NourishED Research Foundation (NRFi)

Interoception & Interoceptive Awareness in Binge Eating Disorder

**Sept 25, 2024**

[nourished@nourishedRFi.org](mailto:nourished@nourishedrfi.org) | 206-819-9647

1207 Delaware Ave, Wilmington, DE, 19806

1821 Walnut Street, Boulder, CO 80302

[www.nourishedrfi.org](http://www.nourishedrfi.org)

A logo for a research foundation

Description automatically generated

Table of Contents

[I. Interoception in Eating Disorders & Mental Health 2](#_Toc178154740)

[II. Stress & Interoception Disruption 11](#_Toc178154741)

[III. Interoception in BED 12](#_Toc178154742)

[1. General 12](#_Toc178154743)

[2. Nadershahi, Bray 14](#_Toc178154744)

[3. Martin (not active clinical trial) 20](#_Toc178154745)

[4. No Control 20](#_Toc178154746)

[IV. Interoception in Other Eating Disorders 20](#_Toc178154747)

[1. “Mixed EDs” (which can include BED) 20](#_Toc178154748)

[2. “EDNOS” (“Eating Disorder Not Otherwise Specified,” which included BED before publication of the DSM-V in 2013). 20](#_Toc178154749)

[V. Autism in BED 21](#_Toc178154750)

# Interoception in Eating Disorders & Mental Health

(1-13)

#### Weng, H. Y., et al. (2020). "Focus on the Breath: Brain Decoding Reveals Internal States of Attention During Meditation." Front Hum Neurosci 14: 336.

Meditation practices are often used to cultivate interoception or internally-oriented attention to bodily sensations, which may improve health via cognitive and emotional regulation of bodily signals. However, it remains unclear how meditation impacts internal attention (IA) states due to lack of measurement tools that can objectively assess mental states during meditation practice itself, and produce time estimates of internal focus at individual or group levels. To address these measurement gaps, we tested the feasibility of applying multi-voxel pattern analysis (MVPA) to single-subject fMRI data to: (1) learn and recognize internal attentional states relevant for meditation during a directed IA task; and (2) decode or estimate the presence of those IA states during an independent meditation session. Within a mixed sample of experienced meditators and novice controls (N = 16), we first used MVPA to develop single-subject brain classifiers for five modes of attention during an IA task in which subjects were specifically instructed to engage in one of five states [i.e., meditation-related states: breath attention, mind wandering (MW), and self-referential processing, and control states: attention to feet and sounds]. Using standard cross-validation procedures, MVPA classifiers were trained in five of six IA blocks for each subject, and predictive accuracy was tested on the independent sixth block (iterated until all volumes were tested, N = 2,160). Across participants, all five IA states were significantly recognized well above chance (>41% vs. 20% chance). At the individual level, IA states were recognized in most participants (87.5%), suggesting that recognition of IA neural patterns may be generalizable for most participants, particularly experienced meditators. Next, for those who showed accurate IA neural patterns, the originally trained classifiers were applied to a separate meditation run (10-min) to make an inference about the percentage time engaged in each IA state (breath attention, MW, or self-referential processing). Preliminary group-level analyses demonstrated that during meditation practice, participants spent more time attending to breath compared to MW or self-referential processing. This paradigm established the feasibility of using MVPA classifiers to objectively assess mental states during meditation at the participant level, which holds promise for improved measurement of internal attention states cultivated by meditation.

#### van Dyck, Z., et al. (2020). "Gastric interoception and gastric myoelectrical activity in bulimia nervosa and binge-eating disorder." Int J Eat Disord.

OBJECTIVE: Identifying factors that control food intake is crucial to the understanding and treatment of eating disorders characterized by binge eating. In healthy individuals, stomach distension plays an important role in the development of satiation, but gastric sensations might be overridden in binge eating. The present study investigated the perception of gastric signals (i.e., gastric interoception) and gastric motility in patients experiencing binge-eating episodes, that is, bulimia nervosa (BN) and binge-eating disorder (BED). METHOD: Twenty-nine patients with BN or BED (ED group) and 32 age-, sex-, and BMI-matched healthy controls (HC group) participated in the study. The onset of satiation and stomach fullness were assessed using a novel 2-step water load test (WLT-II). Gastric myoelectrical activity (GMA) was measured by electrogastrography (EGG) before and after ingestion of noncaloric water. RESULTS: Individuals in the ED group drank significantly more water until reporting satiation during the WLT-II. The percentage of normal gastric myoelectrical power was significantly smaller in the ED group compared to HC, and negatively related to the number of objective binge-eating episodes per week in patients with BN or BED. Power in the bradygastria range was greater in ED than in HC participants. DISCUSSION: Patients with EDs have a delayed response to satiation compared to HC participants, together with abnormal GMA. Repeated binge-eating episodes may induce disturbances to gastric motor function.

#### Romano, K. A., et al. (2020). "Somatic symptoms and binge eating in women's daily lives." J Psychosom Res 135: 110161.

OBJECTIVE: The present study aimed to determine whether the momentary severity of women's somatic symptoms was concurrently and prospectively associated with their engagement in binge eating in naturalistic settings. METHOD: Thirty women (M(age) = 34.13, SD = 13.92) who had engaged in binge eating at least once over the month prior to study entry completed a 14-day ecological momentary assessment (EMA) protocol. During each of the 14 days, participants received five semi-random surveys via text message that assessed momentary somatic symptom severity (i.e., headaches, stomachaches/pain, chest/heart pain, faintness/dizziness, shortness of breath, fatigue) and disordered eating behaviors. Generalized estimating equations were used to determine whether momentary somatic symptoms were concurrently and prospectively (i.e., by participants' next assessment) associated with the occurrence of binge eating behavior, while controlling for age and body mass index. RESULTS: At the within-person level, more severe stomachaches/pain, faintness/dizziness, shortness of breath, and fatigue were concurrently associated with an increased likelihood of engaging in binge eating. Further, at the between-person level, more severe stomachaches/pain, chest/heart pain, shortness of breath, and fatigue in general were associated with binge eating across the EMA protocol. Momentary stomachache/pain severity also prospectively predicted women's engagement in binge eating behavior at the next assessment. CONCLUSIONS: The present results provide initial evidence that multiple somatic symptoms may serve as momentary correlates or proximal antecedents of binge eating behavior in women's daily lives. Somatic symptoms may consequently prove useful to target in eating disorder treatments, perhaps via interoceptive exposure interventions.

#### Martin, E., et al. (2019). "Interoception and disordered eating: A systematic review." Neurosci Biobehav Rev 107: 166-191.

Deficits in interoception have been associated with disordered eating but there has been no systematic review of whether the interoceptive deficits are observed across all types of disordered eating and across interoceptive modalities. There has also been no evaluation of whether deficits in interoception play a causal role in the development of disordered eating. Nor has there been a review of the moderating/mediating factors of the relationship between interoception and disordered eating. To address these gaps we conducted a systematic review using PRISMA guidelines. 104 studies with 32883 participants were included. Deficits in interoception were observed across disordered eating types and interoceptive modalities suggesting that interoception may constitute a transdiagnostic feature of disordered eating. There is currently limited evidence on the causal role of interoception in the development of disordered eating and no studies have formally analysed the moderators/mediators. Future mechanistic research examining particular dimensions of interoception will provide insights into the specific interoceptive deficits associated with disordered eating and could lead to the development of improved therapies.

