Review

Psikiyatride Güncel Yaklaşımlar-Current Approaches in Psychiatry 2026; 18(1):207-223

doi: 10.18863/pgy.1609278

Polyvagal Theory and Interoception-Based Interventions: Approaches to Strengthen Mental Resilience

Polivagal Teori ve İnterosepsiyon Temelli Müdahaleler: Ruhsal Dayanıklılığı Güçlendirme Yaklaşımları

Merve Umay Candaş Demir[1], Mahmut Can Hasateş[2]

[1]Üsküdar University, Istanbul
[2]Işık University, Istanbul

ABSTRACT

Humans survive by establishing healthy bonds, and these bonds provide emotional regulation, especially in the caregiver-infant relationship. Polyvagal Theory suggests that the autonomic nervous system supports survival by assessing environmental and internal safety signals. Interoception plays a crucial role in this process, referring to the ability to sense the body's internal states. In recent years, interoception-based therapies have proven effective in the treatment of psychopathologies, especially post-traumatic stress disorder. Interoceptive-based interventions, such as trauma-informed yoga, can improve individuals who do not respond to traditional treatment by enhancing emotional regulation and body awareness. The aim of this study is to examine the effects of human-to-human relationships on mental health in the digitalized world, within the framework of Polyvagal Theory. In particular, it emphasizes the important role of interoception in the bond we establish with ourselves and its significance in psychotherapy. The study proposes an approach that supports mental health by discussing the therapeutic effects of interoception and the role of these skills in improving communication between individuals. The study also offers suggestions on how interoception-based interventions can be utilized in clinical practice. Such therapies help individuals form healthier bonds with both themselves and others.

Keywords: Vagus nerve, autonomic nervous system, interoception, body mind therapy, trauma, yoga

ÖZ

İnsanlar, sağlıklı bağlar kurarak hayatta kalmayı sürdürürler ve bu bağlar, özellikle bakım veren-bebek ilişkisinde duygusal düzenleme sağlar. Polivagal Teori, otonom sinir sisteminin çevresel ve içsel güvenlik sinyallerini değerlendirerek hayatta kalmayı desteklediğini öne sürer. Interosepsiyon, bu süreçte önemli bir rol oynar ve bedenin içsel durumlarını hissetme yeteneğini ifade eder. Son yıllarda, beden-zihin terapilerinden olan interosepsiyon temelli müdahalelerin, özellikle travma sonrası stres bozukluğu gibi psikopatolojilerin tedavisinde etkili olduğu bulunmuştur. İnteroseptif temelli müdahalelerden olan Travmaya Duyarlı Yoga gibi yöntemler, duygusal düzenleme ve beden farkındalığını artırarak geleneksel tedaviye yanıt vermeyen bireylerde iyileşme sağlayabilir. Bu çalışmanın amacı, dijitalleşen dünyada insan-insana ilişkinin ruh sağlığı üzerindeki etkilerini, Polivagal Teori çerçevesinde incelemektir. Özellikle, interosepsiyonun, kendimizle kurduğumuz bağdaki rolünün ve psikoterapideki yerinin vurgulanması hedeflenmiştir. Çalışma, interosepsiyonun terapötik etkilerini ve bu becerilerin, bireyler arasındaki iletişim becerilerini geliştirmedeki rolünü tartışarak ruh sağlığını destekleyen bir yaklaşım önerir. Bu çalışma interosepsiyon temelli müdahalelerin klinik uygulamalarda nasıl kullanılabileceğine dair öneriler de sunmaktadır. Bu tür terapiler, bireylerin hem kendileriyle hem de başkalarıyla daha sağlıklı bağlar kurmalarını destekleyecektir.

Anahtar sözcükler: Vagus siniri, otonom sinir sistemi, interosepsiyon, beden-zihin terapisi, travma, yoga

Address for Correspondence: Merve Umay Candaş Demir, Üsküdar University NP Feneryolu Medical Center, Istanbul, Türkiye
e-mail: merveumay.candasdemir@uskudar.edu.tr
Received: 29.12.2024 | **Accepted:** 04.05.2025

Introduction

Humans are born designed to form bonds (Erskine et al. 2022). Moreover, they need to establish secure bonds with others in order to survive (Bowlby 1988). The most basic example of this is the relationship between the caregiver and the baby (Morelen et al. 2016). The infant regulates their emotions, while at the same time the infant regulates the caregiver (Brumariu 2015). This joint regulation process creates mental and physical health in the caregiver-infant dyad based on reciprocity, connection, and trust (Porges 2023). The pathway we use to reach secure attachment and protect both our mental and physical health passes through our autonomic nervous system (Dana 2021).

Polyvagal Theory (PVT) sheds light on the mind-body relationship (Porges 2009). According to this theory, the sympathetic and parasympathetic systems within our autonomic nervous system support survival by capturing cues from the environment and internal organs about whether a sensation is safe or threatening (Porges 2004). PVT, based on the homeostatic balance between sympathetic and parasympathetic systems, also suggests new approaches to the treatment of depression, anxiety, and post-traumatic stress disorder (PTSD) (Neuhuber & Berthoud 2022).

At this point, the most important concept that provides homeostatic balance is interoception (Sennesh et al. 2022). Although interoception has been prominent in the literature since the early 2000s, it is a concept that is defined at a transdiagnostic point in terms of the physical and mental health of the individual and is much needed to be investigated in relation to its place in psychopathologies (Ceunen et al. 2016). It is seen that Interoception-Based Interventions under Body-Mind therapies have recently expanded toward auxiliary body-based techniques such as Trauma Sensitive Yoga and aerobics (Mehling et al. 2018, Putica et al. 2024). Yoga is an interoceptive method that aims to develop body awareness.

The primary aim of this study is to examine the impact of human-to-human relationships and bonding on mental health in the context of a digitalized world shaped by technological advancements, particularly artificial intelligence, within the framework of PVT (Porges 2011). In parallel, it seeks to highlight the significance of interoception in psychotherapy, which is regarded as an integral component of the bonds that individuals form with themselves and others (Craig 2002). Accordingly, the study's contribution to the literature lies in its discussion of the concept of interoception through the lens of PVT. Furthermore, it aims to elucidate the role that communication skills with others play in preventive mental health services and the treatment of psychiatric disorders (Mehling et al. 2009, Khalsa et al. 2018). In this way, it is anticipated to inform the design of future research in this domain. Additionally, the article plans to explore the effects of Trauma-Sensitive Yoga practices on various psychopathologies and the role of interoception-based interventions in clinical practice.

Polyvagal Theory

The theory focuses on the transition from reptiles to mammals as a starting point (Porges 2021a). Our autonomic nervous system (ANS) works like a risk assessment machine. The brainstem is the first to respond to safety and danger cues. Brainstem structures control sucking, swallowing, breathing, and vocalization circuits, which are early developmental survival reflexes. As these pathways mature, the social interaction system that supports homeostasis is formed (Porges 2021b). Primarily, in order to survive, the infant needs to effectively regulate sucking-swallowing-breathing-vocalization. For example, it has been observed that premature babies born with an immature ventral vagus nerve have the potential for tachycardia (increased heart rate) or bradycardia (a sudden and large decrease in heart rate) (Reed et al. 1999). This is mainly because the premature infant, born with a reptilian rather than a mammalian autonomic nervous system without a functional ventral vagus, is more prone to respond via the dorsal vagal pathway. For reptiles, which do not need oxygen as much as mammals, this response corresponds to the freezing response, which promotes survival in the face of predators. However, for the newborn, which requires oxygen, this response carries the potential for death (Porges 2009). PVT calls this the "vagal paradox."

In this framework, studies focusing on the causes of neonatal heart rate and new mortality have revealed that during the transition from reptiles to mammals, mammals developed a functional diaphragm and a cardioinhibitory vagal pathway starting from the nucleus ambiguus (Porges 2009). Indeed, this vagal pathway provides the dynamics of respiratory sinus arrhythmia and is recognized by PVT as an indicator of good health (Porges 2011).

Based on this information, it is emphasized that the brainstem regulates via the evolutionarily older dorsal vagus pathway and the newer modern ventral vagus pathway in mammals (Porges 2011, Porges 2021a). The ventral vagal pathway, located in the brainstem, is activated via cardioinhibitory fibers for social interaction and calming, thus maintaining a balance between the sympathetic and parasympathetic systems. In the ongoing developmental process, the OSS provides the activation of the sympathetic nervous system with the flight-fight response and the activation of the parasympathetic nervous system with the freeze response through the vagus nerve, the Xth (tenth) cranial nerve, which is called the "wandering" and longest nerve (Porges 2011). The vagus nerve plays a role in the management of emotions, stress, and interpersonal relationships through heart rate and respiration (Porges 2021a). The vagus nerve, the main component of the parasympathetic nervous system, contains 80% afferent sensory neurons and 20% efferent motor neurons. The afferent neurons, which constitute the majority of the information flow, are defined in the literature as interoception (Engelen et al. 2023). Afferent fibers extend from the internal organs to the brain and transmit information to the brain about mechanical, thermal, chemical, metabolic, hormonal conditions, and the physiological state of the skin, muscles, joints, teeth, and all internal organs (Craig 2002).

