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Sensory processing disorders in individuals with psychiatric diagnoses – A literature review

Natalia Grobelna[1], Radosław Rutkowski[2], Filip Rybakowski[1], Janusz Rybakowski[1,3], Ewa Ferensztajn-Rochowiak[1]

[1] Department of Adult Psychiatry, Poznan University of Medical Sciences, Poland
[2] Poznan University of Physical Education, Department of Musculoskeletal Rehabilitation, Poznan, Poland.
[3] Correspondent member of the Polish Academy of Sciences

Summary

The paper aims to present the relationship between sensory processing disorder (SPD) and psychiatric disorders, the resulting practical implications, and possible future research directions. Previous research has shown a significant relationship between SPD and a wide range of disorders, from the autism spectrum to affective and anxiety disorders and schizophrenia. Assessing SPD according to Winnie Dunn's Four Quadrant Model, identifies 4 types of sensory processing: Low Registration, Sensation Seeking, Sensory Sensitivity, and Sensation Avoiding. The model allows analysis of the functioning of people with psychiatric disorders, highlighting the importance of diagnosis and sensory therapy as an important component of support in psychiatric treatment. Understanding these relationships is essential for developing more effective therapeutic strategies that take into account the specificity of sensory processing in people with psychiatric disorders. The article emphasises the clinical implications related to SPD and presents diagnostic tools aimed at improving diagnosis and therapy by psychiatrists and psychotherapists. The authors highlight the potential benefits of using sensory therapy as an adjunct to traditional treatments and underscore the need for further research to better understand the complexity of the relationship between SPD and psychiatric disorders, which could help improve patients' quality of life.

Key words: sensory processing disorder, Dunn's Four Quadrants Model, psychiatric disorders

Introduction

The theory of sensory processing, developed by American occupational therapist A. Jean Ayres [1] has evolved over the years, leading to the emergence of concepts

such as sensory integration, sensory processing disorders (SPD) and sensory processing sensitivity. Sensory processing disorders, as defined by Miller et al. [2], are neurological condition where there is an abnormal response to sensory stimuli received through the senses. Individuals with SPD may struggle with properly receiving, organising and interpreting this information, leading to significant difficulties in daily functioning and social interactions. Miller et al. [2] identifies several subtypes of SPD, which include sensory modulation disorder, sensory-based motor disorder and sensory discrimination disorder.

Interest in sensory processing began among child psychiatrists and psychologists, mainly concerning children with developmental disorders, learning difficulties and autism spectrum disorder. Winnie Dunn's approach to sensory processing disorders focuses on the differences in responses to sensory stimuli. She outlined these differences in the Four Quadrant Model, which classifies sensory responses based on two dimensions: sensory threshold (low or high) and response strategy (active or passive). This allows for the identification of four sensory processing profiles: Sensation Seeking, Sensation Avoiding, Sensory Sensitivity, and Low Registration [3]. At one end of the spectrum, individuals with a high sensory threshold require stronger stimuli to reach activation and often do not notice various sensory inputs. Those with a Low Registration profile (high neurological threshold, passive response) are often perceived as withdrawn, inattentive, or unmotivated, as they may not notice dirty hands, someone entering a room, or even develop bruises without realising it. On the other hand, Sensation Seekers (high neurological threshold, active response) prefer a stimulus-rich environment and actively seek additional sensory experiences in their daily lives, such as engaging in sports or listening to loud music. However, their behaviours may sometimes be viewed as risky or associated with difficulties in planning for the future.

At the opposite end are individuals with a low neurological threshold. Sensory Sensitivity (low neurological threshold, passive response) involves easily noticing sensory stimuli, which can cause discomfort in stimulus-rich environments. These individuals may be easily distracted by movement, sounds, or smells that others may not even perceive. Their responses are passive, in contrast to those with a Sensation Avoiding profile, (low neurological threshold, active response) who actively try to limit sensory input. They often avoid places with excessive sensory stimulation, prefer routines in their daily activities and negatively react to disruptions in their habits.

Dunn emphasises that her approach addresses the diversity of sensory processing styles and their impact on individuals' daily lives, including not only people with sensory processing disorders but also neurotypical individuals, viewing these differences as a natural variation within the human population. The application of Winnie Dunn's concept can be particularly valuable in therapy for sensory processing disorders, especially in individuals with autism spectrum disorders (ASD) or

anxiety disorders. Additionally, it allows for the personalisation of education to meet the sensory needs of students, adaptation of environments and interventions in elder care facilities, and improvement of workplace conditions tailored to the sensory profiles of employees.

It has been shown that sensory processing disorder can persist into adulthood and is associated with difficulties in social and emotional functioning, leading to lower self-esteem, social discomfort and anxiety [4]. Over the last two decades, there has been growing interest in the connections between sensory processing and mental disorders in the adult population. Nevertheless, neither the American DSM-5 [5] classification nor the European ICD (both versions 10 and 11) [6] recognise sensory integration disorders as a psychiatric diagnosis. However, sensory processing disorder has been classified in the *Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood DC: 0-3 R* from 2005, which is an important supplement to DSM and ICD [7]. In everyday clinical practice, the issue of SPD in adults with psychiatric disorders is very poorly recognised, from diagnosis, through psychoeducation, to therapy.

This article will discuss the clinical relationships between sensory processing disorders and psychiatric disorders in both children and adults (with an emphasis on the adult population), the frequency of co-occurrence of both disorders, diagnostic aspects, as well as therapeutic implications and possible future research directions. Due to the vast scope of the subject in its theoretical and historical aspects, we refer interested readers to our article titled *The Phenomenon of Sensory Processing – Historical Overview, Theoretical Models, and Neurophysiological Underpinnings* (under review), where these issues are discussed in more detail [8]. The literature review methodology was based on the PRISMA model, as illustrated in Figure 1.