#### Frank, G. K. W., et al. (2019). "The Neurobiology of Eating Disorders." Child Adolesc Psychiatr Clin N Am 28(4): 629-640.

Eating disorders are severe psychiatric illnesses with a typical age of onset in adolescence. Brain research in youth and young adults may help us identify specific neurobiology that contributes to onset and maintenance of those disorders. This article provides a state-of-the-art review of our current understanding of the neurobiology of anorexia nervosa and bulimia nervosa. This includes brain structure and function studies to understand food restriction, binge-eating or purging behaviors, cognitive and emotional factors, as well as interoception. Binge-eating disorder and avoidant restrictive food intake disorder are also discussed, but the literature is still very small.

#### Khalsa, S. S., et al. (2018). "Interoception and Mental Health: A Roadmap." Biological Psychiatry: Cognitive Neuroscience and Neuroimaging 3(6): 501-513.

Interoception refers to the process by which the nervous system senses, interprets, and integrates signals originating from within the body, providing a moment-by-moment mapping of the body’s internal landscape across conscious and unconscious levels. Interoceptive signaling has been considered a component process of reflexes, urges, feelings, drives, adaptive responses, and cognitive and emotional experiences, highlighting its contributions to the maintenance of homeostatic functioning, body regulation, and survival. Dysfunction of interoception is increasingly recognized as an important component of different mental health conditions, including anxiety disorders, mood disorders, eating disorders, addictive disorders, and somatic symptom disorders. However, a number of conceptual and methodological challenges have made it difficult for interoceptive constructs to be broadly applied in mental health research and treatment settings. In November 2016, the Laureate Institute for Brain Research organized the first Interoception Summit, a gathering of interoception experts from around the world, with the goal of accelerating progress in understanding the role of interoception in mental health. The discussions at the meeting were organized around four themes: interoceptive assessment, interoceptive integration, interoceptive psychopathology, and the generation of a roadmap that could serve as a guide for future endeavors. This review article presents an overview of the emerging consensus generated by the meeting.

#### Kumar, S., et al. (2017). "The Brain Basis for Misophonia." Curr Biol 27(4): 527-533.

Misophonia is an affective sound-processing disorder characterized by the experience of strong negative emotions (anger and anxiety) in response to everyday sounds, such as those generated by other people eating, drinking, chewing, and breathing [1-8]. The commonplace nature of these sounds (often referred to as "trigger sounds") makes misophonia a devastating disorder for sufferers and their families, and yet nothing is known about the underlying mechanism. Using functional and structural MRI coupled with physiological measurements, we demonstrate that misophonic subjects show specific trigger-sound-related responses in brain and body. Specifically, fMRI showed that in misophonic subjects, trigger sounds elicit greatly exaggerated blood-oxygen-level-dependent (BOLD) responses in the anterior insular cortex (AIC), a core hub of the "salience network" that is critical for perception of interoceptive signals and emotion processing. Trigger sounds in misophonics were associated with abnormal functional connectivity between AIC and a network of regions responsible for the processing and regulation of emotions, including ventromedial prefrontal cortex (vmPFC), posteromedial cortex (PMC), hippocampus, and amygdala. Trigger sounds elicited heightened heart rate (HR) and galvanic skin response (GSR) in misophonic subjects, which were mediated by AIC activity. Questionnaire analysis showed that misophonic subjects perceived their bodies differently: they scored higher on interoceptive sensibility than controls, consistent with abnormal functioning of AIC. Finally, brain structural measurements implied greater myelination within vmPFC in misophonic individuals. Overall, our results show that misophonia is a disorder in which abnormal salience is attributed to particular sounds based on the abnormal activation and functional connectivity of AIC.

#### Brewer, R., et al. (2016). "Alexithymia: a general deficit of interoception." R Soc Open Sci 3(10): 150664.

Alexithymia is a sub-clinical construct, traditionally characterized by difficulties identifying and describing one's own emotions. Despite the clear need for interoception (interpreting physical signals from the body) when identifying one's own emotions, little research has focused on the selectivity of this impairment. While it was originally assumed that the interoceptive deficit in alexithymia is specific to emotion, recent evidence suggests that alexithymia may also be associated with difficulties perceiving some non-affective interoceptive signals, such as one's heart rate. It is therefore possible that the impairment experienced by those with alexithymia is common to all aspects of interoception, such as interpreting signals of hunger, arousal, proprioception, tiredness and temperature. In order to determine whether alexithymia is associated with selectively impaired affective interoception, or general interoceptive impairment, we investigated the association between alexithymia and self-reported non-affective interoceptive ability, and the extent to which individuals perceive similarity between affective and non-affective states (both measured using questionnaires developed for the purpose of the current study), in both typical individuals (n = 105 (89 female), mean age = 27.5 years) and individuals reporting a diagnosis of a psychiatric condition (n = 103 (83 female), mean age = 31.3 years). Findings indicated that alexithymia was associated with poor non-affective interoception and increased perceived similarity between affective and non-affective states, in both the typical and clinical populations. We therefore suggest that rather than being specifically associated with affective impairment, alexithymia is better characterized by a general failure of interoception.

#### Frank, G. K. (2015). "Advances from neuroimaging studies in eating disorders." CNS Spectr 20(4): 391-400.

Over the past decade, brain imaging has helped to better define eating disorder-related brain circuitry. Brain research on gray matter (GM) and white matter (WM) volumes had been inconsistent, possibly due to the effects of acute starvation, exercise, medication, and comorbidity, but newer studies have controlled for such effects. Those studies suggest larger left medial orbitofrontal gyrus rectus volume in ill adult and adolescent anorexia nervosa after recovery from anorexia nervosa, and in adult bulimia nervosa. The orbitofrontal cortex is important in terminating food intake, and altered function could contribute to self-starvation. The right insula, which processes taste but also interoception, was enlarged in ill adult and adolescent anorexia nervosa, as well as adults recovered from the illness. The fixed perception of being fat in anorexia nervosa could be related to altered insula function. A few studies investigated WM integrity, with the most consistent finding of reduced fornix integrity in anorexia and bulimia nervosa-a limbic pathway that is important in emotion but also food intake regulation. Functional brain imaging using basic sweet taste stimuli in eating disorders during the ill state or after recovery implicated repeatedly reward pathways, including insula and striatum. Brain imaging that targeted dopamine-related brain activity using taste-reward conditioning tasks suggested that this circuitry is hypersensitive in anorexia nervosa, but hyporesponsive in bulimia nervosa and obesity. Those results are in line with basic research and suggest adaptive reward system changes in the human brain in response to extremes of food intake-changes that could interfere with normalization of eating behavior.

#### Wolk, J., et al. (2014). "Enhanced cardiac perception predicts impaired performance in the Iowa Gambling Task in patients with panic disorder." Brain Behav 4(2): 238-246.