The "hierarchy," one of the concepts put forward by the PVT, refers to the neurophysiological basis of the development of an adaptive response of the CNS to stimuli through three hierarchical pathways (Porges 1995). The first of these three pathways is the unmyelinated dorsal vagal pathway of the parasympathetic nervous system, which originates from the dorsal nucleus of the vagus, the most primitive system that developed approximately 500 million years ago. Here, conditions such as the freezing response, immobilization, vasovagal syncope, playing dead, and behavioral shutdown are observed (Porges 2011, Porges 2021a). The second pathway is the sympathetic nervous system, from which the flight-fight response evolved around 400 million years ago. When this system is activated, the body prepares for action: heart rate increases, breathing decreases, pupils dilate, digestion and reproduction stop, often more for survival than social interaction. The hypothalamic-pituitary-adrenal (HPA) axis is stimulated and causes the release of glucocorticoids, which are defined as stress (Levine 2000). The third pathway is the myelinated ventral vagus pathway, which starts from the nucleus ambiguus, the newest part of the autonomic nervous system, and suppresses sympathetic activation in the heart and the HPA axis to keep calm. At the same time, this system includes the Social Engagement System proposed by Porges (Porges 1995, Porges 2009, Porges 2023). The Social Engagement System enables the person to connect with others by controlling the muscles of the face and head through the myelinated ventral vagus nerve starting from the brainstem region called the nucleus ambiguus (Porges 2011). Thus, the individual perceives the "other" as safe or threatening through voice, facial expression, gestures, and mimics, laying the foundation for social interaction (Porges 2020, Porges 2023). Here, there are soothing, talking, listening, reciprocity, nurturing relationships, and thus the ventral vagal state supports compassionate connections (Stellar et al. 2015). The neuroanatomical bases of the Social Engagement System are presented in Table 1.

In some cases, the three nervous systems (dorsal vagal pathway, sympathetic activation, ventral vagal pathway) are activated together (Porges 2007). For example, when the sympathetic nervous system and the ventral vagal pathway are activated together with the social connection system, our body is ready for movement in a safe space in activities such as dancing, running together, playing soccer, or exploring (Sullivan et al. 2018). On the other hand, when the parasympathetic nervous system, the dorsal vagal pathway, and the social connection system are activated together, immobilization occurs, providing a peaceful bonding environment without entering the freezing response, where there is inertial trust (Cartes & Porges 2011).

The CNS has an extensive network of neuroreception, which also perceives safety signals from both the external world (by capturing clues such as facial expression and tone of voice) and the body to react to

threats (Porges 2023). "Neuroception" is the second concept of PVT, which includes interoception (internal perception) and extroception (external perception), a nonverbal experience. It has the task of reflexively keeping the organism alive by assessing risk without awareness. In neurocognition of insecurity, the individual concludes that bonding with others would not be safe, and sympathetic activation and/or dorsal vagal collapse occurs. On the other hand, in safety neurocognition, the social connection system is activated by ventral vagal activation, along with the shutdown of the sympathetic and dorsal vagal systems (Porges 2021a).

On the other hand, neuroception, if individuals distinguish friend from foe in social interactions and detect trust, social interaction and adaptation can be achieved, while if they confirm distrust, ventral vagal activation is withdrawn and the cardioinhibitory vagal brake on the heart is discharged (Porges 1995, Porges 2023). As a matter of fact, the individual needs the vagal brake capacity to regulate the nervous system in a healthy way in daily life (Porges 1995, Dana 2021). The vagal brake is defined as the ability to self-regulate through ventral vagal parasympathetic activation (Porges 2011). The observable form of this ability has been determined as the rhythmic change in respiratory sinus arrhythmia (RSA—Respiratory Sinus Arrhythmia), and although it is the task of the ventral vagus to reduce the heart rate to an average of 72 beats per minute, high RSA is an indication that the vagal brake is working dynamically (Austin et al. 2007). Thus, individuals can demonstrate social participation behaviors, regulate emotions, and establish secure bonds (Porges 2007, Porges 2011). As much as it is functional to protect ourselves in the presence of a threat, it is also important for our nervous system to calm down when the threat passes in order to protect both physical and mental health (Flores and Porges 2017). Otherwise, the system gets stuck at a single point, causing a chronic stress response, and then the individual becomes vulnerable to various physical and mental illnesses (Porges 2021a). When the aforementioned social participation behavior occurs, autonomous security is achieved, and the onset of attachment with "co-regulation," one of the main concepts identified for PVT, takes place (Haeyen 2024). Co-regulation is defined as an interaction process based on reciprocity and a balance of giving and receiving. It supports the formation of a secure bond between the autonomic nervous systems of individuals, which is critical for both mental and physical health (Carter and Porges 2011).

In response to the objections to the physiological principles put forward by the theory (Grossman 2023), the theory's creator, Porges, stated that as the areas of use of PVT increase (medicine, education, business, psychology, etc.), practitioners cannot convey the theory correctly enough, the scientific basis of the theory is misunderstood, and more studies are needed on its place and importance in clinical practice (Porges 2023, Haeyen 2024).

In summary, PVT encourages the socialization of individuals and reveals that a sense of trust and spiritual maturation will be built through social bonds. In this framework, the individual becomes open to exploring the environment in a safe space only under conditions where the ventral vagal activation and/or social connection system is active and the vagal brake is dynamic (Porges 2023). Within the framework of all the health disciplines, PVT draws a route for workers in the mental health field. This route includes assessing the vagal tones of the clients, being open to clues about their nervous systems, analyzing and developing neuroception skills correctly. In addition, it aims to regulate and functionalize the nervous systems of clients together with co-regulation, thus promoting interventions that support the nervous system and integrating them into treatments (Porges and Dana 2018).

Body-Mind Relationship

ANS is a system that evaluates sensations from the environment and internal organs, supporting our survival and playing an important role in our mental and physical health (Damasio 1999). One of these sensations, exteroception, facilitates the individual in establishing harmonious relationships with their immediate environment by processing data from our five sensory organs: hearing, touch, taste, and vision (Craig 2002, Gallace and Spence 2014). Indeed, studies have shown that individuals with hearing loss have an increased risk of social isolation and depression (Hogan et al. 2009). In studies conducted during the Covid-19 pandemic, where impairments in the sense of smell and taste were seen intensely, it was revealed

that impairments in these senses negatively affected individuals' depression and anxiety levels and caused a decrease in self-confidence (Javed et al. 2022).

Based on the hypothesis that the sense of touch is important for social connection, a study examining the relationship between touch perception and loneliness found that lonely individuals have a low ability to comprehend positive, supportive social cues, which paves the way for loneliness (Sporta et al. 2022). On the other hand, our senses of proprioception and interoception, which can be overlooked today, have been frequently researched recently (Chen et al. 2021, de Nooiji and Zampieri 2023). Proprioception enables the individual to create awareness of their own body with information from muscles, joints, and tendons. It allows the coordination of movements (de Nooiji and Zampieri 2023). Today, it has been reported that proprioceptive disorders affect the social bonds the individual establishes with the environment, and they prevent learning, especially with poor short-term memory functions, in the development of psychomotor skills (Finzi et al. 2016, Horvath et al. 2020). It has been stated that exercises contributing to the development of proprioceptive skills can support individuals in achieving body-mind integrity and coping with problems such as stress, anxiety, and depression more easily (Emerson et al. 2009, Emerson et al. 2018).

To summarize, exteroceptive, interoceptive, and proprioceptive senses have an important place in the body-mind connection. Especially when considering interoception, this concept becomes a step forward in understanding the body-mind relationship within the framework of PVT. PVT states that each path of the autonomic nervous system communicates with the internal organs through the sense of interoception (Craig 2009). From this perspective, it has been suggested that we may need to take a closer look at the concept of interoception to better understand the body-mind relationship.

Interoception

Today, interoception is more than just sensations from internal organs, as defined by physiologist Sherrington in 1906, in addition to exteroception and proprioception (Critchley and Harrison 2013, Ceunen et al. 2016). The concept of interoception refers to perceiving, recognizing, interpreting, and integrating messages coming from within the organism, especially from the gastrointestinal, respiratory, and cardiovascular systems (Garfinkel et al. 2015). It enables us to recognize bodily sensations such as hunger, fullness, need for the toilet, fatigue, sweating, chills, and to develop an appropriate response (Cameron 2001, Craig 2009, Ceunen et al. 2016, Berntson and Khalsa 2021, Suksasilp and Garfinkel 2022). At the same time, it is not limited to any specific sensation but is based on past experiences, memories, associations, attitudes, beliefs, and emotions, integrating them into the total experience that forms the subjective representation of the body's state (Cameron 2001, Craig 2009, Ceunen et al. 2016). For example, in response to fear, interoceptive arousal symptoms may include muscle tension, an increased heart rate, pupil dilation, and hormonal changes. However, if the individual is not facing a real threat, an interoceptive misjudgment occurs (Machorrinho et al. 2019). In this context, interoception is defined by Fowler (2002) as, "The interoceptive system constitutes the material self as a whole, and how we perceive these sensations from our body determines our mood, well-being, and emotions." Moreover, interoception creates a subjective sense of self (Damasio et al. 2013).