1. Methodology of literature review based on the PRISMA model

Given the review nature of this publication, the inclusion criteria covered studies on both adults and children, healthy individuals as well as those with mental disorders. Research based on animal models regarding sensory processing was also included. There was no exclusion criterion for the age, gender, or the number of studied groups. Articles from 1972 to 2023 were considered. Only works in English were eligible for analysis.

Three databases were utilised for the analysis: PubMed, SCOPUS and Google Scholar. Consideration was given to opinion pieces, literature reviews, meta-analyses, and academic textbooks. In cases of uncertainty about individual studies, researchers committed to contacting the authors to obtain detailed information.

For searching articles in PubMed, key words such as “sensory processing”, “sensory integration”, “sensory processing disorder”, “autism spectrum disorder”, “ASD”, “hypersensitivity”, “hyposensitivity”, “sensory seeking”, “sensory avoidance”, “schizo-

phrenia", "bipolar affective disorders", "depression", "anorexia", "mood disorders", "anxiety disorders", "occupational therapy" were used. Exclusion key words included "case description", and "case analysis". Due to the wide range of terminology in the literature on sensory processing, we chose to include in the search results only terms that are clearly defined and associated with well-established theoretical models that have application in research with adults. The key conceptual framework for this review was W. Dunn's (1997; 1999) Four Quadrant Model, which assumes differences in sensory threshold levels and response strategies, and allows for the identification of four processing profiles: Sensation Seeking, Sensory Sensitivity, Low Registration, and Sensation Avoiding. The model has been widely adapted to studies of adult populations, including those with psychiatric diagnoses, and has the practical advantage of the presence of validated diagnostic tools (e.g. the Adolescent/Adult Sensory Profile), which allows standardisation of measurement and facilitates intergroup comparisons. In this regard, the term "sensory reactivity" – although present in the literature and used, among others, by continuators of the thought of A. Jean Ayres – was not included in the search strategy, as it does not explicitly refer to a coherent system of concepts and research tools applied to adults with mental disorders.

This procedure was repeated for the other databases. The initial key word search was supplemented by a manual search to identify all missing or incomplete articles.

The search began with the PubMed database using key words related to the relationship between sensory processing and autism spectrum disorder according to the scheme below, which was then repeated for the other mental disorders discussed in the article.

((((((((((sensory processing[Title/Abstract]) AND (autism spectrum disorder[Title/Abstract])) OR (sensory integration[Title/Abstract])) AND (autism[Title/Abstract])) OR (sensation avoiding[Title/Abstract])) OR (sensation seeking[Title/Abstract])) OR (sensory sensitivity[Title/Abstract])) OR (low registration[Title/Abstract])) OR (sensory processing sensitivity)) OR (occupational therapy)) NOT (case study[Title/Abstract])) NOT (case report[Title/Abstract])

The selection of studies was conducted by two independent authors. In the first stage, duplicate studies were eliminated. Then, titles and abstracts were reviewed to determine their inclusion for further analysis. After excluding based on the abstract, the relevance of the studies was examined twice by analysing the full text. This process eliminated studies that were not relevant to the research topic or the sources of which were poorly described. After a second analysis, four previously rejected articles were included. Finally, the consistency of the topic and results of the publications was analysed. This concluded the selection of studies, identifying only the essential literature strictly related to the topic of the paper, by the journal's requirements. Ultimately, 89 articles were qualified, which formed the basis for this publication. A detailed description is provided in Figure 1.