OBJECTIVE: Somatic marker theory predicts that somatic cues serve intuitive decision making; however, cardiovascular symptoms are threat cues for patients with panic disorder (PD). Therefore, enhanced cardiac perception may aid intuitive decision making only in healthy individuals, but impair intuitive decision making in PD patients. METHODS: PD patients and age-and sex-matched volunteers without a psychiatric diagnosis (n = 17, respectively) completed the Iowa Gambling Task (IGT) as a measure of intuitive decision making. Interindividual differences in cardiac perception were assessed with a common mental-tracking task. RESULTS: In line with our hypothesis, we found a pattern of opposing associations (Fisher's Z = 1.78, P = 0.04) of high cardiac perception with improved IGT-performance in matched control-participants (r = 0.36, n = 14) but impaired IGT-performance in PD patients (r = -0.38, n = 13). CONCLUSION: Interoceptive skills, typically assumed to aid intuitive decision making, can have the opposite effect in PD patients who experience interoceptive cues as threatening, and tend to avoid them. This may explain why PD patients frequently have problems with decision making in everyday life. Screening of cardiac perception may help identifying patients who benefit from specifically tailored interventions.

#### Napadow, V., et al. (2014). "The brain circuitry mediating antipruritic effects of acupuncture." Cereb Cortex 24(4): 873-882.

Itch is an aversive sensory experience and while systemic therapies, such as acupuncture, have shown promise in alleviating itch in patients suffering from chronic itch, their antipruritic mechanisms are unknown. As several lines of evidence implicate brain-focused mechanisms, we applied functional magnetic resonance imaging and our validated temperature-modulation itch model to evaluate the underlying brain circuitry supporting allergen-induced itch reduction in atopic dermatitis patients by acupuncture, antihistamine, and respective placebo treatments. Brain response to allergen itch demonstrated phase dependency. During an increasing itch phase, activation was localized in anterior insula and striatum, regions associated with salience/interoception and motivation processing. Once itch reached peak plateau, robust activation was noted in prefrontal cognitive and premotor areas. Acupuncture reduced itch and itch-evoked activation in the insula, putamen, and premotor and prefrontal cortical areas. Neither itch sensation nor itch-evoked brain response was altered following antihistamine or placebo acupuncture. Greater itch reduction following acupuncture was associated with greater reduction in putamen response, a region implicated in motivation and habitual behavior underlying the urge to scratch, specifically implicating this region in acupuncture's antipruritic effects. Understanding brain circuitry underlying itch reduction following acupuncture and related neuromodulatory therapies will significantly impact the development and applicability of novel therapies to reduce an itch.

#### Dunn, B. D., et al. (2010). "Listening to your heart. How interoception shapes emotion experience and intuitive decision making." Psychol Sci 21(12): 1835-1844.

Theories proposing that how one thinks and feels is influenced by feedback from the body remain controversial. A central but untested prediction of many of these proposals is that how well individuals can perceive subtle bodily changes (interoception) determines the strength of the relationship between bodily reactions and cognitive-affective processing. In Study 1, we demonstrated that the more accurately participants could track their heartbeat, the stronger the observed link between their heart rate reactions and their subjective arousal (but not valence) ratings of emotional images. In Study 2, we found that increasing interoception ability either helped or hindered adaptive intuitive decision making, depending on whether the anticipatory bodily signals generated favored advantageous or disadvantageous choices. These findings identify both the generation and the perception of bodily responses as pivotal sources of variability in emotion experience and intuition, and offer strong supporting evidence for bodily feedback theories, suggesting that cognitive-affective processing does in significant part relate to "following the heart."

#### Kim, J. A., et al. (1999). "Drug-onset cues as signals: intraadministration associations and tolerance." J Exp Psychol Anim Behav Process 25(4): 491-504.

On the basis of a conditioning analysis of drug tolerance, drug-associated cues become associated with the drug effect. These cues elicit conditional compensatory responses and modulate the expression of tolerance. Although there are many findings consistent with the conditioning analysis of tolerance, there also are contrary findings. The results of these experiments suggest that some of the apparently contradictory findings result because interoceptive pharmacological cues, as well as exteroceptive environmental cues, are paired with a drug effect. That is, within each administration, early drug-onset cues may become associated with the later, larger drug effect, and these pharmacological cues may overshadow simultaneously present environmental cues. We demonstrate the contribution of such intraadministration associations to tolerance to the analgesic effect of morphine and to the expression of conditional compensatory hyperalgesia.

# Stress & Interoception Disruption

Note: there is an abundance of literature that support connection. Here’s one.

(14)

#### Santamaría-García, H., et al. (2024). "Allostatic Interoceptive Overload Across Psychiatric and Neurological Conditions." Biol Psychiatry.

Emerging theories emphasize the crucial role of allostasis (anticipatory and adaptive regulation of the body's biological processes) and interoception (integration, anticipation, and regulation of internal bodily states) in adjusting physiological responses to environmental and bodily demands. In this review, we explore the disruptions in integrated allostatic interoceptive mechanisms in psychiatric and neurological disorders, including anxiety, depression, Alzheimer's disease, and frontotemporal dementia. We assess the biological mechanisms associated with allostatic interoception, including whole-body cascades, brain structure and function of the allostatic interoceptive network, heart-brain interactions, respiratory-brain interactions, the gut-brain-microbiota axis, peripheral biological processes (inflammatory, immune), and epigenetic pathways. These processes span psychiatric and neurological conditions and call for developing dimensional and transnosological frameworks. We synthesize new pathways to understand how allostatic interoceptive processes modulate interactions between environmental demands and biological functions in brain disorders. We discuss current limitations of the framework and future transdisciplinary developments. This review opens a new research agenda for understanding how allostatic interoception involves brain predictive coding in psychiatry and neurology, allowing for better clinical application and the development of new therapeutic interventions.

# Interoception in BED

## General

(2-4, 15)

#### Wiss, D. and N. Avena (2020). Food Addiction, Binge Eating, and the Role of Dietary Restraint: Converging Evidence from Animal and Human Studies. Binge Eating. G. K. Frank and L. A. Berner, Springer Nature Switzerland AG: 193-209.

With emerging evidence of a biological basis to binge eating, questions about the role of food addiction (FA) have stimulated scholarly debate. A major criticism of the FA construct is its failure to account for dietary restraint and weight suppression, known contributors to binge eating. In this chapter, we examine animal and human models of addiction-like eating in the context of binge eating. Overlapping mechanisms such as reward dysfunction, craving, impulsivity, and attentional bias from animal and human studies are discussed. Directionality of the binge eating cascade is explored across different theoretical models with empirical support for multiple pathways. We offer a “Diet Drives the Binge” theory of food addiction, and a “Food Environment Drives Addiction” theory of binge eating. While FA research highlights the neurobiological vulnerability of certain people, there is less consensus about effective interventions at the individual level. We discuss current controversies surrounding FA and important findings that may have public health implications.

#### van Dyck, Z., et al. (2020). "Gastric interoception and gastric myoelectrical activity in bulimia nervosa and binge-eating disorder." Int J Eat Disord.