In this context, it is noteworthy that the concept of mentalization, related to interoception, is important in the literature. Mentalization refers to the individual's ability to recognize, understand, and express mental states such as emotions, thoughts, desires, and beliefs. On the other hand, it refers to the ability to use the same skills for others (Bateman and Fonagy 2016). When interoception is considered as a supportive concept, the "mentalization of interoceptive sensations" suggests that the ability to reflect on oneself will begin by focusing primarily on "current" bodily signals (Duquette and Ainley 2019). Here, mentalization is particularly thought of as the ability to understand the meaning of sensations affecting the individual, and the prerequisite for this process is focusing on present interoceptive sensations (Duquette and Ainley 2019).

According to the findings of a growing body of studies, interoceptive dysfunctions have been observed in various psychopathologies, such as depression (Simons et al. 2016, Zhou et al. 2024), eating disorders

(Khalsa et al. 2022, Kaloğlu and Hocaoğlu 2023, Velkoff et al. 2024), addictions (Mattioni et al. 2024), obsessive-compulsive disorders (Eng et al. 2020), schizophrenia (Yao and Thakkar 2022, Torregrossa et al. 2022), post-traumatic stress disorder (Schaan et al. 2019, Reinhardt et al. 2020, Leech et al. 2024), and anxiety disorders (Puigcerver et al. 2024).

For example, it is known that individuals with panic disorder show hypersensitivity to bodily sensations, and this sensitivity feeds fear and anxiety cycles through misinterpretations (Domschke et al. 2010). These individuals often have irritable bowel syndrome as a comorbid diagnosis (Tsao et al. 2009). On the other hand, it has been found that individuals with eating disorders often have very low or no awareness of body sensations such as hunger and satiety (Herbert and Pollatos 2014). Thus, both low and high levels of interoception are significant in terms of psychopathology (Khalsa et al. 2022).

Depression is another psychopathology in which interoceptive functions are impaired (Khalsa et al. 2018). Impairments in interoceptive skills reduce the individual's capacity to cope with stress and make them vulnerable to depression (Khalsa et al. 2018). Studies have shown that individuals diagnosed with depression have decreased levels of interoceptive awareness, particularly with the inability to perceive heartbeats, and they cannot evaluate signals from their own body in a healthy way, leading to difficulties in emotion regulation (Eggart et al. 2021).

In studies with individuals diagnosed with obsessive-compulsive disorder (OCD), who tend to over-interpret bodily sensations, it has been suggested that this body sensitivity may trigger compulsive behavior cycles due to fear of contamination (Bragdon et al. 2020). Additionally, a study investigating the role of interoception in the relationship between OCD and suicidal behavior found that decreased body sensations cause a bodily disconnection that increases the desire for death, while increased bodily sensations may increase the risk of suicide by causing difficulties in emotion regulation skills (Blenger et al. 2023).

Similar to OCD, individuals diagnosed with PTSD have hypersensitivity to bodily sensations, and these sensations are associated with traumatic memories. Additionally, it was found that body awareness decreased, and dissociation symptoms were observed in some individuals (Price and Hooven 2018). These findings suggest that both high and low levels of interoception play a role in maintaining psychopathologies through a similar mechanism (Khalsa et al. 2018). Therefore, the assessment of interoceptive functions may be crucial in understanding and treating psychopathologies.

It is thought that future studies on this subject are needed to determine the role of interoception in psychiatric disorders and to design the best ways to plan individualized interoceptive interventions. The patient-therapist relationship is a safe harbor to help the patient discover new perspectives and facilitate change (Ovalle et al. 2023). Providing this safe harbor is related to how individualized the treatment is (Nord and Garfinkel 2023).

Interoception and the Brain

Studies suggest that interoceptive deficits may represent a transdiagnostic mechanism in mental disorders (Khalsa et al. 2018, Lafcı Fahrioğlu and İlgi 2019, Brewer et al. 2021, Nord et al. 2021). In this context, it can be argued that the assessment of interoceptive skills should be a part of the diagnosis and treatment for each psychopathological disorder. Craig (2009) defined this concept within a neurobiological framework by revealing important findings on the processing of interoception in the anterior insula region, which is considered the 5th lobe of the brain. Since then, numerous studies have investigated the relationship between interoception, emotional experiences, and psychological functions (Barrett 2017).

Interoception works through pathways that receive, process, and transmit information from organs. These pathways include afferent fibers from sensory receptors in peripheral organs such as the heart, lungs, gut, and skin, which transmit signals to the spinal cord, brain stem, hypothalamus, and thalamus, and then to cortical regions such as the insular cortex, anterior cingulate cortex, and prefrontal cortex (Berntson and Khalsa 2021). Interoceptive pathways include the insular cortex and anterior cingulate cortex (Nord and Garfinkel 2022).

Recent neuroimaging studies have highlighted the importance of the insula in many brain diseases (Namkung and Sawa 2017). The insula works with the anterior cingulate cortex in the regulation of body sensations, and the anterior cingulate cortex is involved in the emotional and cognitive processing of interoceptive information (Medford and Critchley 2010). Additionally, the prefrontal cortices are involved in the conscious processing of interoception, enabling individuals to recognize bodily reactions such as heart rate and respiration and to interact socially based on this information (Berntson and Khalsa 2021). In fact, research has shown that secure attachment and positive social interactions strengthen emotional regulation through the insular cortex (Li et al. 2021). Studies have revealed that insula activation is related to anxiety and fear (Terasawa et al. 2013).

In a recent study 22 healthy volunteers were given interoceptive training for 40 minutes a day, at least 4 times a week, and examined with brain imaging techniques. The study observed that the participants were able to shift their attention resources from exteroception to interoception. This training increased the participants' interoceptive accuracy and led to a reduction in somatic symptoms, anxiety levels, and neuroticism. At the same time, brain regions, including the anterior insular cortex and the cognitive control network, were strengthened after interoceptive training (Sugawara et al. 2024).

The anterior cingulate cortex and anterior insular cortex are also active in the "bottom-up" processes of interoception. The anterior insular cortex and dorsolateral prefrontal cortex are involved in the "top-down" processes of interoception, which are thought to provide cognitive control of emotion. Based on research, it has been suggested that mindfulness-based cognitive therapies can benefit individuals with hypersensitivity to interoceptive sensations by strengthening the "top-down" pathway of interoception (Segal and Walsh 2016, Sugawara et al. 2024). The "bottom-up" neural circuit of interoception is connected to the vagus nerve. Activation of the vagus nerve helps balance the autonomic nervous system and facilitates the development of interoceptive skills (Porges and Dana 2018). It is often emphasized that yoga, which activates the bottom-up pathway, plays an important role in the development of interoceptive skills in individuals with low interoceptive awareness (Van der Kolk et al. 2014, Emerson 2023, Sugawara et al. 2024). The vagus nerve's role in the regulation of interoceptive skills is explained by the PVT, which emphasizes interoception in establishing relationships and social bonds with oneself and others, revealing the biophysiological basis of the sense of security (Porges 2023).

In individuals with PTSD, lower levels of activity have been found in the left insula, which is part of the interoceptive pathways, along with the thalamus, medial prefrontal cortex, and anterior cingulate gyrus (Herringa et al. 2012). This indicates that after a traumatic experience, individuals may become disconnected from their sense of self and body, which is essential for experiencing the world and relationships safely (Nord and Garfinkel 2022). The need to feel safe is functionally our body's way of communicating through the autonomic nervous system. It affects our mental and physical health, social relationships, cognitive processes, and behavioral repertoire, serving as a collaborative physiological infrastructure (Porges 2023). Philosopher and psychotherapist Gendlin (1997) emphasized that trust is not only a "felt" mental experience but also a physical reflection. While secure attachment enables individuals to establish healthier and more satisfying relationships (Bowlby 1988), chronic insecurity can increase the risk of stress-related diseases by creating constant increases in heart rate and blood pressure through sympathetic nervous system activation (Sapolsky 2004). Furthermore, feeling secure may improve an individual's empathy and social connection skills by increasing insula activation (Taylor et al. 2010).

Measurement Tools Developed for Interoception

Various measurement tools have been developed for the assessment and conceptualization of interoception in the literature. Garfinkel (2015) outlined three definitions of interoception: first, interoceptive accuracy, which is measured through objective tests such as the heart rate detection task, second, interoceptive sensibility, determined by self-assessment scales focusing on the individual's internal states, and third, interoceptive awareness, which relates to the performance of both interoceptive accuracy and sensitivity (Garfinkel et al. 2015).