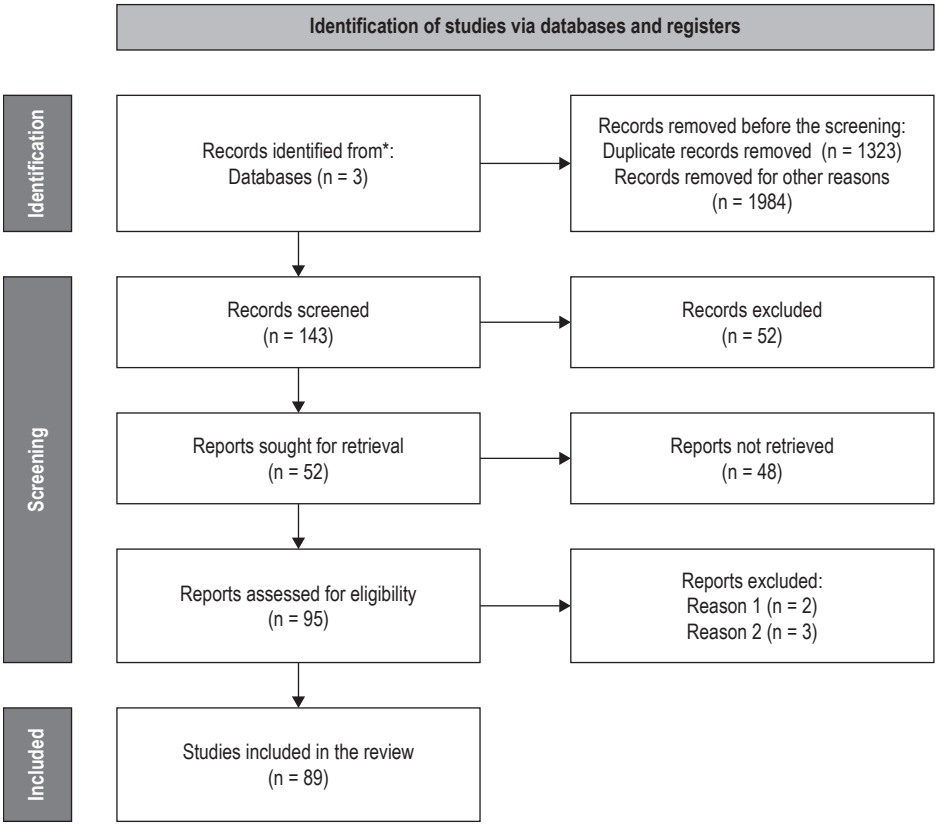

Figure 1. **PRISMA model**

2. Assessment of sensory processing

Several methods are available for assessing sensory processing: self-assessment questionnaires and examiner assessments, psychophysical assessment, direct behavioural observation, neuroimaging, and brain bioelectrical activity studies (EEG). Currently, there is no single test that can assess all aspects of sensory processing, and each method has its advantages and limitations in clinical practice [9]. Among scientific works, a multimodal approach using various methods is recommended to objectify research findings.

In clinical practice and scientific research, questionnaires dedicated to the general population of adults and adolescents are most commonly used, such as the *Adolescent/ Adult Sensory Profile* (AASP) [10], *Sensory Profile* [3], *Sensory Over-Responsivity Scale* [11], *Sensory Perception Quotient* [12], *Adult Sensory Interview* [13], and *Short*

Sensory Profile [14]. Due to the reference norms and the ease of application and interpretation in everyday clinical practice, we describe these methods in more detail, with particular emphasis on two selected methods that can be applied to the adult population. A fundamental limitation of self-assessment questionnaires is the reliability of results and often difficulties in their application among patients with mental disorders [15]. In the case of an examiner assessments, it is important to consider the limitations arising from the examiner's skills, understanding of sensory processing, and the often time-consuming nature of the process, especially with patients who have communication difficulties.

The AASP questionnaire identifies four sensory profiles: Sensory Sensitivity, Low Registration, Sensation Seeking, and Sensation Avoiding, according to Winnie Dunn's Four Quadrant Model (Figure 2). It applies to populations in three age ranges: 11–17 years, 18–64 years, and 65 years and older. It includes 60 questions related to six aspects of sensory processing: smell/taste, vision, movement in response to proprioceptive and vestibular stimuli, touch, activity level, and hearing, assessed on a 5-point frequency scale of occurrence of a particular reaction/behaviour, from "almost never" to "almost always". The sum of points in each of the four quadrants yields results defined as lower ("less" or "significantly less than most people") or higher ("more" or "significantly more than most people") compared to reference values ("similar to most people"). Each quadrant is treated as a separate continuum, however, they are connected to one another, e.g. the Sensory Sensitivity area often correlates with Sensation Avoiding.

A longer version of the AASP is the *Sensory Profile* questionnaire, consisting of 125 questions, developed by Dunn for caregiver-assessed frequency of a patient's reaction to a sensory stimulus [3]. Questions are divided into three categories: sensory information processing from the senses, stimulus modulation and behavioural-emotional response. According to the scale construction, a lower score indicates more severe symptoms. The questionnaire is divided into questions with low and high arousal thresholds. A high threshold describes the lack of response or the need for a stimulus of greater intensity. A low arousal threshold describes the perception of stimuli of lower intensity or irritability caused by sensory stimuli. This scale is mainly used among patients with a diagnosis of autism spectrum disorder. The Polish adaptation of the *Short Sensory Profile-2* was published in 2019 [16].