OBJECTIVE: Identifying factors that control food intake is crucial to the understanding and treatment of eating disorders characterized by binge eating. In healthy individuals, stomach distension plays an important role in the development of satiation, but gastric sensations might be overridden in binge eating. The present study investigated the perception of gastric signals (i.e., gastric interoception) and gastric motility in patients experiencing binge-eating episodes, that is, bulimia nervosa (BN) and binge-eating disorder (BED). METHOD: Twenty-nine patients with BN or BED (ED group) and 32 age-, sex-, and BMI-matched healthy controls (HC group) participated in the study. The onset of satiation and stomach fullness were assessed using a novel 2-step water load test (WLT-II). Gastric myoelectrical activity (GMA) was measured by electrogastrography (EGG) before and after ingestion of noncaloric water. RESULTS: Individuals in the ED group drank significantly more water until reporting satiation during the WLT-II. The percentage of normal gastric myoelectrical power was significantly smaller in the ED group compared to HC, and negatively related to the number of objective binge-eating episodes per week in patients with BN or BED. Power in the bradygastria range was greater in ED than in HC participants. DISCUSSION: Patients with EDs have a delayed response to satiation compared to HC participants, together with abnormal GMA. Repeated binge-eating episodes may induce disturbances to gastric motor function.

#### Romano, K. A., et al. (2020). "Somatic symptoms and binge eating in women's daily lives." J Psychosom Res 135: 110161.

OBJECTIVE: The present study aimed to determine whether the momentary severity of women's somatic symptoms was concurrently and prospectively associated with their engagement in binge eating in naturalistic settings. METHOD: Thirty women (M(age) = 34.13, SD = 13.92) who had engaged in binge eating at least once over the month prior to study entry completed a 14-day ecological momentary assessment (EMA) protocol. During each of the 14 days, participants received five semi-random surveys via text message that assessed momentary somatic symptom severity (i.e., headaches, stomachaches/pain, chest/heart pain, faintness/dizziness, shortness of breath, fatigue) and disordered eating behaviors. Generalized estimating equations were used to determine whether momentary somatic symptoms were concurrently and prospectively (i.e., by participants' next assessment) associated with the occurrence of binge eating behavior, while controlling for age and body mass index. RESULTS: At the within-person level, more severe stomachaches/pain, faintness/dizziness, shortness of breath, and fatigue were concurrently associated with an increased likelihood of engaging in binge eating. Further, at the between-person level, more severe stomachaches/pain, chest/heart pain, shortness of breath, and fatigue in general were associated with binge eating across the EMA protocol. Momentary stomachache/pain severity also prospectively predicted women's engagement in binge eating behavior at the next assessment. CONCLUSIONS: The present results provide initial evidence that multiple somatic symptoms may serve as momentary correlates or proximal antecedents of binge eating behavior in women's daily lives. Somatic symptoms may consequently prove useful to target in eating disorder treatments, perhaps via interoceptive exposure interventions.

#### Martin, E., et al. (2019). "Interoception and disordered eating: A systematic review." Neurosci Biobehav Rev 107: 166-191.

Deficits in interoception have been associated with disordered eating but there has been no systematic review of whether the interoceptive deficits are observed across all types of disordered eating and across interoceptive modalities. There has also been no evaluation of whether deficits in interoception play a causal role in the development of disordered eating. Nor has there been a review of the moderating/mediating factors of the relationship between interoception and disordered eating. To address these gaps we conducted a systematic review using PRISMA guidelines. 104 studies with 32883 participants were included. Deficits in interoception were observed across disordered eating types and interoceptive modalities suggesting that interoception may constitute a transdiagnostic feature of disordered eating. There is currently limited evidence on the causal role of interoception in the development of disordered eating and no studies have formally analysed the moderators/mediators. Future mechanistic research examining particular dimensions of interoception will provide insights into the specific interoceptive deficits associated with disordered eating and could lead to the development of improved therapies.

## Nadershahi, Bray

(4, 6, 16-21)

#### Martin, E., et al. (2019). "Interoception and disordered eating: A systematic review." Neurosci Biobehav Rev 107: 166-191.

Deficits in interoception have been associated with disordered eating but there has been no systematic review of whether the interoceptive deficits are observed across all types of disordered eating and across interoceptive modalities. There has also been no evaluation of whether deficits in interoception play a causal role in the development of disordered eating. Nor has there been a review of the moderating/mediating factors of the relationship between interoception and disordered eating. To address these gaps we conducted a systematic review using PRISMA guidelines. 104 studies with 32883 participants were included. Deficits in interoception were observed across disordered eating types and interoceptive modalities suggesting that interoception may constitute a transdiagnostic feature of disordered eating. There is currently limited evidence on the causal role of interoception in the development of disordered eating and no studies have formally analysed the moderators/mediators. Future mechanistic research examining particular dimensions of interoception will provide insights into the specific interoceptive deficits associated with disordered eating and could lead to the development of improved therapies.

#### Khalsa, S. S., et al. (2018). "Interoception and Mental Health: A Roadmap." Biological Psychiatry: Cognitive Neuroscience and Neuroimaging 3(6): 501-513.

Interoception refers to the process by which the nervous system senses, interprets, and integrates signals originating from within the body, providing a moment-by-moment mapping of the body’s internal landscape across conscious and unconscious levels. Interoceptive signaling has been considered a component process of reflexes, urges, feelings, drives, adaptive responses, and cognitive and emotional experiences, highlighting its contributions to the maintenance of homeostatic functioning, body regulation, and survival. Dysfunction of interoception is increasingly recognized as an important component of different mental health conditions, including anxiety disorders, mood disorders, eating disorders, addictive disorders, and somatic symptom disorders. However, a number of conceptual and methodological challenges have made it difficult for interoceptive constructs to be broadly applied in mental health research and treatment settings. In November 2016, the Laureate Institute for Brain Research organized the first Interoception Summit, a gathering of interoception experts from around the world, with the goal of accelerating progress in understanding the role of interoception in mental health. The discussions at the meeting were organized around four themes: interoceptive assessment, interoceptive integration, interoceptive psychopathology, and the generation of a roadmap that could serve as a guide for future endeavors. This review article presents an overview of the emerging consensus generated by the meeting.

#### Jenkinson, P. M., et al. (2018). "Self-reported interoceptive deficits in eating disorders: A meta-analysis of studies using the eating disorder inventory." J Psychosom Res 110: 38-45.

OBJECTIVE: An impairment of the ability to sense the physiological condition of the body - interoception - has long been proposed as central to the onset and maintenance of eating disorders. More recent attention to this topic has generally indicated the presence of interoceptive deficits in individuals with an eating disorder diagnosis; however, possible links with specific diagnosis, BMI, age, illness duration, depression, and alexithymia remain unclear from individual studies. This meta-analysis aimed to provide a necessary quantitative overview of self-reported interoceptive deficits in eating disorder populations, and the relationship between these deficits and the previously mentioned factors. METHODS: Using a random effects model, our meta-analysis assessed the magnitude of differences in interoceptive abilities as measured using the Eating Disorder Inventory in 41 samples comparing people with eating disorders (n = 4308) and healthy controls (n = 3459). Follow-up and moderator analysis was conducted, using group comparisons and meta-regressions. RESULTS: We report a large pooled effect size of 1.62 for eating disorders with some variation between diagnostic groups. Further moderator analysis showed that BMI, age and alexithymia were significant predictors of overall effect size. CONCLUSION: This meta-analysis is the first to confirm that large interoceptive deficits occur in a variety of eating disorders and crucially, in those who have recovered. These deficits may be useful in identifying and distinguishing eating disorders. Future research needs to consider both objective and subjective measures of interoception across different types of eating disorders and may fruitfully examine interoception as a possible endophenotype and target for treatment.

