a locus of disruption across psychiatric disorders. **Coauthors: Adam R. Teed, Jason A. Avery, Sahib S. Khalsa**

LOTTE GERRITSEN, Ph.D. (POSTER 6), *Utrecht University*

Interoception as a Transdiagnostic Marker for Psychopathology. Background: Low interoceptive abilities are common in a variety of psychopathology, including eating disorders, post-traumatic stress disorder, anxiety disorders and depression. Furthermore, empirical evidence shows that participants with low interoceptive abilities have more difficulties in verbalizing their feelings, show decreased emotional memory and have worse emotion regulation skills. As such it could well be that interoception can be considered a transdiagnostic marker, that already plays a role early on in the development of psychopathology. We are therefore currently setting up studies to explore the role of interoception in a large range of psychopathology in subclinical populations with social anxiety, depression and eating disorders. In these populations we will study how interoceptive skills are related to emotion regulation and symptom severity. Methods: We will test Interoceptive Accuracy (IAc), by using the recently developed and validated heart rate discrimination task. Interoceptive Sensibility (IS) will be assessed using the multidimensional assessment of interoceptive awareness (MAIA)– version 2 questionnaire. Interoceptive awareness will be assessed by the correlation between IAc and IS. Inclusion of participants will start early February and as such we hope to have some preliminary data available in the end of March. **Coauthors: Maria Giapraki, Gabriel Ibarra Zanella**

ELEANOR PALSER, Ph.D. (POSTER 7), *University of California San Francisco*

Heightened Vagal Tone Promotes Greater Social Attention in Dyslexia: An Embodied Strength-Based Perspective. Dyslexia is a neurodevelopmental condition diagnosed based on poor reading ability, but little is known about the condition outside academic achievement. Anecdotal evidence suggests that people with dyslexia are over-represented amongst occupations that value and rely on strengths in creativity, flexible thinking, and social skills, although scant empirical work has sought to investigate the adaptive or compensatory psychobiological systems that might underlie such strengths. The parasympathetic branch of the autonomic nervous system, acting on the body via the vagus nerve, supports flexible, adaptive responding and predicts a host of socioemotional advantages, including empathy, prosocial behavior, and positive emotionality. Here, we investigated whether tonic vagal activity is heightened in 24 children with dyslexia, relative to 24 matched neurotypical children, and whether this predicts greater autonomic and behavioral responses during an empathy task. Results indicated higher tonic vagal tone in dyslexia, $B = 0.39, t = 2.81, p = .007$, which in turn predicted greater cardiac deceleration, $F(1,44) = 5.03, p = .030$, and concentration facial behavior, $F(1,44) = 5.03, p = .030, B = 2.71, t = 2.05, p = .046$, during the empathy task. Cardiac deceleration is known to support sustained attentional focus and promote prosocial

responding. These findings suggest that greater activity of the vagus, a key interoceptive pathway, promotes greater social attention in dyslexia, and introduces a novel psychobiological explanation for socioemotional strengths in this population. **Coauthors: Nathaniel A. Morris, Ashlin R. K. Roy, Christina R. Veziris, Sarah R. Holley, Bruce L. Miller, Maria Luisa Gorno, Virginia E. Sturm**

EVA ELLEN DICKER, B.A. (POSTER 8), *Rice University*

Exploring the Interaction between Emotion Regulation and Inflammation on Changes in Episodic Memory in Older Adults. Older adults experience chronic, low-grade inflammation as a result of age-related dysregulation, resulting in higher concentrations of circulating proinflammatory cytokines such as Interleukin (IL)-6 and (IL)-8. This predicts the development of physical decline and cognitive decline. In contrast, older adults demonstrate relative emotional strengths compared to younger adults by engaging in more adaptive emotion regulation strategies. Emotion regulation is associated with altered immune functioning, and such a link may be an important biological pathway by which interventions targeting affect may improve immune system-related cognitive outcomes. Thus, the aim of this study was to investigate whether emotion regulation strategies differentially moderate the effect of inflammatory cytokine levels on cognitive decline. This study used data from the Survey of Mid-life Development in the U.S. (MIDUS), where 189 adults (mean age = 53 years) participated in two data collections, 10 years apart. Regression models measured whether timepoint 1 self-report of cognitive reappraisal moderated the effect of timepoint 1 IL-6, and IL-8 (pg/mL) levels on a composite z-score of episodic memory (immediate and delayed word recall task) at the timepoint 1 and timepoint 2. Another set of regressions was conducted using the same predictors and criterion, except for timepoint 1 self-report suppression, another emotion regulation strategy. All four models controlled for age, sex, BMI, smoking status, alcohol use status, race, education, and self-rated health. Timepoint 1 self-reported cognitive reappraisal and IL-8 predicted higher episodic memory scores at timepoint 2. There was a marginally significant negative interaction between the effects. These findings indicate that inflammation and emotion regulation strategies may be linked to memory decline and could potentially provide a therapeutic target for interventions to improve immune system-related cognitive outcomes. **Coauthors: Stephanie L. Leal, Chris P. Fagundes, Bryan T. Denny**