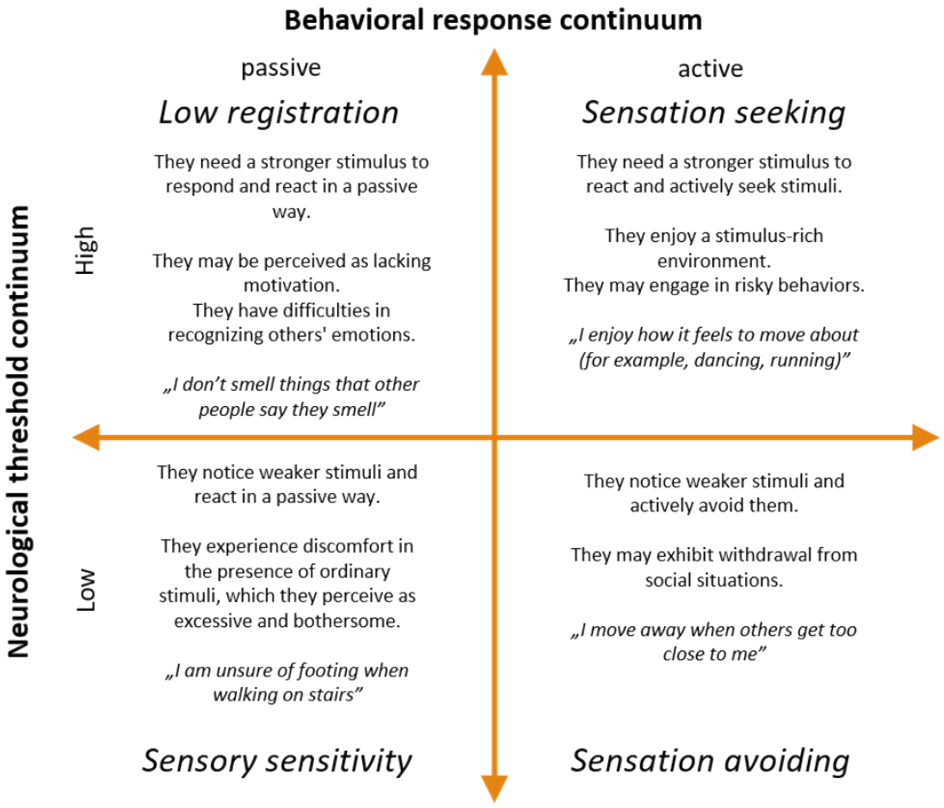

Figure 2. **The Four Quadrant Model based on Winnie Dunn – own translation**

There are also other questionnaire tools, which specifically address the population of individuals with ASD, such as the *Sensory Perception Quotient* (SPQ) [12], developed by Tavassoli et al. in 2014, which measures sensory perception, indicating how individuals with ASD process stimuli such as sounds or touch. The *Sensory Processing Scale* (SPS) by Schoen et al. [17] assesses responses to stimuli, hypersensitivity and avoidance of stimuli, helping to identify specific sensory difficulties affecting functioning. Additionally, the *Interoception Sensory Questionnaire* (ISQ), created by Suzman et al. [18], focuses on interoception, or the perception of internal signals, which is often different in individuals with ASD.

Psychophysical methods concerning to sensory processing include detection, differentiation, adaptation, timing, and accuracy of responses, subjective intensity, and pleasure experienced from stimuli [19]. Most methods focus on a single sensory dimension (e.g. smell) using laboratory conditions, objectively applied stimuli and specialised measurement techniques [20]. For example, stimulus detection tests as-

sess the minimum intensity level at which a person can detect a stimulus, allowing for the identification of individuals with reduced or heightened sensory sensitivity. Another group includes physiological measurement methods, which record the body's responses to stimuli. An example is skin conductance (galvanic skin response, GSR), which measures changes in sweat gland activity as an indicator of emotional arousal in response to sensory stimuli [21]. Heart rate variability (HRV) is another indicator that can reflect responses to stimuli, particularly in the context of autonomic nervous system regulation [22]. Additionally, the startle response examines the body's involuntary reaction to sudden stimuli and can be used to assess hypersensitivity to auditory or visual stimuli [23].

Although psychophysical methods can be considered more objective than self-report questionnaires and researcher assessments, there is currently no validated method that allows for a comprehensive evaluation of all dimensions of sensory processing. This significantly limits the use of such methods in clinical practice, restricting them primarily to scientific research. On the other hand behavioural observation focuses more on the functional assessment of behaviour (e.g., repetitive actions, spinning) rather than on the neurophysiological basis [24].

Neuroimaging techniques have significantly contributed to expanding knowledge about the neurobiology underlying sensory processing disorders in individuals with autism spectrum disorder. Functional magnetic resonance imaging (fMRI), as well as electroencephalography (EEG), which measures the brain's electrical activity, have been used to examine abnormal neural processing in ASD [25]. These techniques have revealed atypical connectivity patterns in brain networks responsible for sensory integration, suggesting that disruptions in both local and global neural networks may contribute to sensory processing differences. However, the main limitation of their application is the cost and they are used primarily in scientific rather than clinical settings.

3. Differences in sensory processing in selected groups of the general population

It is estimated that SPD occurs in about 5% of the general population [26] and is associated with inappropriate behaviour patterns, reduced functioning and decreased quality of life [28]. A correlation was found between higher scores in Sensation Avoiding, Sensory Sensitivity, and Low Registration among individuals with higher levels of anxiety [27]. The relationship between SPD and the experience of pain [28], negative affect [28], interpersonal difficulties [4], as well as satisfaction and quality of life has also been described [28]. It has been shown that adolescents with a higher tendency for sensation seeking are more likely to engage in leisure activities, predominantly of a creative type in contrast to those with higher scores in Low Registration and Sensation Avoiding, who were reluctant to undertake additional activities, and whose activity is mainly focused on manual and self-improvement skills [29]. A correlation

was found between higher scores in Sensory Sensitivity and Low Registration with an increased risk of perceived stress and feelings of burnout during the COVID-19 pandemic [30]. Studies using DTI have indicated that differences in the microstructure of white matter may be related to the arousal threshold for sensory stimuli among young adults [31].

Few studies focusing on the older adult group over the age of 50 have shown that they tend to avoid stimuli, have difficulties registering them and occasionally show tendencies towards stimulus modulation disorder, which leads to hypersensitivity [32]. It has been found that difficulties in registering stimuli in this group correlate with deficits in cognitive and executive functions, and significantly affect daily functioning and reduce quality of life [33]. Research indicates that individuals with passive strategies for coping with sensory stimuli struggle more in daily activities, which ultimately leads to a gradual restriction of their life activities. On the other hand, individuals who seek stimuli and enjoy sensory-rich environments experience a higher quality of life and better well-being [33]. A.J. Ayres [1] observed that children with sensory processing difficulties may experience problems with movement planning, coordination, balance, as well as functioning in daily life. Her research demonstrated that improving sensory processing can significantly impact motor, cognitive and social development, which became the foundation for sensory integration therapy aimed at enhancing the brain's ability to organise sensory stimuli in an efficient and useful manner for the individual.

4. The relationship between sensory processing and mental disorders – results of previous research

Increasing attention is being paid to sensory processing disorders in relation to mental disorders. A recently published meta-analysis demonstrated a co-occurrence between SPD and most mental disorders, with the study group showing higher scores for Low Registration, Sensory Sensitivity and Sensation Avoiding, and lower scores for Sensation Seeking [35]. A higher prevalence of SPD was described among populations diagnosed with schizophrenia [34], as well as depressive and anxiety disorders [35], showing a link between SPD and mood, temperament and daily functioning [28].