#### Aloi, M., et al. (2017). "Social Cognition and Emotional Functioning in Patients with Binge Eating Disorder." Eur Eat Disord Rev 25(3): 172-178.

OBJECTIVE: This study aims to evaluate the theory of mind ability in a sample of obese patients with and without binge eating disorder (BED) and to explore the correlations between emotional and clinical assessments. METHODS: Overall, 20 non-BED, 16 under-threshold BED and 22 BED obese patients completed a battery of tests assessing social cognition and eating disorder psychopathology. RESULTS: Binge eating disorder, non-BED and under-threshold-BED obese patients showed similar ability to recognise others' emotions, but BED obese patients exhibited a deficit in recognising their own emotions as demonstrated by more impaired levels of alexithymia and interoceptive awareness and were more depressed. High positive correlations were evident between binging, depression, interoceptive awareness and alexithymia. CONCLUSIONS: Binge eating disorder patients have a comparable ability to understand others' emotions but a more impaired capacity to understand and code their own emotions compared with non-BED obese patients. This impairment is highly correlated with depression. Copyright © 2017 John Wiley & Sons, Ltd and Eating Disorders Association.

#### Vinai, P., et al. (2015). "Psychopathological characteristics of patients seeking for bariatric surgery, either affected or not by binge eating disorder following the criteria of the DSM IV TR and of the DSM 5." Eat Behav 16: 1-4.

We evaluate whether there are any significant differences in psychopathology between severe obese patients affected by Binge Eating Disorder diagnosed following both the DSM IV TR and the DSM5 criteria, and severe obese patients not having an eating disorder. METHOD: 118 severe obese patients seeking treatment at a center for bariatric surgery in northern Italy were asked to take part in the current study for a period of six months. Average participant age was 44.27 years, SD 12.42. Age ranged from 18 to 67 years. Average patient BMI was 45.03, SD 7.11, ranging from 32.14 to 66.16 kg/m(2). Seventy seven of the patients (65.3%) were females and 41 (34.7%) were males. BED diagnosis was determined following the diagnostic criteria of both the DSM IV TR and the DSM 5. The presence of other eating disorders was excluded through a clinical screening using the Eating Disorder Inventory (EDI). Patient eating habits and the presence of emotional eating were appraised using the Three-Factor Eating Questionnaire. Levels of depression and anxiety were evaluated using the Beck Depression Inventory and the State Trait Anxiety Inventory. RESULTS: 57 out of 118 patients were found to be affected by BED following the DSM 5 criteria; among them 24 followed those of the DSM IV TR. BED patients scored higher on four subscales of the Eating Disorders Inventory: Drive for thinness (DT), Bulimia (B), Body dissatisfaction (BD) and Interoceptive awareness (IA) on the STAI and on the Disinhibition and Hunger subscales of the TFEQ. DISCUSSION: The results confirm the presence of high levels of psychopathology among patients diagnosed with BED, even if they have been diagnosed following the criteria of the DSM 5. There is a great overlap in psychopathology between BED patients diagnosed following the DSM IV TR and the DSM 5 criteria.

#### Ramacciotti, C. E., et al. (2008). "Shared psychopathology in obese subjects with and without binge-eating disorder." Int J Eat Disord 41(7): 643-649.

OBJECTIVE: To investigate obese people with/without binge-eating Disorder (BED) in terms of shared psychopathological features pertaining to spectrum of eating disorders. METHOD: One-hundred obese adult patients with a BMI > 30 kg/m(2) referred to an Eating Disorder Unit and/or hospital weight-loss programs were administered the BED Clinical Interview, the Eating Disorder Inventory, and the Structured Clinical Interview for Anorexic-Bulimic Spectrum, Self-Report. RESULTS: Twenty-seven subjects satisfied DSM-IV research criteria for current BED; compared to nonbingeing obese subjects, BED ones were characterized by greater weight-shape concerns influencing self-esteem (p = .05), overall impairment due to the overweight condition (p < .005), psychological distress leading to professional help (p < .001), dichotomous reasoning (p = .01) and secondary social phobia due to the overweight condition (p < .005). Compared to the other group, BED obese subjects scored higher at the following EDI subscales: bulimia (p < .0001), ineffectiveness (p < .01), interoceptive awareness and social insecurity (p < .05). CONCLUSION: The results of this study highlight the role of cognitive mechanisms such as dichotomous reasoning and weight-shape concerns unduly influencing self-esteem as a hallmark of BED in obese patients, and the importance of investigating eating disorder psychopathology by adopting a dimensional perspective, rather than strictly focusing on categories when dealing with obese patients.

#### Raymond, N. C., et al. (1995). "Pain thresholds in obese binge-eating disorder subjects." Biol Psychiatry 37(3): 202-204.

#### de Zwaan, M., et al. (1994). "Eating related and general psychopathology in obese females with binge eating disorder." Int J Eat Disord 15(1): 43-52.

One hundred obese women with a mean age of 39.2 years, and a mean body mass index (BMI) of 35.9 kg/m2 were evaluated before entering a treatment study for weight reduction. According to the results of a structured interview, subjects were divided into four groups: (1) no overeating episodes, (2) episodic overeating episodes without the feeling of loss of control, (3) overeating plus the sense of loss of control (binge eating), and (4) full diagnostic criteria for binge eating disorder (BED). One-way analyses of variance (ANOVAs) revealed significant positive associations between binge eating and eating/weight-related characteristics such as a history of frequent weight fluctuations, the amount of time spent dieting, drive for thinness, and a tendency for disinhibition of eating. Furthermore, subjects exhibited more feelings of ineffectiveness, stronger perfectionistic attitudes, more impulsivity, less self-esteem, and less interoceptive awareness the more problems with binge eating they reported. The results support the idea that binge eaters might be a distinct subgroup among the obese population, and corroborate the utility of a diagnosis of BED in identifying the most disturbed obese subjects with regard to the variables tested.

## Martin (not active clinical trial)

(22, 23)

#### Lattimore, P., et al. (2017). "‘I can’t accept that feeling’: Relationships between interoceptive awareness, mindfulness and eating disorder symptoms in females with, and at-risk of an eating disorder." Psychiatry Res 247: 163-171.

#### Fitzgibbon, M. L., et al. (2003). "A test of the continuity perspective across bulimic and binge eating pathology." International Journal of Eating Disorders 34(1): 83-97.

## No Control

(24, 25)

#### Lammers, M. W., et al. (2015). "Predictors of outcome for cognitive behaviour therapy in binge eating disorder." European Eating Disorders Review 23(3): 219-228.

#### Fassino, S., et al. (2004). "Clinical, psychopathological and personality correlates of interoceptive awareness in anorexia nervosa, bulimia nervosa and obesity." Psychopathology 37(4): 168-174.

# Interoception in Other Eating Disorders

## “Mixed EDs” (which can include BED)

(26)

#### Dancyger, I. F. and P. Garfinkel (1995). "The relationship of partial syndrome eating disorders to anorexia nervosa and bulimia nervosa1." Psychol Med 25(5): 1019-1025.