Laboratory experiments typically focus on interoceptive accuracy, which is measured by assessing heart rate with an electrocardiogram and asking individuals to count their heartbeats. This is an objective measurement related to the experience and regulation of emotions (Pollatos et al. 2009). For interoceptive sensibility, several scales are used in the literature, including the Body Awareness Questionnaire adapted by Mehling et al. (2009), the Interoception Sense Questionnaire created by LFiene et al. (2018), the Interoceptive Accuracy Scale (IAS) developed by Murphy et al. (2020), and the Interoceptive Sensitivity and Attention Scale by Bogaerts et al. (2022). The Multidimensional Assessment of Interoceptive Awareness (MAIA-II), developed by Mehling et al. (2012), assesses interoceptive awareness and sensitivity. It is a standardized, multidimensional measurement tool that can be used quickly outside laboratory settings, making it more generalizable. Following efforts to improve the scale and validate it in new sample groups, the second version of the MAIA-II, consisting of 8 dimensions and 37 items, was published (Mehling et al. 2018). This scale has been widely used worldwide and has been adapted into 20 different languages. The Turkish standardization of the MAIA-II was conducted by Özpınar et al. in 2021, resulting in a version with 6 subscales and 32 items (Özpınar et al. 2021). The subscales include 'Awareness' (awareness of uncomfortable, comfortable, and neutral body sensations), 'No Distraction' (the tendency to ignore or distract oneself from pain or discomfort), 'No Worry' (the tendency not to worry despite pain or discomfort), 'Attentional Regulation' (the ability to focus attention on body sensations), 'Emotional Awareness' (awareness of the connection between body sensations and emotional states), and 'Trusting' (the belief that one's body is reliable and safe). The Cronbach alpha coefficient for the total scale (32 items) was found to be 0.72. When examining the Cronbach alpha coefficients for the subscales, the values were as follows: $\alpha = 0.86$ for "Secure Attachment" and $\alpha = 0.77$ for "Insecure Attachment."

Interception Based Interventions

Therapy approaches differ in terms of the components they focus on. While bottom-up therapies target cognitive processes, top-down therapies target the nervous system and integrate interoceptive processes into psychotherapies (Duquette and Ainley 2019). The main reason for this difference is the integration of emotion, external, and internal sensation processes (Seth and Friston 2016). Interoceptive skills are the neural substructure of subjective awareness that enables the individual to perceive his/her emotional experience, and when the individual reaches subjective awareness, this has an impact on cognition and behavior.

It is thought that interoceptive skills may have a transdiagnostic role in explaining psychiatric disorders ranging from panic disorder to substance use disorder and even from childhood traumas to PTSD symptoms (Khoury et al. 2018, Van der Kolk 2019). Symptoms such as flashbacks, triggers, avoidance, self-numbing, hyperarousal, constant vigilance, difficulty in emotion regulation, dissociation, attention problems, and somatic pains, which are among the main symptoms of PTSD, are indicators that the individual experiences the trauma "in the body" (Jaycox and Foa 1996, Van der Kolk 2019). Traumatic experiences often threaten the integrity of the body, and individuals experience a disconnection between their bodies and minds (Herman 2007).

At the same time, brain imaging studies (positron emission tomography and functional magnetic resonance imaging) have revealed that the functionality of the prefrontal cortex, regions related to interoceptive skills, and the speech center called Broca's area in the left hemisphere of the brain is impaired, which weakens the individual's control and ability to express themselves with words following traumatic experiences (Rogalsky et al. 2008, Van der Kolk 2019, Gajardo-Vidal et al. 2021, Herron et al. 2024). For this reason, the effectiveness of classical speech therapies is limited today (Lee et al. 2022).

There are many approaches used in trauma treatment (Paul et al. 2012). The International Society for Traumatic Stress Studies (ISTSS) and the World Health Organization (WHO) state that Eye Movement Desensitization and Reprocessing (EMDR) is an evidence-based psychotherapy for the treatment of PTSD in children, adolescents, and adults (WHO 2013, Bisson et al. 2019, Melegkovits et al. 2023). In recent years, the effectiveness of EMDR therapy has frequently been the subject of research (Perlini et al. 2020, Onofri 2023). It has been stated that EMDR therapy can provide homeostasis in the autonomic nervous system

and reduction in physiological symptoms by integrating the cognitive-physical and emotional elements involved in traumatic memory (Sack et al. 2008, Shapiro and Laliotis 2011, Shapiro 2016). EMDR has also been shown to support the ventral vagal pathway from the perspective of PVT (Sack et al. 2008, Poli et al. 2023). Individual trauma-focused Cognitive Behavioral Therapy and EMDR were found to be more effective in reducing the severity of symptoms compared to standard care and waiting lists (De Jongh et al. 2019, Gjerstad et al. 2024). On the other hand, it has been reported that traumatic stimuli are re-experienced during therapy and that there are significant relapse rates and treatment discontinuation due to deficiencies in physical and emotional regulation (Cloitre et al. 2011, Ford et al. 2011, Sele et al. 2023).

Although therapies such as Cognitive Behavioral Therapy, Dialectical Behavior Therapy, Acceptance and Commitment Therapy, EMDR, and Mindfulness are useful in the treatment of trauma, it is emphasized in the literature that without bodywork, cognition-oriented therapies may be insufficient (Van der Kolk 2014, Van der Kolk 2019). Some individuals may lack sensory awareness or hypersensitivity, especially in PTSD, anxiety disorders, and somatization disorders (Khalsa et al. 2015). At this point, the inclusion of Interoception-Based Interventions (IBI), which are used to increase the body awareness that individuals need, in psychotherapies comes to the fore (Loizzo 2016). It has been reported that IBI is used for various psychopathologies, especially post-traumatic stress-related disorders, which improve emotional regulation by increasing individuals' perceptions of their bodies or supporting them to control existing hypersensitivity (Heim et al. 2023). In other words, approaches focusing on interoception are non-invasive psychological or behavioral approaches that aim to increase an individual's awareness of their internal, bodily sensations through specific experiences (Farb et al. 2015, Loizzo 2016).

On the other hand, when individuals come to the psychotherapy room, whether they have a psychiatric diagnosis or not, they bring with them the intense emotions they feel towards the world, themselves, and others, and the difficulties they have in verbalizing their challenging experiences (Patterson 2014). They often have difficulties in recognizing their bodily experiences, expressing emotions, and reading the body correctly (Loizzo 2016). Interoception-based interventions (IBI) aim to provide homeostasis by helping people recognize, interpret, and manage emotions, and interoceptive mechanisms have been frequently studied in relation to recent psychopathologies (Putica et al. 2025). These interventions can also help treatment, especially in patients with somatic symptoms, by providing body-mind integration (Herbert and Pollatos 2014).

In a meta-analysis study that examined 11 different studies focused on Body-Mind Therapies, including IBI, in individuals with chronic pain symptoms, evidence of improvement in interoceptive awareness was found after body-mind therapies. Additionally, it was reported that body-mind therapies resulted in improvements in sub-dimensions such as not worrying, trusting, and self-regulation, in addition to the total score of general interoceptive awareness (Gnall et al. 2024).

Based on these results, interoception is a determinant of psychological well-being, which refers to both physical and mental well-being and the individual's potential for self-realization and this effort (Hanley et al. 2017). In another systematic review study investigating the effectiveness of IBI in reducing symptoms and improving interoceptive skills in mental disorders, 31 studies between 2000 and 2021 were analyzed, and it was stated that IBI is potentially effective in improving interoception in mental disorders (Heim et al. 2023).

Interoceptive Exposure is a therapy technique used in Cognitive Behavioral Therapy, which is also used in PTSD, and is often addressed in anxiety disorders (Lee et al. 2006). In a systematic review of the effectiveness of IBI for PTSD 19 studies were examined, and it was found that integrative exercises improved interoceptive awareness and regulation, and interoceptive-based exposure interventions reduced the individual's anxiety sensitivity and thus were effective on post-traumatic stress disorder symptoms (Putica et al. 2025).

Recently, it is possible to see that many studies have been conducted on interoception and mental health. In a study using the Multidimensional Interoceptive Awareness Inventory, Five-Dimensional Mindfulness Scale, and Psychological Well-Being Scale, data were collected from 478 participants (Hanley et al. 2017). According to the findings of the study, there is a statistically significant relationship between interoception

and psychological well-being. Based on these results, interoception is a determinant of psychological well-being, which refers to both physical and mental well-being and the individual's potential for self-realization (Hanley et al. 2017).

Interoceptive exposure exercises applied for this purpose involve triggering harmless body sensations associated with bodily arousal. For example, spinning in a chair triggers dizziness, running in place, breathing in and out rapidly triggers hyperventilation, exhaling through a straw recreates the sensation of shortness of breath by inhaling, looking at a painting of small squares for a long time can cause visual hallucinations. With these exercises, body sensations are recreated in a controlled way. The aim is for the individual to realize that they have control over their body sensations and not to catastrophize these sensations (Putica et al. 2025). Exposure to unpleasant bodily sensations is important to reduce the fear response to these body sensations, thus informing both the body and the mind that these bodily symptoms are not dangerous.