Studies indicate that SPD often co-occurs with the experience of distress and difficulties in interpersonal relationships [4], as well as with the occurrence of anxiety as a state and as a trait, being a factor influencing personality development [27]. Systematic reviews of the literature covering large groups of subjects have shown that the intensity of Sensory Sensitivity is associated with lower quality of life, fluctuations in psychological well-being, daily functioning, and general health [27]. A recent meta-analysis of data from 2022, on a group of over 2000 people, found that sensory processing disorders constitute a non-specific transdiagnostic phenotype associated with a wide spectrum of mental disorders [35].

Knowledge of the sensory processing profile in clinical practice can find wide application in various groups of patients, from children with autism to adults with mood and anxiety disorders. At the same time, existing methodological limitations and the diversity of diagnostic tools indicate the need for further development of standards for the assessment and therapy of sensory processing in various clinical contexts. A summary of current research is presented in Table 1.

4.1. Autism spectrum disorder

A considerable amount of research on sensory processing involves individuals with autism spectrum disorder (ASD) [36]. The National Institute for Health and Care Excellence (NICE) guidelines from 2012 emphasised the need for increased knowledge and awareness of sensory processing in this patient group [37]. The following year, the current DSM-5 classification was published, which includes sensory processing disorder under the second criterion for diagnosing ASD: "Restricted, repetitive patterns of behaviour, interests, or activities", describing them as "Hyper – or hypo-reactivity to sensory input or unusual interest in sensory aspects of the environment (e.g. apparent indifference to pain, heat, cold, inappropriate responses to specific sounds and textures, excessive smelling or touching of objects, fascination with lights or spinning objects)".

A 2018 meta-analysis based on 11 studies among ASD patients demonstrated correlations of sensory processing variations with attention focus and adaptive skills [38]. However, researchers noted the limited value of the evidence due to the small number of available publications. One of the latest studies attempting to describe the neurobiological basis of ASD showed a possible co-occurrence between the AMPA receptor and sensory integration disorders, suggesting potential therapeutic implications related to the use of its antagonists [39]. A 2017 article in *Nature Reviews Neuroscience* indicated that observed differences in sensory processing in genetic animal models might serve as a promising source of biomarkers for ASD [40].

Patients with ASD often show deviations in all four quadrants compared to the healthy population, with age-related differences tending to decrease, except for results in sensation seeking scale [41]. SPD in ASD patients may play a significant role in auto – and allo-aggressive behaviours, as well as stereotypical behaviours [38]. Furthermore, it has been shown that sensory processing disorders are associated with cortisol levels, where hypersensitivity to auditory stimuli correlated with higher cortisol levels and increased arousal during play [42]. Variations in sensory processing also correlate with level of community activity engagement [43]. Literature reviews have indicated a probable link between sensory processing disorders and sleep problems in the paediatric population [44]. Possible therapeutic methods, such as swimming activities or massage, were also suggested, highlighting the multidimensional nature of the clinical approach and its impact on alleviating ASD symptoms [49].

Sensory processing profiles also show gender differences in the clinical picture of individuals with ASD [45], which is crucial for constructing diagnostic tools, as undiagnosed ASD in women often leads to consequences such as the development of mental disorders, low self-esteem, educational and professional difficulties, and poorer quality of life.

Researchers have demonstrated the consistency of most of Ayres' theoretical assumptions with neurobiological studies in ASD, confirming the relevance of the theory proposed in the 1970s [46]. The effectiveness of occupational therapy has been described among patients with ASD in terms of improving functioning, increasing independence and reducing behavioural disorders [47].

Ayres' successors continued to expand research on sensory processing, focusing on specific population groups. Cermak and Daunhauer [50] studied sensory processing in children with autism, demonstrating that they have significant difficulties with sensory modulation, manifesting as either hypersensitivity or hyposensitivity to various stimuli, particularly tactile and auditory stimuli. May-Benson and Koomar [51], in her research on children with SPD, highlighted difficulties in integrating stimuli from different senses, which impacts their ability to plan movements and motor development. Lane et al. [52] extended the research to children with autism and attention deficit hyperactivity disorder (ADHD), showing problems with hyperreactivity to sensory stimuli, leading to increased anxiety levels and difficulties with concentration. This study confirmed Ayres' original hypotheses about the relationship between sensory processing and cognitive and emotional functioning. In summary, the work of Ayres' successors, developing her approach, points to specific sensory processing profiles in various population groups, such as children with ASD, ADHD, or SPD, and confirms the effectiveness of therapy for sensory processing disorders in these groups.

4.2. Schizophrenia

In the population diagnosed with schizophrenia, relevantly higher scores for Sensation Avoiding and Low Registration have been observed in comparison to the control group [48]. This aligns with earlier studies indicating possible sensory processing disturbances in schizophrenia [35], where sensory sensitivity has been described as a component of attention concentration disorders, experienced by patients as a sensation that sounds are louder and colours more vivid. Sensation Avoiding in schizophrenia is characterised by the need for a stable, undemanding environment with few environmental and social stimuli [49]. In the case of higher scores in Low Registration, individuals with schizophrenia often struggle to respond to a stimulus or to match the appropriate significance to the received stimulus, which can lead to delayed reactions [50]. Some researchers suggest that anhedonia, a common symptom of schizophrenia, may be seen as the extreme opposite of behaviours associated with the Sensation

Seeking profile [51]. A negative correlation between Sensation Seeking and negative symptoms has been reported [36].