## “EDNOS” (“Eating Disorder Not Otherwise Specified,” which included BED before publication of the DSM-V in 2013).

(27-29)

#### Nyman-Carlsson, E., et al. (2015). "Eating Disorder Inventory-3, validation in Swedish patients with eating disorders, psychiatric outpatients and a normal control sample." Nordic Journal of Psychiatry 69(2): 142-151.

#### Herraiz-Serrrano, C., et al. (2015). "Parental rearing and eating psychopathology." Actas Esp Psiquiatr 43(3): 91-98.

#### Nevonen, L., et al. (2006). "Validating the EDI-2 in three Swedish female samples: eating disorders patients, psychiatric outpatients and normal controls." Nordic Journal of Psychiatry 60(1): 44-50.

# Autism in BED

(30-36)

#### Pruccoli, J., et al. (2023). "Food and Development: Children and Adolescents with Neurodevelopmental and Comorbid Eating Disorders-A Case Series." Behav Sci (Basel) 13(6).

The impact of psychiatric comorbidities in the diagnosis and treatment of feeding and eating disorders (FEDs) represents an emerging research topic. The current literature, nonetheless, lacks studies investigating the developmental paths of individuals with FEDs and comorbid neurodevelopmental disorders (NDDs). Here, we report 11 cases of children and adolescents with comorbid FEDs and NDDs, as assessed along the neuropsychological, psychopathological, and nutritional developmental pathways. The onset of FED-related psychopathology was preceded, sometimes undiagnosed, by altered neurodevelopmental features leading to specific NDD diagnoses (autism spectrum disorder-ASD; attention-deficit/hyperactivity disorder-ADHD; specific learning disorder-SLD). NDDs appeared to influence the diagnoses and treatments of FEDs, frequently with an impact on socio-relational and emotional premorbid features, and on the possibility to receive and attend FED-targeted treatments. Further studies should longitudinally contribute to assessing the experiences of care and neurodevelopmental pathways of children with FEDs and specific NDD comorbidities.

#### Price, D. (2022). Unmasking Autism: Discovering the New Faces of Neurodiversity. NY, Harmony Books.

For every visibly Autistic person you meet, there are countless “masked” Autistic people who pass as neurotypical. Masking is a common coping mechanism in which Autistic people hide their identifiably Autistic traits in order to fit in with societal norms, adopting a superficial personality at the expense of their mental health. This can include suppressing harmless stims, papering over communication challenges by presenting as unassuming and mild-mannered, and forcing themselves into situations that cause severe anxiety, all so they aren’t seen as needy or “odd.”

In Unmasking Autism, Dr. Devon Price shares his personal experience with masking and blends history, social science research, prescriptions, and personal profiles to tell a story of neurodivergence that has thus far been dominated by those on the outside looking in. For Dr. Price and many others, Autism is a deep source of uniqueness and beauty. Unfortunately, living in a neurotypical world means it can also be a source of incredible alienation and pain. Most masked Autistic individuals struggle for decades before discovering who they truly are. They are also more likely to be marginalized in terms of race, gender, sexual orientation, class, and other factors, which contributes to their suffering and invisibility. Dr. Price lays the groundwork for unmasking and offers exercises that encourage self-expression, including:

• Celebrating special interests

• Cultivating Autistic relationships

• Reframing Autistic stereotypes

• And rediscovering your values

It’s time to honor the needs, diversity, and unique strengths of Autistic people so that they no longer have to mask—and it’s time for greater public acceptance and accommodation of difference. In embracing neurodiversity, we can all reap the rewards of nonconformity and learn to live authentically, Autistic and neurotypical people alike.

#### Solmi, F., et al. (2021). "Trajectories of autistic social traits in childhood and adolescence and disordered eating behaviours at age 14 years: A UK general population cohort study." J Child Psychol Psychiatry 62(1): 75-85.

BACKGROUND: Some people with eating disorders have difficulties with social communication. However, no longitudinal evidence regarding the direction of this association exists. We investigated trajectories of autistic social traits across childhood and adolescence in adolescents with and without disordered eating behaviours in early adolescence. METHODS: We used data from the Avon Longitudinal Study of Parents and Children. Our disordered eating measure indicated presence of any, monthly and weekly disordered eating (fasting, purging, dieting, binge eating) at age 14 years. Autistic social traits were reported by mothers using the Social and Communication Disorders Checklist (SCDC) at age seven, 11, 14 and 16 years. We modelled SCDC score trajectories using multilevel negative binomial models adjusting for a number of child- and maternal-level confounders. RESULTS: Of the 5,381 adolescents included in our sample, 421 (7.8%) experienced one or more disordered eating behaviours, and 148 (2.8%) weekly episodes. Adolescents with disordered eating had a 20% increase in SCDC scores (relative risk (RR) 1.23, 95% confidence interval (CI):1.14, 1.32) compared to those without disordered eating. This association was particularly apparent for those reporting weekly (RR 1.43, 95%CI: 1.27, 1.61) as opposed to monthly disordered eating (RR 1.12, 95%CI: 1.01, 1.22). CONCLUSIONS: Greater autistic social traits in childhood could represent a risk factor for the development of disordered eating in adolescence. Although mechanisms of this association need to be elucidated, clinicians should be aware that autistic social traits could have predated the eating disorder when managing people with these conditions.

#### Björk, A., et al. (2021). "High prevalence of neurodevelopmental problems in adolescents eligible for bariatric surgery for severe obesity." Acta Paediatr 110(5): 1534-1540.

AIM: To assess the prevalence of neurodevelopmental problems in adolescents with severe obesity and their associations with binge eating and depression. METHODS: Data were collected at inclusion in a randomised study of bariatric surgery in 48 adolescents (73% girls; mean age 15.7 ± 1.0 years; mean body mass index 42.6 ± 5.2 kg/m(2) ). Parents completed questionnaires assessing their adolescents' symptoms of attention-deficit/hyperactivity disorder and autism spectrum disorder and reported earlier diagnoses. Patients answered self-report questionnaires on binge eating and depressive symptoms. RESULTS: The parents of 26/48 adolescents (54%) reported scores above cut-off for symptoms of the targeted disorders in their adolescents, but only 15% reported a diagnosis, 32% of adolescents reported binge eating, and 20% reported symptoms of clinical depression. No significant associations were found between neurodevelopmental problems and binge eating or depressive symptoms. Only a third of the adolescents reported no problems in either area. CONCLUSION: Two thirds of adolescents seeking surgical weight loss presented with substantial mental health problems (reported by themselves or their parents). This illustrates the importance of a multi-professional approach and the need to screen for and treat mental health disorders in adolescents with obesity.

#### Nickel, K., et al. (2019). "Systematic Review: Overlap Between Eating, Autism Spectrum, and Attention-Deficit/Hyperactivity Disorder." Front Psychiatry 10: 708.