DAISUKE UENO, Ph.D. (POSTER 9), *Kyoto Prefectural University of Medicine*

A Pilot Study of the Correlations between Interoceptive Accuracy, Confidence in Interoceptive Accuracy, Interoceptive Awareness, and Mood in Elderly. Interoceptive improvement plays a key role in improving mood. Interoceptive accuracy (IA) has been found to improve after receiving feedback (FB) regarding the correctness of trials, and mental health can improve after interoceptive training. Some studies reported that IA is correlated with interoceptive awareness and confidence in IA. However, no study has examined the correlation between interoceptive improvement, confidence in IA, interoceptive awareness, and mood in older adults. Nineteen participants (mean age = 75.32±7.49, 10 women) completed a scale on interoceptive awareness using (Multidimensional Assessment of Interoceptive Awareness; MAIA, and Somatosensory Amplification Scale; SSAS) before an original heartbeat-counting task (HCT in 15 seconds as practice, followed by 25, 35, and 45 seconds) assessing IA and an HCT with FB (in 15 seconds as practice with five trials, followed by 25, 35, and 45 seconds with 15 trials, respectively). Participants answered their confidence ratings on a 1–10 scale for IA in HCT before each second block, and a scale for the positive and negative mood (PANAS) before and after all HCTs. The IA improved in 45s block comparing with 25s block ($F [2, 36] = 8.44, p < .01$). We calculated Spearman's rank correlation coefficients (ρ) between variables and adjusted the p-value using Benjamini and Hochberg's method. A mean IA with FB was positively correlated with positive mood at before and after HCTs (before, $\rho = .71, p = .001$, after, $\rho = .65, p = .002$) as well as confidence in IA ($\rho = .81, p < .0001$). The original HCT's mean IA was positively correlated with confidence in IA ($\rho = .71, p = .001$). There was no correlation between MAIA, SSAS, and IA. This study suggests that older adults seem to improve their IA by receiving FB, and a positive mood relates to improving their IA. Confidence in IA in each trial also relates to IA improvement, but trait interoceptive awareness, such as MAIA and SSAS, does not relate to IA improvement. **Coauthors: Teruyuki Matsuoka, Toshiyuki Tominaga, Yuka Kato, Rika Onoda, Jin Narumoto**

CARLOS CAMPOS, M.A. (POSTER 10), *University of Porto & Polytechnic Institute of Porto*

Dissociating Self-Reported Interoceptive Accuracy and Attention: Evidence from a Portuguese Community Sample. Background: The 2x2 factorial model has been recently proposed as a promising framework to measure individual differences in interoception. The first factor addresses which domain is being measured (interoceptive accuracy vs. attention), while the second distinguishes how it is being measured (self-report beliefs vs. objective performance). Aim: The current study examined the association between self-reported interoceptive accuracy and attention. We hypothesized no linear association between these constructs, although a quadratic U-shaped association was expected. Furthermore, alexithymia should be differentially related to interoceptive accuracy and attention. Methods: An online community sample ($n = 515$) completed the Interoceptive Accuracy Scale (IAS), the Body Perception Questionnaire (BPQ) - indexing self-reported interoceptive attention, and the Toronto Alexithymia Scale (TAS). Pearson correlations, Steiger's Z-test, polynomial regression analysis, and two-lines testing were used for statistical analysis. Results: IAS was positively correlated with BPQ, $r = .204, p < .001$. In the polynomial regression analysis, the linear model indicated a positive association between IAS and BPQ (4.2%),