In this context, interoception-based interventions such as carbon dioxide inhalation, which effectively reduce panic attacks, have been developed based on classical cognitive models that reveal the misinterpretation of bodily signals. Interoception is an important tool for understanding the interaction between emotional experiences and bodily states. IBI is particularly beneficial for individuals experiencing a lack of bodily awareness or emotional regulation problems (Khalsa et al. 2015), especially for panic disorder (Nardi et al. 2006, Rahman et al. 2014).

In another psychotherapy approach, Mindfulness-Based Cognitive Therapy (MBCT) uses mindfulness techniques to correct cognitive distortions and improve emotional regulation (Sipe and Eisendrath 2012). MBCT exercises aim to increase interoceptive awareness and enable individuals to restructure their relationship with their body sensations (Zeidan et al. 2010, Sipe and Eisendrath 2012). Biofeedback, which is one of the perception-based interventions, allows individuals to monitor and control their bodily processes (e.g., heartbeat, muscle tension) through visual or auditory feedback. This method can help individuals increase their interoceptive awareness and better understand their bodies (McCraty et al. 2009).

The harmonious functioning of the sympathetic and parasympathetic branches in the CNS — activation of the sympathetic nervous system and increase in heart rate while inhaling and activation of the parasympathetic nervous system and decrease in heart rate while exhaling — is necessary for the mental and physical health of the individual, and heart rate variability reveals the relative balance between these two systems (Van der Kolk 2014, Van der Kolk 2019). Heart rate variability is high in healthy individuals. Individuals with psychiatric diagnoses and autonomic nervous system dysfunction cannot establish a balance between breathing and heart rate due to poor heart rate variability (Göçen and Özden 2024). This increases susceptibility to various mental illnesses such as heart diseases, cancers, depression, and PTSD (Van der Kolk 2019).

Within the framework of all this information, there are studies suggesting that Hatha Yoga can be a method of correcting heart rate variability in individuals (Van der Kolk 2014, Van der Kolk 2019). Trauma-Sensitive Yoga (TSY), created especially for people who have experienced interpersonal trauma, was designed to be used as a supportive treatment method at the Trauma Center in Massachusetts in 2003 and is a body-mind therapy focused on increasing the interoceptive awareness of the individual and is also a form of Hatha Yoga (Emerson 2023).

In general, it is also suggested that EMDR may be more effective for singular events such as car accidents and natural disasters (Shapiro 2016). However, singular interpersonal events such as sexual assault or deliberate harm to another person may be exceptions, and EMDR developed specifically for individuals who have experienced complex trauma in interpersonal relationships can be used in such cases (Emerson 2023).

What makes Trauma-Sensitive Yoga (TSY) different from other forms of yoga is that it uses an inviting, inclusive language (Hooper 2012). Bodily autonomy is emphasized by offering participants options for each form, avoiding contact, and respecting the participant's bodily boundaries, not forcing the person into any

posture. It is described as a gentle teaching approach (Emerson 2023). This approach was developed based on the idea that individuals with trauma experience disconnection between their body and their mind. TSY also includes safe physical movements to release trauma stored in the body. The bodywork involved in TSY provides both a top-down and bottom-up regulation system, while balancing the sympathetic and parasympathetic nervous systems and improving interoception (Emerson 2023).

All of these approaches highlight the importance of interoceptive awareness, whether through direct exposure to bodily sensations or through mindfulness-based practices, in treating trauma and improving mental health outcomes.

Conclusion

What Descartes, the founder of modern philosophy, discovered on his journey to attain knowledge that leaves no room for doubt and can be trusted with certainty is that the senses often mislead us. He concluded this based on the proposition "Cogito, ergo sum" ("I think, therefore I am"), asserting that we are subjects who perceive the world as "res cogitans" ("conscious mind-thinking thing") (Descartes 2016). However, dualists universally accept the idea that the mind affects the body, and the body affects the mind (Priest 2018).

According to Descartes, the needs of the body, such as hunger and thirst, should be addressed by the mind. Thus, the body and mind are interconnected. Descartes viewed sensations like hunger, thirst, and pain as forms of thinking and suggested that one could be mistaken about the sensations of one's own body (Descartes 2016). Furthermore, Descartes believed that the body and mind interact through the pineal gland, which he referred to as the "central headquarters" of this interaction (Descartes 2016).

In contrast, modern neuroscience suggests that interoception may serve as the bridge between the body and the mind. Interoception refers to the nervous system's role in interpreting both internal and external experiences, determining the true subjective awareness of emotional experiences and bodily sensations. It plays a crucial role in maintaining homeostasis in the body, though it is not always experienced at the level of awareness. Despite this, it impacts cognition, behavior, and the quality of life of individuals. Bodily sensations experienced outside the level of awareness can be perceived as catastrophic and may pose a threat to the individual.

It is essential to understand the role of psychotherapeutic techniques that target interoception and interoceptive mechanisms in treating psychopathologies, especially in terms of both physical and mental health. Including interoceptive measures in clinical trials may help understand existing treatments and develop new ones. To be comprehensive, such measures should explore different interoceptive axes (e.g., gastric, respiratory, cardiac) at neural, behavioral, and subjective levels. It may be especially beneficial to apply interoception-based therapies to clients who show interoceptive impairments. Such interventions could also be considered in cases where clients show little or no response to existing therapy.

When applied appropriately, interoception-based interventions have the potential to enhance existing psychotherapy approaches. However, further clinical research is necessary to broaden their application. It is expected that interoception-based interventions may become more widely used in clinical practice within the framework of mind-body therapies in the future (Farb et al. 2015).

References

Austin MA, Riniolo TC, Porges SW (2007) Borderline personality disorder and emotion regulation: Insights from the polyvagal theory. Brain Cogn, 65:69-76.

Bateman A, Fonagy P (2016) Mentalization-Based Treatment For Personality Disorders: A Practical Guide. Oxford, Oxford University Press.

Belanger AN, Timpano KR, Eng GK, Bragdon LB, Stern ER (2023) Associations between suicidality and interoception in obsessive-compulsive disorder. J Obsessive Compuls Relat Disord, 39:100844.

Berntson GG, Khalsa SS (2021) Neural circuits of interoception. Trends Neurosci, 44:17-28.

Bisson JI, Berliner L, Cloitre M, Forbes D, Jensen TK, Lewis C et al. (2019) The international society for traumatic stress studies new guidelines for the prevention and treatment of posttraumatic stress disorder: methodology and development process. J Trauma Stress, 32:475-483.

Bogaerts K, Walentynowicz M, Van Den Houte M, Constantinou E, Van den Bergh O (2022) The interoceptive sensitivity and attention questionnaire: evaluating aspects of self-reported interoception in patients with persistent somatic symptoms, stress-related syndromes, and healthy controls. Psychosom Med, 84:251-260.

Bragdon LB, Eng GK, Belanger A, Collins KA, Stern ER (2021) Interoception and obsessive-compulsive disorder: a review of current evidence and future directions. Front Psychiatry, 12:686482.

Brewer R, Murphy J, Bird G (2021) Atypical interoception as a common risk factor for psychopathology: a review. Neurosci Biobehav Rev, 130:470-508.

Brumariu LE (2015) Parent-child attachment and emotion regulation. New Dir Child Adolesc Dev, 148:31-45.

Bryant RA, Dawson KS, Azevedo S, Yadav S, Cahill C, Kenny L et al. (2023) Augmenting trauma-focused psychotherapy for post-traumatic stress disorder with brief aerobic exercise in Australia: a randomised clinical trial. Lancet Psychiatry, 10:21-29.

Cameron OG (2001) Interoception: the inside story—a model for psychosomatic processes. Psychosom Med, 63:697-710.

Carter CS, Porges EC (2011) Parenthood, stress, and the brain. Biol Psychiatry, 70:804-805.

Cattie JE, Allbaugh LJ, Visser KH, Ander I, Kaslow NJ (2021) Tailoring trauma-sensitive yoga for high-risk populations in public-sector settings. Int J Yoga Therap, 31:15.

Ceunen E, Vlaeyen JW, Van Diest I (2016) On the origin of interoception. Front Psychol, 7:743.

Chen WG, Schloesser D, Arensdorf AM, Simmons JM, Cui C, Valentino R et al. (2021) The emerging science of interoception: sensing, integrating, interpreting, and regulating signals within the self. Trends Neurosci, 44:3-16.

Cloitre M, Courtois CA, Charuvastra A, Carapezza R, Stolbach BC, Green BL (2011) Treatment of complex PTSD: results of the ISTSS expert clinician survey on best practices. J Trauma Stress, 24:615-627.

Craig AD (2002) How do you feel? Interoception: the sense of the physiological condition of the body. Nat Rev Neurosci, 3:655-666.