Background: Links between eating disorders (EDs) [e.g., anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED)] and the major neurodevelopmental disorders of autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD) have been repeatedly highlighted. In both ASD and ADHD, these links range from an elevated risk for EDs to common symptomatic overlaps and etiological commonalities with EDs. Methods: We performed a systematic literature search (through July 2019) with Medline via Ovid for epidemiological data on EDs (AN, BN, and BED) in combination with both ASD and ADHD. Results: The reviewed studies showed that, on average, 4.7% of patients with certain ED diagnoses (AN, BN, or BED) received an ASD diagnosis. Reliable data on the prevalence of EDs in ASD samples are still scarce. Comorbid ASD is most commonly diagnosed in patients with AN. The prevalence of ADHD in EDs ranged between 1.6% and 18%. Comorbid ADHD was more often reported in the AN-binge eating/purging subtype and BN than in the AN restrictive subtype. The prevalence of EDs in ADHD ranged between no association and a lifetime prevalence of 21.8% of developing an ED in women with ADHD. Conclusions: Studies on the prevalence rates of EDs in ADHD and ASD and vice versa are heterogeneous, but they indicate frequent association. While there is growing evidence of clinical overlaps between the three disorders, it remains difficult to determine whether overlapping characteristics (e.g., social withdrawal) are due to common comorbidities (e.g., depression) or are instead primarily associated with EDs and neurodevelopmental disorders. Furthermore, prospective studies are required to better understand how these disorders are related and whether ADHD and ASD could be either specific or nonspecific predisposing factors for the development of EDs.

#### Dell'Osso, L., et al. (2019). "Autistic Traits and Illness Trajectories." Clin Pract Epidemiol Ment Health 15: 94-98.

In the framework of increasing attention towards autism-related conditions, a growing number of studies have recently investigated the prevalence and features of sub-threshold Autistic Traits (ATs) among adults. ATs span across the general population, being more pronounced in several clinical groups of patients affected by psychiatric disorders. Moreover, ATs seem to be associated with specific personality features in non-clinical population, implying both a higher vulnerability towards psychopathology and extraordinary talents in specific fields. In this framework, the DSM-5's Autism Spectrum Disorder (ASD) presentations may be considered as the tip of an iceberg that features several possible clinical and non-clinical phenotypes. Globally, the autism spectrum may be considered as a trans-nosographic dimension, which may not only represent the starting point for the development of different psychopathological trajectories but also underlie non-psychopathological personality traits. These different trajectories might be shaped by the specific localization and severity of the neurodevelopmental alteration and by its interaction with the environment and lifetime events. In this wider framework, autistic-like neurodevelopmental alterations may be considered as a general vulnerability factor for different kinds of psychiatric disorders, but also the neurobiological basis for the development of extraordinary abilities, eventually underlying the concept of geniality. Moreover, according to recent literature, we hypothesize that ATs may also be involved in the functioning of human mind, featuring the peculiar sense of "otherness" which can be found, with different grades of intensity, in every human being.

#### Nazar, B. P., et al. (2016). "ADHD Rate in Obese Women With Binge Eating and Bulimic Behaviors From a Weight-Loss Clinic." Journal of Attention Disorders 20(7): 610-616.

Objective: Few studies have demonstrated a possible association between ADHD and obesity in adults. The aim of this study was to investigate the prevalence of ADHD in a sample of obese women seeking treatment, and its relations with binge eating and bulimic behaviors. Method: We performed a cross-sectional study in a clinical sample of one hundred fifty-five women, with a mean age of 38.9 (+10.7) years and a mean body mass index (BMI) of 39.2 (+5.29). Participants were evaluated with semistructured interviews and completed self-report psychiatric rating scales. Results: The rate of ADHD in the sample was of 28.3%. The presence of ADHD was significantly correlated with more severe binge eating, bulimic behaviors, and depressive symptomatology. Conclusion: Similar to previous studies, a higher than expected rate of ADHD was observed among obese women. ADHD in obese individuals may be a risk factor for greater severity of disordered eating patterns.

# References

1. Weng HY, Lewis-Peacock JA, Hecht FM, Uncapher MR, Ziegler DA, Farb NAS, et al. Focus on the Breath: Brain Decoding Reveals Internal States of Attention During Meditation. *Frontiers in human neuroscience* (2020) 14:336. Epub 2020/10/03. doi: 10.3389/fnhum.2020.00336.

2. van Dyck Z, Schulz A, Blechert J, Herbert BM, Lutz APC, Vögele C. Gastric Interoception and Gastric Myoelectrical Activity in Bulimia Nervosa and Binge-Eating Disorder. *The International journal of eating disorders* (2020). Epub 2020/05/14. doi: 10.1002/eat.23291.

3. Romano KA, Heron KE, Smith KE, Crosby RD, Engel SG, Wonderlich SA, et al. Somatic Symptoms and Binge Eating in Women's Daily Lives. *Journal of psychosomatic research* (2020) 135:110161. Epub 2020/06/07. doi: 10.1016/j.jpsychores.2020.110161.

4. Martin E, Dourish CT, Rotshtein P, Spetter MS, Higgs S. Interoception and Disordered Eating: A Systematic Review. *Neuroscience and biobehavioral reviews* (2019) 107:166-91. Epub 2019/08/28. doi: 10.1016/j.neubiorev.2019.08.020.

5. Frank GKW, Shott ME, DeGuzman MC. The Neurobiology of Eating Disorders. *Child Adolesc Psychiatr Clin N Am* (2019) 28(4):629-40. Epub 2019/08/25. doi: 10.1016/j.chc.2019.05.007.

6. Khalsa SS, Adolphs R, Cameron OG, Critchley HD, Davenport PW, Feinstein JS, et al. Interoception and Mental Health: A Roadmap. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging* (2018) 3(6):501-13. doi: <https://doi.org/10.1016/j.bpsc.2017.12.004>.

7. Kumar S, Tansley-Hancock O, Sedley W, Winston JS, Callaghan MF, Allen M, et al. The Brain Basis for Misophonia. *Current biology : CB* (2017) 27(4):527-33. doi: 10.1016/j.cub.2016.12.048.

8. Brewer R, Cook R, Bird G. Alexithymia: A General Deficit of Interoception. *R Soc Open Sci* (2016) 3(10):150664. Epub 2016/11/18. doi: 10.1098/rsos.150664.

9. Frank GK. Advances from Neuroimaging Studies in Eating Disorders. *CNS spectrums* (2015) 20(4):391-400. Epub 2015/04/24. doi: 10.1017/s1092852915000012.

10. Wolk J, Sutterlin S, Koch S, Vogele C, Schulz SM. Enhanced Cardiac Perception Predicts Impaired Performance in the Iowa Gambling Task in Patients with Panic Disorder. *Brain and behavior* (2014) 4(2):238-46. Epub 2014/04/01. doi: 10.1002/brb3.206.

11. Napadow V, Li A, Loggia ML, Kim J, Schalock PC, Lerner E, et al. The Brain Circuitry Mediating Antipruritic Effects of Acupuncture. *Cerebral cortex (New York, NY : 1991)* (2014) 24(4):873-82. Epub 2012/12/12. doi: 10.1093/cercor/bhs363.

12. Dunn BD, Galton HC, Morgan R, Evans D, Oliver C, Meyer M, et al. Listening to Your Heart. How Interoception Shapes Emotion Experience and Intuitive Decision Making. *Psychological science* (2010) 21(12):1835-44. Epub 2010/11/26. doi: 10.1177/0956797610389191.

13. Kim JA, Siegel S, Patenall VR. Drug-Onset Cues as Signals: Intraadministration Associations and Tolerance. *Journal of experimental psychology Animal behavior processes* (1999) 25(4):491-504. Epub 1999/10/26.