but the quadratic term explained an additional 12.7% of the variance. Two-lines testing indicated a U-shaped association between self-report interoceptive accuracy and attention. IAS was negatively correlated with TAS, $r = -.291$, $p < .001$, while there was no significant association between BPQ and TAS, $r = -.030$, $p = .500$, as these correlations were statistically different. Implications: These results suggest that interoceptive accuracy and attention can be dissociated using self-report measures and may display a quadratic U-shaped association, providing further evidence for the 2x2 factorial model. Future studies should explore the non-linear relationship between interoceptive accuracy and attention using alternative questionnaires and performance-based measures. **Coauthors: Nuno Barbosa Rocha, Fernando Barbosa**

MATEO LEGANES-FONTENEAU, Ph.D. (POSTER 11), Rutgers University

Resonance Breathing Can Improve Cardiac Interoceptive Awareness. Interoception, the ability to perceive internal bodily sensations, and heart rate variability (HRV) share common psycho-physiological pathways underlying the characterisation of mental health disorders. Here we examine if resonance breathing can improve interoceptive awareness. In a two-session laboratory study ($n=63$) interoception was measured using the cardiac discrimination task. Baroreflex functioning was measured as HRV at 0.1 Hz (a proxy of afferent baroreflex activation) and baroreflex sensitivity (BRS). Cardiovascular indices were measured during a low cognitive demand baseline task and during a resonance and control paced breathing tasks, after which changes in interoception were measured. We found that changes in 0.1 Hz HRV and BRS during resonance breathing positively correlate with increases in cardiac interoception after the paced breathing task. That is, the extent to which paced breathing engages the resonant properties of the cardiovascular system facilitates the perception of participants' own heartbeat. This research bridges the fields of interoception and cardiovascular functioning to provide a new window to the application of resonance breathing to mental health disorders. It also provides a novel characterisation of the cardiovascular basis of interoceptive awareness and advances our understanding of the mechanisms by which the brain integrates cardiac signals through interoceptive inference processes. **Coauthor: Jennifer Buckman**

PIETRA TAYLOR BRUNI, M.S. (POSTER 12), Vanderbilt University

Comparing Measures of Interoception Between Cardiac and Respiratory Domains. Interoception provides information about the internal state and condition of the human body—it is most typically measured using heartbeat tasks. However, there are mounting criticisms against focusing exclusively on signals that originate in the heart. The primary goal of this study was to assess interoception in two distinct domains, cardiac and respiratory. Two laboratory tasks measured interoception: a Heartbeat Tracking Task and a Respiratory Discrimination Task. Sixty adults (mean age = 46.07 years) were recruited from the community. Three measures of interoception were extracted: Interoceptive accuracy (IAcc), Interoceptive awareness (IAwe), and self-reported confidence. Results from this experiment indicated that IAcc and IAwe were not correlated across domains. Of note, a significant difference was found between the two estimates of IAcc (heartbeat; ($M= 3.24$, $SD = 1.62$); respiratory; ($M= 2.91$, $SD = 1.18$)); ($t(118) = -3.24$, $p < 0.001$), indicating that participants were more accurate at assessing interoception in the respiratory than in the cardiac domain. These results show dissociable outcomes for two methods of assessing interoception. Given the prominent role interoception has in maintaining homeostatic functioning by interpreting and discriminating among internal bodily signals, future work would benefit from developing additional paradigms to investigate interoception across other conditions and domains. **Coauthor: Jo-Anne Bachorowski**