Researchers addressing this issue have indicated that different results in the sensory processing profile of schizophrenia and bipolar affective disorder may also stem from the phrasing of questions in the AASP questionnaire, as the questions mostly concern the frequency of experiencing stimuli, not their intensity. This may suggest that patients with schizophrenia are as frequently sensitive to the same stimuli as patients with bipolar affective disorder, but they experience more intense discomfort associated with it.

4.3 Affective disorders

In relation to individuals with bipolar disorder (BD), contrary to expectations, higher Sensation Seeking scores were not found to occur more frequently than in the control group [52], while higher scores on the Sensation Avoiding scale were observed compared to the healthy group. One possible reason why significantly higher scores for Sensation Seeking were not observed (despite being 4–5 points higher following a recent manic episode) is the construction of the questionnaire. The statements do not emphasise impulsivity or the undertaking of risky activities observed in mania but merely reflect engagement in daily activities in response to sensory stimuli. Other studies have shown that patients with BD have higher values for Sensation Avoiding, Sensory Sensitivity and Low Registration compared to the healthy population [53]. A nearly fivefold lower tendency for Sensation Seeking in relation to depression in the course of BD confirms earlier observations [54] that patients in this group are characterised by emotional under-reactivity and inhibition [55].

Research indicates that the type of sensory profile is not dependent on the clinical state but rather forms a consistent pattern that may co-occur with temperamental traits and thus is considered a characteristic feature of affective disorders [60]. However, the type of sensory profile may change in intensity during disease episodes. Research has demonstrated a relationship between higher scores in Low Registration and increased depressive mood and a sense of hopelessness, a negative correlation between higher scores in Sensation Seeking and anhedonia [59], and a positive correlation with a hyperthymic temperament, which has been indicated as a potential protective factor against suicide [56]. Further research is needed to determine whether the Sensation Seeking profile can be a protective factor against the occurrence of affective symptoms and their consequences [61]. Among patients diagnosed with BD, higher scores in Low Registration and Sensory Sensitivity have been linked to increased symptoms of irritability and engagement in risky behaviours [57].

Among patients diagnosed with depression, studies have shown that the sensory processing profile differs in all four quadrants compared to the healthy population [58]. It was noted that patients with dominance of Low Registration had a greater intensity

of depressive symptoms both in the population with ASD [59] and in the population of patients with BD [61]. In one comparative study for populations diagnosed with unipolar and bipolar depression [60], no significant differences in sensory processing were found, but the association of Low Registration, Sensory Sensitivity and Sensation Avoiding with reduced quality of life was clearer for the group with unipolar depression. Additionally, sensory processing profile in this group was associated with alexithymia, impulsivity and a sense of hopelessness [61].

4.4 Other mental disorders

The relationship between SPD and anxiety disorders, such as generalised anxiety [62] and obsessive-compulsive disorders [63], has been described, particularly higher scores in Low Registration, Sensory Sensitivity and Sensation Avoiding correlated with anxiety disorders [64]. It has been hypothesised that SPD symptoms in childhood may contribute to the development of anxiety disorders in adulthood [66]. It has been shown that the dominance of Low Registration is associated with diminished emotional responses in post-traumatic stress disorder (PTSD) [37]. Additionally, this profile was a significant predictor of anxiety, with men scoring high on the Low Registration scale displaying greater trait anxiety than women [27].

Studies in the group of patients with personality disorders have shown higher scores for Sensory Sensitivity and Sensation Avoiding in women with borderline personality traits [65]. Sensory Sensitivity fits into the pattern of personality disorders as a characteristic co-occurring with increased emotional reactivity and a tendency to overly expressed reactions in response to stimuli, meaning that such individuals are more susceptible to being overwhelmed by sensory stimuli and often perceive the environment as unpredictable and anxiety-provoking. Withdrawal from activities with a sense of discomfort and anxiety as a characteristic feature of borderline personality disorders may be explained by a higher score on the Sensation Avoiding scale.

Recent studies conducted among children and adolescents diagnosed with anorexia suggest that higher scores in sensory sensitivity observed in this patient group may be a consequence of chronic starvation [66]. A small percentage of patients (both adults and children) with ADHD have been reported to exhibit sensory processing disorders [67], primarily characterised by a dominance of Low Registration and Sensory Sensitivity traits, suggesting that these individuals perceive stimuli selectively, leading to responses perceived by others as atypical and unpredictable [68].

5. Practical applications of sensory processing theory

The practical applications of sensory processing theory are vast and pertain to both healthy individuals and those with mental disorders. Understanding differences in sensory processing among students can be used by teachers to tailor teaching meth-

ods and support their development [69]. In patients with mental disorders, therapy for sensory processing disorders can help regulate emotions, and reduce stress, anxiety and aggression. Breathing techniques, massages, or appropriately chosen visual stimuli improve mood regulation and reduce psychopathological symptoms [70]. By exposing patients who show heightened hypersensitivity or hyposensitivity traits to controlled sensory stimuli, therapists can help increase tolerance to stimuli and thereby improve patient functioning. Therapy for sensory processing disorders can also positively affect cognitive functions, such as memory, concentration and attention, by activating relevant brain areas [71]. It can be an effective tool in reducing behavioural disorders, such as aggression, self-harm, or impulsivity [72], and patients may experience increased self-awareness, better control over their reactions and greater satisfaction with daily functioning [73]. Therapy for sensory processing disorders can also be useful as a tool for facilitating other forms of therapy, such as cognitive-behavioural therapy [74]. An interesting direction is also the design of environments in hospitals, care homes, or clinics, taking into account the sensory needs of patients [80].