Craig AD (2009) How do you feel—now? The anterior insula and human awareness. Nat Rev Neurosci, 10:59-70.

Damasio A, Damasio H, Tranel D (2013) Persistence of feelings and sentience after bilateral damage of the insula. Cereb Cortex, 23:833-846.

Damasio AR (1999) The Feeling of What Happens: Body and Emotion in the Making of Consciousness, New York, Harcourt Brace.

Dana D (2021) Terapide Polivagal Teori: Ruhsal Düzenlemenin Ritmine Uymak (Çeviri Ed. İG Şan). İstanbul, Psikonet Yayıncılık.

De Jongh A, Amann BL, Hofmann A, Farrell D, Lee CW (2019) The status of EMDR therapy in the treatment of posttraumatic stress disorder 30 years after its introduction. Journal of EMDR Practice and Research, 13:261-269.

De Nooij JC, Zampieri N (2023) The making of a proprioceptor: a tale of two identities. Trends Neurosci, 46: 1083–1094.

Descartes (2016) Meditasyonlar (Çeviri Ed. E. Sunar). İstanbul, Say Yayınları.

Domschke K, Stevens S, Pfleiderer B, Gerlach AL (2010) Interoceptive sensitivity in anxiety and anxiety disorders: an overview and integration of neurobiological findings. Clin Psychol Rev, 30:1-11.

Duquette P, Ainley V (2019) Working with the predictable life of patients: the importance of "mentalizing interoception" to meaningful change in psychotherapy. Front Psychol, 10:2173.

Eggart M, Lange A, Binser MJ (2021) Interoception in depression: mechanisms, modulating factors, and therapeutic implications. Front Psychiatry, 12:643371.

Emerson D (2023) Terapide Travmaya Duyarlı Yoga (Çeviri Ed. ET Dere), İstanbul. Aura Yayınevi.

Emerson D, Hopper E (2012) Overcoming Trauma Through Yoga: Reclaiming Your Body. Berkeley, CA, North Atlantic Books.

Emerson D, Sharma R, Chaudhry S, Turner J (2009) Trauma-sensitive yoga: principles, practice, and research. Int J Yoga Therap, 19:123-128.

Emerson M, Bivens S, Walsdorf K (2018) Proprioceptive exercise and its role in mental health. J Phys Ther Sci, 30:29-34.

Eng GK, Collins KA, Brown C, Ludlow M, Tobe RH, Iosifescu DV et al. (2020) Dimensions of interoception in obsessive-compulsive disorder. J Obsessive Compuls Relat Disord, 27:100584.

Engelen T, Solcà M, Tallon-Baudry C (2023) Interoceptive rhythms in the brain. Nat Neurosci, 26:1670-1684.

Erskine RG, Moursund JP, Trautmann RL (2022) Beyond Empathy: A Therapy of Contact-in-Relationship. London, Routledge.

Farb N, Daubenmier J, Price CJ, Gard T, Kerr C, Dunn BD et al. (2015) Interoception, contemplative practice, and health. Front Psychol, 6:763.

Finzi E, Rosenthal NE (2016) Emotional proprioception: treatment of depression with afferent facial feedback. J Psychiatr Res, 80:93-96.

Fischer JM, Kandil FI, Kessler CS, Nayeri L, Zager LS, Rocabado Hennhöfer T et al. (2022) Stress reduction by yoga versus mindfulness training in adults suffering from distress: a three-armed randomized controlled trial including qualitative interviews (RELAX study). J Clin Med, 11:5680.

Flores PJ, Porges SW (2017) Group psychotherapy as a neural exercise: bridging polyvagal theory and attachment theory. Int J Group Psychother, 67:202-222.

Ford JD, Steinberg KL, Zhang W (2011) A randomized clinical trial comparing affect regulation and social problem-solving psychotherapies for mothers with victimization-related PTSD. Behav Ther, 42:560-578.

Fowler CJ (2003) Visceral sensory neuroscience: interoception. Brain, 126:1505-1506.

Gajardo-Vidal A, Lorca-Puls DL, Team P, Warner H, Pshdary B, Crinion JT et al. (2021) Damage to broca's area does not contribute to long-term speech production outcome after stroke. Brain, 144:817-832.

Gallace A, Spence C (2014) In Touch With the Future: The Sense of Touch From Cognitive Neuroscience to Virtual Reality. Oxford, Oxford University Press.

Garfinkel SN, Seth AK, Barrett AB, Suzuki K, Critchley HD (2015) Knowing your own heart: distinguishing interoceptive accuracy from interoceptive awareness. Biol Psychol, 104:65-74.

Gendlin ET (1997) Experiencing and the Creation of Meaning: A Philosophical and Psychological Approach to the Subjective. Evanston, IL, Northwestern University Press.

Gjerstad SF, Nordin L, Poulsen S, Spadaro EFA, Palic S (2024) How is trauma-focused therapy experienced by adults with PTSD? a systematic review of qualitative studies. BMC Psychol, 12:135.

Gnall KE, Sinnott SM, Laumann LE, Park CL, David A, Emrich M (2024) Changes in interoception in mind-body therapies for chronic pain: a systematic review and meta-analysis. Int J Behav Med, 31:833-847.

Göçen HB, Özden AV (2024) Autonomic dysfunction in psychiatric disorders, Psikiyatride Güncel Yaklaşımlar. 16:401-409.

Grossman P (2023) Fundamental challenges and likely refutations of the five basic premises of the polyvagal theory. Biol Psychol, 180:108589.

Guu SF, Chao YP, Huang FY, Cheng YT, Ng HYH, Hsu CF et al. (2023) Interoceptive awareness: MBSR training alters information processing of salience network, Front Behav Neurosci. 17:1008086.

Haeyen S (2024) A theoretical exploration of polyvagal theory in creative arts and psychomotor therapies for emotion regulation in stress and trauma. Front Psychol, 15:1382007.

Hanley AW, Mehling WE, Garland EL (2017) Holding the body in mind: interoceptive awareness, dispositional mindfulness and psychological well-being. J Psychosom Res, 99:13-20.

Heim N, Bobou M, Tanzer M, Jenkinson PM, Steinert C, Fotopoulou A (2023) Psychological interventions for interoception in mental health disorders: a systematic review of randomized-controlled trials. Psychiatry Clin Neurosci, 77:530-540.

Herbert BM, Pollatos O (2014) Interoception and regulation of emotions: implications for understanding and treating somatic symptom disorder. Curr Opin Psychiatry, 27:345-352.

Herman J (2007) Travma ve İyileşme: Şiddetin Sonuçları, Ev İçi İstismardan Siyasi Teröre (Çeviri Ed. T Tosun). İstanbul, Literatür Yayıncılık.

Herriga R, Phillips M, Almeida J, Insana S, Germein A (2012) Post-traumatic stress symptoms correlate with smaller subgenual cingulate, caudate, and insula volumes in unmedicated combat veterans. Psychiatry Res Neuroimaging, 203:139-145.

Herron TJ, Schendel K, Curran BC, Lwi SJ, Spinelli MG, Ludy C et al. (2024) Is broca's area critical for speech and language? evidence from lesion-symptom mapping in chronic aphasia. Front Lang Sci, 3:1398616.

Horváth Á, Ragó A, Ferentzi E, Körmendi J, Köteles F (2020) Short-term retention of proprioceptive information. Q J Exp Psychol, 73:2148-2157.

Javed N, Ijaz Z, Khair AH, Dar AA, Lopez ED, Abbas R et al. (2022) COVID-19 loss of taste and smell: potential psychological repercussions. Pan Afr Med J, 43:38.

Jaycox LH, Foa EB (1996) Obstacles in implementing exposure therapy for PTSD: case discussions and practical solutions. Clin Psychol Psychother, 3:176-184.

Kaloğlu HA, Hocaoglu C (2023) Suicidal behavior in eating disorders. Psikiyatride Güncel Yaklaşımlar, 15:687-696.

Kerr CE, Shaw JR, Wasserman RH, Chen VW, Kanojia A, Bayer T et al. (2008) Tactile acuity in experienced Tai Chi practitioners: evidence for use dependent plasticity as an effect of sensory-attentional training. Exp Brain Res, 188:317-322.

Khalsa SS, Adolphs R, Cameron OG, Critchley HD, Davenport PW, Feinstein JS et al. (2018) Interoception and mental health: a roadmap, Biol Psychiatry Cogn Neurosci Neuroimaging. 3:501-513.

Khalsa SS, Berner LA, Anderson LM (2022) Gastrointestinal interoception in eating disorders: charting a new path. Curr Psychiatry Rep, 24:47-60.

Khalsa SS, Lapidus RC (2016) Can interoception improve the pragmatic search for biomarkers in psychiatry?. Front Psychiatry, 7:121.

Khoury NM, Lutz J, Schuman-Olivier Z (2018) Interoception in psychiatric disorders: a review of randomized, controlled trials with interoception-based interventions. Harv Rev Psychiatry, 26:250-263.