PAIGE ALYSSA FREEBURG (POSTER 13), Baylor University

Meaning Behind the Movement: Affective Consequences of Attributing Sacred Meaning to Fluid and Nonfluid Arm Movements. The psychological constructionist view of emotion posits that emotions occur when people ascribe meaning to changes in the body within a certain situation or context. Therefore, it is possible that emotions could be evoked depending on the meaning ascribed to arm movements. The present study experimentally manipulated the meaning (sacred vs. nonsacred) participants ($n = 422$) attributed to fluid and nonfluid arm movements. The effects of movement fluidity, movement sacredness, and their interaction were examined for positive emotions and self-transcendent positive emotions. Attributing sacred meaning to arm movements led to greater experiences of self-transcendent positive emotions, $F(1, 415) = 20.18$, $p < .001$, partial $\eta^2 = .046$, and protected against the deleterious effects of nonfluid movement on positive emotions, $F(1, 415) = 5.19$, $p = .023$, partial $\eta^2 = .012$. These findings align with prior research suggesting that embodiment effects are robust for affective outcomes. The present study challenges embodiment research to focus not only on the types of body movements enacted but also on the kinds of meaning attributed to body movements. Future studies should investigate the emotional amplifying and buffering effects of different types of meaning (e.g., purpose) attributed to body movements beyond the arm (e.g., dancing). The present research is in press at *Psychology of Religion and Spirituality*. **Coauthors: Patty Van Cappellen, Juliette L. Ratchford, Sarah A. Schnitker**

DOMINIKA RADZIUN, M.Sc. (POSTER 14), Karolinska Institutet

Cardiac Interoception and Affective Touch Sensitivity are Enhanced in the Blind: Emotional and Mental Health Implications of Increased Sensory Acuity. Introduction: It has been repeatedly shown that visual deprivation is associated with massive cross-modal plasticity. However, not enough attention has been focused on the relation between increased sensory acuity and emotional processing among

blind individuals. Here, we examined the influence of blindness on two interoceptive submodalities that are important for emotional functioning: cardiac interoception and affective touch. Methods: We tested 36 blind and 36 age- and sex-matched sighted volunteers. In experiment 1, we assessed their cardiac interoceptive abilities using the heartbeat counting task. In experiment 2, we measured sensitivity to skin-mediated interoceptive signals by asking about pleasantness of touch delivered in CT-optimal versus CT-non-optimal manner, and also implemented a control task of discriminative touch abilities, the grating orientation task. Results: We found that blind participants perform significantly better than sighted in the task measuring their cardiac interoceptive accuracy ($t = 3.017$, $p = 0.004$). We did not find any significant differences between the groups in subjective dimensions of cardiac interoception, as well as purely physiological measurements (e.g., heart rate). In case of the affective touch, we found that blind individuals rate the touch as significantly more pleasant on palm as compared with forearm ($F = 13.454$, $p < 0.001$). We also replicated the previous findings showing enhanced discriminative tactile acuity in the blind ($t = -3.991$, $p < 0.001$). Discussion: To the best of our knowledge, our experiments are the first investigation of cardiac interoceptive abilities, as well as affective touch sensitivity in the blind. Our results provide an important insight into emotional processing in the absence of vision, given the relevance of interoceptive signals in emotional functioning. Furthermore, they could also be considered a missing link between enhanced sensory abilities and increased anxiety levels in the blind. **Coauthors: Maksymilian Korczyk, Laura Crucianelli, Marcin Szwed, H. Henrik Ehrsson**

EWA KOCHANOWSKA, M.Sc. (POSTER 15), *University of New Hampshire*

Body Awareness in the Moment Predicts Changes in Intertemporal Choice: Evidence from an Ecological Momentary Assessment Study. Temporal discounting refers to an individuals' tendency to value immediate rewards over larger future rewards. Increased discounting has been associated with a host of detrimental outcomes, including higher risk of addiction, clinical diagnoses and mental health symptom severity, social functioning deficits, and poorer overall health status. Given that interoception, the perception of internal sensations from the body, has been theorized to play a critical role in a number of these phenomena, we set out to investigate whether momentary differences in awareness of body sensations are associated with variations in temporal discounting. Participants ($N=116$) completed a 7-day ecological momentary assessment (EMA) protocol, in which they reported their awareness of ongoing bodily activity (e.g., breathing and heart rate), rated their current affect (valence and arousal), and made a single intertemporal choice from which we could derive an estimate of their in-the-moment annual discount rate. Participants made these ratings six times throughout each day at random times. We found that momentary discount rate was significantly negatively associated with momentary body awareness ($B = -.02$, $SE = .01$, $t(3911) = -2.72$, $p = .007$), and this effect remained significant when controlling for self-reported arousal and valence. That is, in moments of increased awareness of bodily sensations, individuals had lower discount rates (i.e., a weaker preference for immediate rewards), even when controlling for concurrent affect. Interestingly, we found no association between participants' self-reported level of general body awareness and a trait-like measure of the individual's discount rate, demonstrating that our novel in-the-moment approach was able to reveal within-person associations between body awareness and temporal discounting that are not attributable to individual differences at a more trait-like level. **Coauthors: Alexandra MacVittie, Caitlin Mills, Jolie Wormwood**