Based on research results analysing the sensory profile, the concept of "sensory rooms" has been developed [75], which contain various types of furnishing elements (rocking chairs, stress balls, weighted blankets) and are intended to intensify or tone down the delivered stimuli. Haig and Hallet [76], in an analysis of 17 studies using sensory rooms for hospitalised psychiatric patients, observed beneficial effects, including increased emotional regulation and support for self-control. The *Snoezelen* occupational therapy (initiated in the Netherlands in the 1970s) has been applied to patients with dementia, pain, intellectual disabilities, or Rett syndrome. The use of *Snoezelen* therapy in psychiatric wards has led to a reduction in stress levels, decreased psychomotor agitation and hostile and aggressive behaviours, which translated into a statistically significant reduction in the number of applied restraint and isolation procedures [77]. Both *Snoezelen* therapy and therapy for sensory processing disorders take into account the impact that various stimuli (visual, auditory, tactile) have on the nervous system. Both methods are used for individuals with neurodevelopmental disorders, such as ASD, ADHD, or intellectual disabilities.

Snoezelen therapy is primarily focused on relaxation, aiming to reduce stress and improve well-being, and is often used as a complementary therapy. In contrast, therapy for sensory processing disorders is a rehabilitative treatment aimed at improving the brain's ability to integrate and process stimuli in a way that enhances daily functioning. Therapy for sensory processing disorders typically takes place in specially equipped sensory or therapy rooms under the supervision of a certified therapist. *Snoezelen*, on the other hand, is more recreational in nature and can be implemented in a variety of care facilities, hospitals, schools, or even private homes [78].

A very important element of treating patients, whether with psychiatric, neurodevelopmental, or neurological disorders, is occupational therapy based on sensory

interactions, such as modelling clay or sensory games [79]. One possible development of occupational therapy is the creation of so-called sensory gardens, which stimulate different senses and offer space for relaxation, reflection and therapy for people with various sensory needs [80]. They represent a natural extension of the *Snoezelen* concept and therapy for sensory processing disorders, combining sensory stimulation with the opportunity to be outdoors and close to nature. Similar to *Snoezelen*, sensory gardens have a relaxing nature and do not require a strict therapeutic structure. Individuals in sensory gardens can freely explore stimuli and engage in experiences at a level that is comfortable for them. Both methods, *Snoezelen* therapy and therapy for sensory processing disorders can be successfully applied in the context of sensory gardens, where users can engage in outdoor sensory experiences.

Currently, the STAR (Sensory Therapies and Research) initiative is under research, which assumes the use of a sensory approach in relationship-based therapy [80]. A tangible benefit of the Wallace Research Foundation (WRF, 1994–2019) project was the funding of a study on the impact of brain training on cognitive control in children with SPD, the results of which contributed to the approval by the U.S. Food and Drug Administration (FDA) of the first digital therapeutic tool to improve attention focus (EndeavorRX) dedicated to children with ADHD.

6. Future research directions

Recently, imaging studies regarding sensory processing as a more objective measurement method have garnered significant interest, compared to the commonly used self-assessment questionnaires. In one study using DTI, disturbances in the white matter microstructure among children with SPD compared to typically developing children were shown, suggesting the use of these differences to develop new imaging biomarkers for neurological disorders based on machine learning algorithms [81]. Another study, also using diffusion tensor imaging, detected greater white matter lateralisation among hypersensitive children compared to typically developing children [82]. Further research in this area could provide clinically useful imaging markers for mental and neurodevelopmental disorders, expand knowledge of the biological basis of sensory processing disorders, and enable the selection of individual therapeutic methods. Recent studies indicate that sensory disorders among patients with ASD can either recede over time, worsen or remain unchanged [83], which justifies further research focusing on changes in sensory processing disorder over time.

One interesting research direction is evaluating the relationship between the sensory profile and the efficacy of pharmacotherapy. It has been shown that individuals with very low scores in Sensation Seeking, Sensory Sensitivity, and an increased tendency for Sensation Avoiding and Low Registration responded better to antidepressant treatment after 6 months of therapy [64]. Moreover, the length of the depressive episode correlated with: (1) greater sensory stimulus registration and less sensory stimulus

avoidance among patients with unipolar disorder; (2) lower sensory stimulus registration and a higher tendency for sensitivity/avoidance among individuals with bipolar affective disorder; (3) lower sensory sensitivity/avoidance in individuals with anxiety disorder. Additionally, the greater intensity of drug side effects correlated with lower sensory sensitivity in individuals with BD [64]. In this context, it seems crucial to study the connections between the sensory profile and the resistance to depression treatment.

In future research, it would be valuable to focus on changes in sensory processing across different stages of life – from childhood, through adulthood, to old age. This could help better tailor therapies to the specific needs of different age groups. There is a need for further development of diagnostic tools that would allow for a more objective assessment of sensory processing. The development of detailed psychophysical or neurophysiological tests (e.g. based on measurements of skin conductance, heart rate variability and brain bioelectrical activity) may lead to more accurate diagnoses. Given the cultural differences in the perception of sensory experiences, research should also focus on validating existing diagnostic tools across different cultures to ensure that diagnoses are accurate while taking cultural context into account.