Klukan K, Lunsford D (2023) Trauma-informed yoga: a scoping review. Occup Ther Ment Health, 40:430-454.

Kolacz J, Kovacic KK, Porges SW (2019) Traumatic stress and the autonomic brain-gut connection in development: polyvagal theory as an integrative framework for psychosocial and gastrointestinal pathology. Dev Psychobiol, 61:796-809.

Lee E, Faber J, Bowles K (2022) A review of trauma specific treatments (TSTs) for post-traumatic stress disorder (PTSD). Clin Soc Work J, 50:147-159.

Lee K, Noda Y, Nakano Y, Ogawa S, Kinoshita Y, Funayama T et al. (2006) Interoceptive hypersensitivity and interoceptive exposure in patients with panic disorder: specificity and effectiveness. BMC Psychiatry, 6:32.

Leech K, Stapleton P, Patching A (2024) A roadmap to understanding interoceptive awareness and post-traumatic stress disorder: a scoping review. Front Psychiatry, 15:1355442.

Levine S (2000) Influence of psychological variables on the activity of the hypothalamic–pituitary–adrenal axis. Eur J Pharmacol, 405:149-160.

Li W, Yang P, Ngetich RK, Zhang J, Jin Z, Li L (2021) Differential involvement of frontoparietal network and insula cortex in emotion regulation. Neuropsychologia, 161:107991.

Loizzo JJ (2016) The subtle body: an interoceptive map of central nervous system function and meditative mind–brain–body integration. Ann N Y Acad Sci, 1373:78-95.

Mattioni L, Sestieri C, Perrucci MG, Spada MM, Ferri F (2024) The role of interoceptive awareness in shaping the relationship between desire thinking and cigarette consumption. Int J Psychophysiol, 201:112369.

McCraty R, Atkinson M, Lipsenthal L, Arguelles L (2009) New hope for correctional officers: an innovative program for reducing stress and health risks. Appl Psychophysiol Biofeedback. 34:251–272.

Medford N, Critchley HD (2010) Conjoint activity of anterior insular and anterior cingulate cortex: awareness and response. Brain Struct Funct, 214:535-549.

Mehling WE (2016) Differentiating attention styles and regulatory aspects of self-reported interoceptive sensibility. Philos Trans R Soc Lond B Biol Sci, 371:20160013.

Mehling WE, Acree M, Stewart A, Silas J, Jones A (2018) The multidimensional assessment of interoceptive awareness, version 2 (MAIA-2), PLoS One. 13:e0208034.

Mehling WE, Chesney MA, Metzler TJ, Goldstein LA, Maguen S, Geronimo C et al. (2018) A 12-week integrative exercise program improves self-reported mindfulness and interoceptive awareness in war veterans with posttraumatic stress symptoms. J Clin Psychol, 74:554-565.

Mehling WE, Gopisetty V, Daubenmier J, Price CJ (2009) Body awareness: construct and self-report measures, PLoS One. 4:5614.

Melegkovits E, Blumberg J, Dixon E, Ehntholt K, Gillard J, Kayal H et al. (2023) The effectiveness of trauma-focused psychotherapy for complex post-traumatic stress disorder: a retrospective study. Eur Psychiatry, 66:e4.

Monteiro DA, Taylor EW, Sartori MR, Cruz AL, Rantin FT, Leite CAC (2018) Cardiorespiratory interactions previously identified as mammalian are present in the primitive lungfish. Sci Adv, 4:0800.

Morelen D, Shaffer A, Suveg C (2016) Maternal emotion regulation: links to emotion parenting and child emotion regulation. J Fam Issues, 37:1891-1916.

Murphy J, Brewer R, Plans D, Khalsa SS, Catmur C, Bird G (2020) Testing the independence of self-reported interoceptive accuracy and attention. Q J Exp Psychol, 73:115-133.

Namkung H, Kim S-H, Sawa A (2017) The insula: an underestimated brain area in clinical neuroscience, psychiatry, and neurology. Trends Neurosci, 40:200-207.

Nardi AE, Valença AM, Lopes FL, Nascimento I, Veras AB, Freire RC (2006) Psychopathological profile of 35% CO_2 challenge test-induced panic attacks: a comparison with spontaneous panic attacks. Compr Psychiatry, 47:209-214.

Navarro-Haro MV, Modrego-Alarcón M, Hoffman HG, López-Montoyo A, Navarro-Gil M, Montero-Marin J et al. (2019) Evaluation of a mindfulness-based intervention with and without virtual reality dialectical behavior therapy® mindfulness skills training for the treatment of generalized anxiety disorder in primary care: a pilot study. Front Psychol, 10:55.

Neuhuber WL, Berthoud HR (2022) Functional anatomy of the vagus system: how does the polyvagal theory comply? Biol Psychol. 174:108425.

Nguyen-Feng VN, Hodgdon H, Emerson D, Silverberg R, Clark CJ (2020) Moderators of treatment efficacy in a randomized controlled trial of trauma-sensitive yoga as an adjunctive treatment for posttraumatic stress disorder, Psychol Trauma. 12:836–846.

Nord CL, Garfinkel SN (2022) Interoceptive pathways to understand and treat mental health conditions. Trends Cogn Sci, 26:499-513.

Nord CL, Lawson RP, Dalgleish T (2021) Disrupted dorsal mid-insula activation during interoception across psychiatric disorders. Am J Psychiatry, 178:761-770.

Ong I, Cashwell CS, Downs HA (2019) Trauma-sensitive yoga: a collective case study of women's trauma recovery from intimate partner violence. Couns Outcome Res Eval, 10:19-33.

Onofri A (2023) Present and future of EMDR in clinical psychology and psychotherapy, volume II. Front Psychol, 14:1138153.

Ovalle A, Fischer C, Dagnino P, Vaccarezza S (2024) Interoceptive awareness and therapist characteristics. Couns Psychother Res, 24:642-651.

Patterson CL, Anderson T, Wei C (2014) Clients pretreatment role expectations, the therapeutic alliance, and clinical outcomes in outpatient therapy. J Clin Psychol, 70:673-680.

Paul LA, Hassija CM, Clapp JD (2012) Technological advances in the treatment of trauma: a review of promising practices. Behav Modif, 36:897-923.

Perlini C, Donisi V, Rossetti MG, Moltrasio C, Bellani M, Brambilla P (2020) The potential role of EMDR on trauma in affective disorders: a narrative review. J Affect Disord, 269:1-11.

Poli A, Cappellini F, Sala J, Miccoli M (2023) The integrative process promoted by EMDR in dissociative disorders: neurobiological mechanisms, psychometric tools, and intervention efficacy on the psychological impact of the COVID-19 pandemic. Front Psychol, 14:1164527.

Porges SW (1995) Orienting in a defensive world: mammalian modifications of our evolutionary heritage a polyvagal theory. Psychophysiology, 32:301–318.

Porges SW (2004) Neuroception: a subconscious system for detecting threats and safety. Zero to Three, 24(5):19-24.

Porges SW (2007) The polyvagal perspective. Biol Psychol, 74:116-143.

Porges SW (2009) The polyvagal theory: new insights into adaptive reactions of the autonomic nervous system. Cleve Clin J Med, 76(Suppl 2):S86-S90.

Porges SW (2011) The Polyvagal Theory: Neurophysiological Foundations Of Emotions, Attachment, Communication, and Self-Regulation. New York, WW Norton.

Porges SW (2020) The COVID-19 pandemic is a paradoxical challenge to our nervous system: a polyvagal perspective. Clin Neuropsychiatry, 17:135-138.

Porges SW (2021a) Cardiac vagal tone: a neurophysiological mechanism that evolved in mammals to dampen threat reactions and promote sociality. World Psychiatry, 20:296-298.

Porges SW (2021b) Polivagal Teori: Duyguların, Bağlanmanın, İletişimin Ve Özdüzenlemenin Nörofizyolojik Temelleri (Çeviri Ed. Mİ Kılıç). Ankara, Nobel Yayıncılık.

Porges SW (2023) The vagal paradox: a polyvagal solution. Compr Psychoneuroendocrinol, 16:100200.

Porges SW, Dana D (2018) Clinical applications of the polyvagal theory: the emergence of polyvagal-informed therapies. New York: WW Norton.

Price CJ, Hooven C (2018) Interoceptive awareness skills for emotion regulation: theory and approach of mindful awareness in body-oriented therapy (MABT). Front Psychol, 9:798.

Priest S (2018) Zihin Üzerine Teoriler (Çeviri Ed. A Dereko). İstanbul, Litera.

Puigcerver M, Molins F, Molins M, Serrano MÁ (2024) Interoception moderates the association between alexithymia and anxiety symptoms. Ansiedad Estrés, 30:35-39.

Putica A, Argus A, Khanna R, Nursey J, Varker T (2025) Interoceptive interventions for posttraumatic stress: a systematic review of treatment and interoception outcomes. Traumatology, 31:195–211..