MARKUS R. TÜNTE, M.Sc. (POSTER 16), *University of Vienna*

Relating Spontaneous and Deliberate Mind Wandering to Interoceptive Accuracy and Attention. Mind wandering is the tendency to drift away from the here and now that can be either deliberate or spontaneous. Recent approaches have focused on the relationship of concepts related to mind wandering, such as mindfulness, to interoception. However, empirical evidence on mind wandering and interoception is still lacking. Here, we report results from two studies measuring interoceptive accuracy and attention as well as deliberate and spontaneous mind wandering. In study 1, participants ($n = 400$) filled out questionnaires measuring interoceptive accuracy and attention, as well as deliberate and spontaneous mind wandering. For self-reported interoceptive attention we found a positive correlation with both deliberate- ($r = .21$, $p < .001$) and spontaneous ($r = .22$, $p < .001$) mind wandering. For self-reported interoceptive accuracy we found a negative correlation with spontaneous- ($r = -.12$, $p = .015$), but no relationship with deliberate ($r = .02$, $p = .63$) mind wandering. In study 2 ($n = 80$) we used heartbeat counting- and detection tasks to measure objective interoceptive accuracy. Although the physiological data is still being processed, preliminary results indicate that the number of counted heartbeats is negatively correlated to spontaneous ($r = -.27$, $p = .015$), but unrelated to deliberate ($r = -.16$, $p = .152$) mind wandering. It will be highly informative whether analysis of the full sample to be presented at the SAS Interoception Preconference confirms these findings. In sum, we report first evidence that interoceptive attention is positively correlated to both spontaneous and deliberate mind wandering. These results indicate that mind wandering is related to attention to interoceptive signals in everyday life. In contrast, interoceptive accuracy is negatively correlated to spontaneous, but shows no relationship with, deliberate mind wandering, which might indicate that spontaneous mind wandering is hindering accurate perception of interoceptive signals. **Coauthor: Stefanie Hoehl**

ESRA AL, M.Sc. (POSTER 17), *Max Planck Institute for Human Cognitive and Brain Sciences*

Cardiac Signals Influence Cortical Motor Excitability and Muscle Activity. Internal bodily signals such as heartbeats can influence human perception and action. For example, somatosensory perception is impaired both during the systolic phase of the cardiac cycle and following stronger cortical responses to heartbeats. Here, we investigate whether these cardiac effects are associated with general changes in cortical excitability. Cortical and corticospinal excitability was assessed using electroencephalographic and electromyographic responses to transcranial magnetic stimulation (TMS) while monitoring cardiac activity using electrocardiography in thirty-six participants. Single pulses of TMS were applied over the right primary motor cortex of the participants. At the end of the TMS experiment, subjects also performed a motor pinch task. Our results demonstrated that cortical and corticospinal excitability was maximal during systole as compared to diastole ($t_{35}=-2.21$, $p=0.03$ and cluster-based permutation t-test, $p=0.01$, respectively). In line with this finding, in the motor task, muscle activity and desynchronization of sensorimotor oscillations (8-25 Hz) were observed to be stronger following muscle contractions during systole ($p=0.01$). Complementing these results, we also observed that TMS led to heart-rate decreases specifically in systole but not in diastole. In addition to the cardiac cycle effects, increases in cortical responses to heartbeats, as measured by heartbeat-evoked potentials, predicted stronger corticospinal excitability. These findings show that systolic cardiac signals are associated with a facilitatory effect on motor excitability. This is in contrast to the cardiac-related sensory attenuation previously reported for somatosensory perception. Altogether these findings thus suggest that action and perception have distinct windows in the cardiac cycle for optimal information processing. **Coauthors: Tilman Stephani, Melina Engelhardt, Arno Villringer, Vadim Nikulin**