Further studies are needed to assess the long-term effectiveness of sensory processing disorder (SPD) therapies in both children and adults. It is important to investigate which patient groups benefit most from interventions and what factors influence the effectiveness of therapy. The development of new therapeutic approaches based on neuroplasticity, such as neurofeedback therapies, mindfulness training, or the integration of virtual reality (VR) techniques, could offer new possibilities for treating SPD. Research should focus on evaluating their effectiveness and safety. It is also worth examining how socio-economic factors, such as stress levels, access to healthcare, or environmental quality (e.g. urban noise), affect sensory processing disorders and the effectiveness of therapy.

A new research direction is also exploring the relationship between sensory processing, the autonomic system and somatic symptoms such as gastrointestinal disorders, migraines, or cardiac rhythm disorders. In a study conducted among adolescents with migraines, lower Sensation Seeking scores, and higher Sensation Avoiding and Sensory Sensitivity scores were observed compared to the healthy group [84]. Researchers conclude that the lesser tendency to seek sensory stimuli among migraine patients is associated with worsened daily functioning and increased pain perception. It has been shown that in a group of individuals with psychiatric disorders, higher scores in Low Registration, Sensory Sensitivity and Sensation Avoiding were associated with respiratory sinus arrhythmia and reduced interest in social life [85]. There is still a lack of genetic research that would explain the basis for the development of sensory processing disorders and their higher incidence in the patient group with mental disorders.

Recapitulation

The article presents a review of the literature on the comorbidity of sensory processing disorders and psychiatric disorders. The analysis of available studies indicates that difficulties in sensory processing can affect daily functioning, quality of life, interpersonal relationships, and participation in social life, emphasising the need to tailor therapy to patients' individual sensory patterns. Sensory processing profiles have broad applications in clinical practice across various patient groups, from children with autism spectrum disorder to adults with mood and anxiety disorders. At the same time, existing methodological limitations and the diversity of diagnostic tools highlight the need for further development of assessment and treatment standards for sensory processing in different clinical and cultural contexts. Additionally, the article highlights the potential benefits of using therapy for sensory processing disorders as a supplement to traditional treatment methods. It also emphasises the need for further research to better understand these relationships and develop more effective therapeutic strategies. This review is crucial for clinicians, therapists and researchers, providing knowledge about the complexity of sensory processing disorders and their impact on mental disorders, which may contribute to improving diagnostic and therapeutic standards in the future.

Table 1. **Comparison of selected publications used in the study**

Authors	Population and diagnosis	Results	Limitations	Sample size	Year of publication
Ben-Avi N, Moshe A, Engel-Yeger B	Adults, without psychiatric disorders	Association of SPD with distress and difficulties in interpersonal relationships	Small sample size, use of only self-report questionnaires	n = 139	2012
Engel-Yeger B, Dunn W	Adults, without psychiatric disorders	Association of Sensory Sensitivity and Low Registration with higher state and trait anxiety	Small sample size, cross-sectional design limits causal conclusions	n = 135	2011
Costa-Lopez B, Ferrer-Cascales R, Ruiz-Robledillo N, Albaladejo-Blazquez N, Baryła-Matejczuk M	Healthy individuals and individuals with psychiatric disorders, adolescents, adults and older adults	Association of Sensory Sensitivity with lower quality of life, fluctuations in well-being, daily functioning, and overall health	Various diagnostic tools and study designs (cross-sectional, randomised, cohort)	n = 1903 (systematic literature review)	2021
van den Boogert F, Klein K, Spaan P, Sizoo B, Bouman YH, Hoogendijk WJ et al.	Adults with psychiatric disorders	SPD as a non-specific transdiagnostic phenotype associated with a wide spectrum of psychiatric disorders	Limitation of analysis to questionnaires, use of only one tool (AASP)	n = 2008 (meta-analysis)	2022

table continued on the next page

Dellapiazza F, Vernhet C, Blanc N, Miot S, Schmidt R, Baghdadli A	Children with autism spectrum disorder	Prevalence of SPD in 82–97% of children with ASD. Association with adaptive behaviour disorders and attention problems	Use of indirect methods for assessing sensory processing, limitation to literature from the last ten years, and lack of control groups in most studies	n = 874 (systematic literature review)	2018
Bagatell N, Chan DV, Syu YC, Lamarche EM, Klinger LG	Adults with autism spectrum disorder	Association of SPD with social functioning	Small sample size, caregiver assessment	n = 6	2022
Engel-Yeger B, Gonda X, Muzio C, Rinosi G, Pompili M, Amore M et al.	Patients with affective disorders	Association of Low Registration, Sensory Sensitivity and Sensation Avoiding with lower quality of life in individuals with recurrent depression	Cross-sectional study design, lack of psychometric tools to assess symptoms of mania/hypomania and depression, lack of a control group	n = 267	2016
Serafini G, Gonda X, Canepa G, Pompili M, Rihmer Z, Amore M et al.	Euthymic patients diagnosed with bipolar disorder and depression	Association of Low Registration with depression, impulsivity, alexithymia and hopelessness	Cross-sectional study design, use of self-report tools only	n = 281	2017
Cervin M	Children and adolescents with obsessive-compulsive and anxiety disorders and healthy children	Higher prevalence of SPD in children with obsessive-compulsive, anxiety disorders and internalising symptoms	Relatively small sample size, cross-sectional study design	n = 214	2023
McMahon K, Anand D, Morris-Jones M, Rosenthal MZ	Adults diagnosed with anxiety disorders and a history of sensory processing disorder in childhood	Association of childhood SPD with anxiety disorders in adulthood; mediating role of emotion dysregulation	Retrospective and cross-sectional study design, self-report questionnaires, predominance of females	n = 231	2019

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Corresponding author: Natalia Grobelna
e-mail: nataliagrobelna07@gmail.com