Rahman MM, Kerskens CM, Chattarji S, O'Mara SM (2014) Chronic immobilization stress occludes in vivo cortical activation in an animal model of panic induced by carbon dioxide inhalation. Front Behav Neurosci, 8:311.

Reed SF, Ohel G, David R, Porges SW (1999) A neural explanation of fetal heart rate patterns: a test of the polyvagal theory. Dev Psychobiol, 35:108-118.

Reinhardt KM, Zerubavel N, Young AS, Gallo M, Ramakrishnan N, Henry A et al. (2020) A multi-method assessment of interoception among sexual trauma survivors. Physiol Behav, 226:113108.

Rhodes AM (2015) Claiming peaceful embodiment through yoga in the aftermath of trauma. Complement Ther Clin Pract, 21:247-256.

Rogalsky C, Matchin W, Hickok G (2008) Broca's area, sentence comprehension, and working memory: an fMRI study. Front Hum Neurosci, 2:327.

Sack M, Lempa W, Steinmetz A, Lamprecht F, Hofmann A (2008) Alterations in autonomic tone during trauma exposure using eye movement desensitization and reprocessing (EMDR)—results of a preliminary investigation. J Anxiety Disord, 22:1264-1271.

Saporta N, Peled-Avron L, Scheele D, Lieberz J, Hurlemann R, Shamay-Tsoory SG (2022) Touched by loneliness—how loneliness impacts the response to observed human touch: a tDCS study. Soc Cogn Affect Neurosci, 17:142–150.

Schaan VK, Schulz A, Rubel JA, Bernstein M, Domes G, Schächinger H et al. (2019) Childhood trauma affects stress-related interoceptive accuracy. Front Psychiatry, 10:750.

Segal ZV, Walsh KM (2016) Mindfulness-based cognitive therapy for residual depressive symptoms and relapse prophylaxis. Curr Opin Psychiatry, 29:7–12.

Sele P, Hoffart A, Cloitre M, Hembree E, Øktedalen T (2023) Comparing phase-based treatment, prolonged exposure, and skills-training for complex posttraumatic stress disorder: a randomized controlled trial. J Anxiety Disord, 100:102786.

Sennesh E, Theriault J, Brooks D, van de Meent JW, Barrett LF, Quigley KS (2022) Interoception as modeling, allostasis as control, Biol Psychol. 167:108242.

Seth AK, Friston KJ (2016) Active interoceptive inference and the emotional brain. Philos Trans R Soc Lond B Biol Sci, 371:20160007.

Shapiro F (2016) EMDR-Göz Hareketleriyle Duyarsızlaştırma ve Yeniden İşlemleme: Temel Prensipler, Protokoller ve Prosedürler (Çeviri Ed. Z Zat, İ Canoğlulları, Z Özmeydan, A Yurtsever). İstanbul, Okuyan Us.

Shapiro F, Laliotis D (2011) EMDR and the adaptive information processing model: integrative treatment and case conceptualization. Clin Soc Work J, 39:191-200.

Shatrova D, Cáncer PF, Caperos JM (2024) The role of interoception in reducing trauma-associated distress: a feasibility study. Eur J Psychotraumatol, 15:2306747.

Sherrington CS (1906) The Integrative Action of the Nervous System. New Haven, Yale University Press.

Sherrington CS (1907) On the proprio-ceptive system, especially in its reflex aspect. Brain, 29:467–482.

Sipe WE, Eisendrath SJ (2012) Mindfulness-based cognitive therapy: theory and practice, Can J Psychiatry. 57:63-69.

Stellar JE, Cohen A, Oveis C, Keltner D (2015) Affective and physiological responses to the suffering of others: compassion and vagal activity. J Pers Soc Psychol, 10:572–585.

Sugawara A, Katsunuma R, Terasawa Y, Sekiguchi A (2024) Interoceptive training impacts the neural circuit of the anterior insula cortex. Transl Psychiatry, 14:206.

Suksasilp C, Garfinkel SN (2022) Towards a comprehensive assessment of interoception in a multi-dimensional framework. Biol Psychol, 168:108262.

Tang YY, Lu Q, Feng H, Tang R, Posner MI (2015) Short-term meditation increases blood flow in anterior cingulate cortex and insula. Front Psychol, 6:212.

Terasawa Y, Shibata M, Moriguchi Y, Umeda S (2013) Anterior insular cortex mediates bodily sensibility and social anxiety. Soc Cogn Affect Neurosci. 8:259–266.

Tibbitts DC, Aicher SA, Sugg J, Handloser K, Eisman L, Booth LD et al. (2021) Program evaluation of trauma-informed yoga for vulnerable populations. Eval Program Plann, 88:101946.

Torregrossa LJ, Amedy A, Roig J, Prada A, Park S (2022) Interoceptive functioning in schizophrenia and schizotypy. Schizophr Res, 239:151–159.

Tsao JC, Mystkowski JL, Zucker B, Craske MG (2009) Impact of anxiety on gastroesophageal reflux disease and irritable bowel syndrome. World J Gastroenterol, 15:2361–2367.

Tseng MH, Fu CP, Cermak SA, Lu L, Shieh JY (2011) The effectiveness of sensory processing interventions on social participation in children with autism spectrum disorders. Am J Occup Ther, 65:562–569.

Van Dam NT, Van Vugt MK, Vago DR, Schmalzl L, Saron CD, Olendzki et al. (2018) Mind the hype: a critical evaluation and prescriptive agenda for research on mindfulness and meditation. Perspect Psychol Sci, 13:36–61.

Van der Kolk BA (2019) Beden Kayıt Tutar: Travmanın İyileşmesinde Beyin, Zihin Ve Beden (Çeviri Ed. NC Maral). Ankara, Nobel Akademik Yayıncılık.

Van der Kolk BA, Laura BA, West J, Rhodes A, Emerson D, Suvak M et al. (2014) Yoga as an adjunctive treatment for posttraumatic stress disorder: a randomized controlled trial. J Clin Psychiatry, 75:22573.

Van der Kolk BA, Spinazzola J, Blaustein ME, Hopper JW, Hopper EK, Korn DL et al. (2007) A randomized clinical trial of eye movement desensitization and reprocessing (EMDR), fluoxetine, and pill placebo in the treatment of PTSD: treatment effects and long-term maintenance. J Clin Psychiatry, 68:37-46.

Van der Kolk BA, Stone L, West JI, Rhodes A, Emerson D, Suvak M et al. (2014) Yoga as an adjunctive treatment for PTSD. J Clin Psychiatry, 75:e559-e565.

Velkoff EA, Perkins NM, Dodd DR, Brown TA, Kaye WH, Wierenga CE (2024) Elevated interoceptive deficits in individuals with eating disorders and self-injurious thoughts and behaviors: a replication and extension. Suicide Life Threat Behav, 54:129–137.

Villemure C, Čeko M, Cotton VA, Bushnell MC (2014) Insular cortex mediates increased pain tolerance in yoga practitioners. Cereb Cortex, 24:2732–2740.

Wald J, Taylor S (2007) Efficacy of interoceptive exposure therapy combined with trauma-related exposure therapy for PTSD: a pilot study. J Anxiety Disord, 21:1050–1060.

Wald J, Taylor S (2008) Responses to interoceptive exposure in people with PTSD: a preliminary analysis of induced anxiety reactions and trauma memories and their relationship to anxiety sensitivity and PTSD symptom severity, Cogn Behav Ther, 37:90–100.

West J, Liang B, Spinazzola J (2017) Trauma sensitive yoga as a complementary treatment for PTSD: a qualitative descriptive analysis. Int J Stress Manag, 24:173–195.

WHO (2013) Guidelines for the Management of Conditions that are Specifically Related to Stress. Geneva, World Health Organization.

Yao B, Thakkar K (2022) Interoception abnormalities in schizophrenia: a review of preliminary evidence and an integration with Bayesian accounts of psychosis. Neurosci Biobehav Rev, 132:757–773.

Zaccari B, Higgins M, Haywood TN, Patel M, Emerson D, Hubbard K et al. (2023) Yoga vs cognitive processing therapy for military sexual trauma–related PTSD: a randomized clinical trial. JAMA Netw Open, 6:e2344862-e2344862.

Zeidan F, Johnson SK, Diamond BJ, David Z (2010) Mindfulness meditation improves cognition: evidence of brief mental training. Conscious Cogn, 19:597–605.

Zhou H, Liu J, Wu Y, Huang Z, Wang W, Ma Y et al. (2024) Unveiling the interoception impairment in various major depressive disorder stages. CNS Neurosci Ther, 30:e14923.

Authors Contributions: The author(s) have declared that they have made a significant scientific contribution to the study and have assisted in the preparation or revision of the manuscript
Peer-review: Externally peer-reviewed.
Ethical Approval: This review study does not require ethical clearance.
Conflict of Interest: No conflict of interest was declared.
Financial Disclosure: No financial support was declared for this study.