14. Santamaría-García H, Migeot J, Medel V, Hazelton JL, Teckentrup V, Romero-Ortuno R, et al. Allostatic Interoceptive Overload across Psychiatric and Neurological Conditions. *Biological psychiatry* (2024). Epub 2024/07/05. doi: 10.1016/j.biopsych.2024.06.024.

15. Wiss D, Avena N. Food Addiction, Binge Eating, and the Role of Dietary Restraint: Converging Evidence from Animal and Human Studies. In: Frank GK, Berner LA, editors. *Binge Eating*. Springer Nature Switzerland AG (2020). p. 193-209.

16. Jenkinson PM, Taylor L, Laws KR. Self-Reported Interoceptive Deficits in Eating Disorders: A Meta-Analysis of Studies Using the Eating Disorder Inventory. *Journal of psychosomatic research* (2018) 110:38-45. Epub 2018/05/17. doi: 10.1016/j.jpsychores.2018.04.005.

17. Aloi M, Rania M, Caroleo M, De Fazio P, Segura-García C. Social Cognition and Emotional Functioning in Patients with Binge Eating Disorder. *European eating disorders review : the journal of the Eating Disorders Association* (2017) 25(3):172-8. Epub 2017/02/18. doi: 10.1002/erv.2504.

18. Vinai P, Da Ros A, Speciale M, Gentile N, Tagliabue A, Vinai P, et al. Psychopathological Characteristics of Patients Seeking for Bariatric Surgery, Either Affected or Not by Binge Eating Disorder Following the Criteria of the Dsm Iv Tr and of the Dsm 5. *Eating behaviors* (2015) 16:1-4. Epub 2014/12/03. doi: 10.1016/j.eatbeh.2014.10.004.

19. Ramacciotti CE, Coli E, Bondi E, Burgalassi A, Massimetti G, Dell'osso L. Shared Psychopathology in Obese Subjects with and without Binge-Eating Disorder. *The International journal of eating disorders* (2008) 41(7):643-9. Epub 2008/06/06. doi: 10.1002/eat.20544.

20. Raymond NC, de Zwaan M, Faris PL, Nugent SM, Achard DM, Crosby RD, et al. Pain Thresholds in Obese Binge-Eating Disorder Subjects. *Biological psychiatry* (1995) 37(3):202-4. Epub 1995/02/01. doi: 10.1016/0006-3223(94)00244-w.

21. de Zwaan M, Mitchell JE, Seim HC, Specker SM, Pyle RL, Raymond NC, et al. Eating Related and General Psychopathology in Obese Females with Binge Eating Disorder. *The International journal of eating disorders* (1994) 15(1):43-52. Epub 1994/01/01. doi: 10.1002/1098-108x(199401)15:1<43::aid-eat2260150106>3.0.co;2-6.

22. Lattimore P, Mead BR, Irwin L, Grice L, Carson R, Malinowski P. ‘I Can’t Accept That Feeling’: Relationships between Interoceptive Awareness, Mindfulness and Eating Disorder Symptoms in Females with, and at-Risk of an Eating Disorder. *Psychiatry research* (2017) 247:163-71.

23. Fitzgibbon ML, Sánchez‐Johnsen LA, Martinovich Z. A Test of the Continuity Perspective across Bulimic and Binge Eating Pathology. *International Journal of Eating Disorders* (2003) 34(1):83-97.

24. Lammers MW, Vroling MS, Ouwens MA, Engels RC, van Strien T. Predictors of Outcome for Cognitive Behaviour Therapy in Binge Eating Disorder. *European Eating Disorders Review* (2015) 23(3):219-28.

25. Fassino S, Pierò A, Gramaglia C, Abbate-Daga G. Clinical, Psychopathological and Personality Correlates of Interoceptive Awareness in Anorexia Nervosa, Bulimia Nervosa and Obesity. *Psychopathology* (2004) 37(4):168-74.

26. Dancyger IF, Garfinkel P. The Relationship of Partial Syndrome Eating Disorders to Anorexia Nervosa and Bulimia Nervosa1. *Psychological medicine* (1995) 25(5):1019-25.

27. Nyman-Carlsson E, Engström I, Norring C, Nevonen L. Eating Disorder Inventory-3, Validation in Swedish Patients with Eating Disorders, Psychiatric Outpatients and a Normal Control Sample. *Nordic Journal of Psychiatry* (2015) 69(2):142-51.

28. Herraiz-Serrrano C, Rodríguez-Cano T, Beato-Fernández L, Latorre-Postigo JM, Rojo-Moreno L, Vaz-Leal FJ. Parental Rearing and Eating Psychopathology. *Actas espanolas de psiquiatria* (2015) 43(3):91-8.

29. Nevonen L, Clinton D, Norring C. Validating the Edi-2 in Three Swedish Female Samples: Eating Disorders Patients, Psychiatric Outpatients and Normal Controls. *Nordic Journal of Psychiatry* (2006) 60(1):44-50.

30. Nazar BP, de Sousa Pinna CM, Suwwan R, Duchesne M, Freitas SR, Sergeant J, et al. Adhd Rate in Obese Women with Binge Eating and Bulimic Behaviors from a Weight-Loss Clinic. *Journal of Attention Disorders* (2016) 20(7):610-6. doi: 10.1177/1087054712455503.

31. Dell'Osso L, Lorenzi P, Carpita B. Autistic Traits and Illness Trajectories. *Clin Pract Epidemiol Ment Health* (2019) 15:94-8. Epub 2019/12/11. doi: 10.2174/1745017901915010094.

32. Pruccoli J, Guardi G, La Tempa A, Valeriani B, Chiavarino F, Parmeggiani A. Food and Development: Children and Adolescents with Neurodevelopmental and Comorbid Eating Disorders-a Case Series. *Behav Sci (Basel)* (2023) 13(6). Epub 2023/06/27. doi: 10.3390/bs13060499.

33. Björk A, Dahlgren J, Gronowitz E, Henriksson Wessely F, Janson A, Engström M, et al. High Prevalence of Neurodevelopmental Problems in Adolescents Eligible for Bariatric Surgery for Severe Obesity. *Acta Paediatr* (2021) 110(5):1534-40. Epub 2020/12/17. doi: 10.1111/apa.15702.

34. Nickel K, Maier S, Endres D, Joos A, Maier V, Tebartz van Elst L, et al. Systematic Review: Overlap between Eating, Autism Spectrum, and Attention-Deficit/Hyperactivity Disorder. *Frontiers in psychiatry* (2019) 10:708. Epub 2019/10/28. doi: 10.3389/fpsyt.2019.00708.

35. Solmi F, Bentivegna F, Bould H, Mandy W, Kothari R, Rai D, et al. Trajectories of Autistic Social Traits in Childhood and Adolescence and Disordered Eating Behaviours at Age 14 Years: A Uk General Population Cohort Study. *Journal of child psychology and psychiatry, and allied disciplines* (2021) 62(1):75-85. Epub 2020/05/04. doi: 10.1111/jcpp.13255.

36. Price D. *Unmasking Autism: Discovering the New Faces of Neurodiversity*. 1 ed. NY: Harmony Books (2022).