SENSORY PROCESSING IN CHILDREN WITH AUTISM- A SCOPING REVIEW

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Abstract:

Difficulties in sensory processing in children with autism have been known since the first descriptions of autism. The oldest and most recent theories of autism are based on the assumption that people with autism process sensory information differently than people without autism. This work aimed to examine sensory patterns and systems of sensory processing in children with autism and children with typical development through a systematic review of the relevant literature. From December 2022 to May 2023 by searching the online databases for publications in the field of autism and sensory processing, namely PubMed, Eric, Web of Science, Google Scholar, and Scopus, a total of 254 publications were identified. After applying inclusion criteria 5 publications that were analyzed. The search was performed by combining the keywords "autism", "sensory processing" "sensory processing disorder". The results show that children with autism manifest more atypical sensory processing than typically developing children. Furthermore, children with autism show differences in sensory patterns and systems, which indicate greater problems and greater concern within sensory processing. These results highlight the importance of developing treatments and interventions aimed at improving sensory processing in children with autism and alleviating the symptoms of atypical sensory processing.

Keywords: autism, sensory processing, sensory processing disorder.

INTRODUCTION

Autism is a neurodevelopmental condition characterized by difficulties in social interaction and communication, as well as restricted and repetitive patterns of behavior, activities, and interests (American Psychiatric Association 2013). The incidence rate has shown an increasing trend according to recent epidemiological studies. In 2006 it was 1:100 among children, 1:88 in 2008 increasing to 1:68 in 2010 (Cho and Ahn, 2016). Autism is earlier and more often diagnosed in individuals of male gender, where recent large population studies report a 1:3 male-female ratio. (Loomes et al., 2017, Zablotsky et al., 2015). For autism to be diagnosed, the main symptoms must appear in the early development period and interfere with the child's daily activities, which refers to the fact that the symptoms are typically recognized in the second year of life, but can be observed even earlier (APA 2013). Some of the most common symptoms are related to attention difficulties and impairment of cognitive, sensory, motor and emotional functions. According to the diagnostic criteria of the DSM-5 classification within the B criteria, which refer to restrictive, repetitive, stereotyped behavior and activities, specific sensory interests are also included as one of the characteristics (APA 2013). Difficulties and specifics in sensory processing in children with autism have been known since the first descriptions of autism, and the oldest and most recent theories of autism are based on the assumption that people with autism process sensory information in a different way compared to other people (Frith, 1989, Hutt and et al., 1964, Mottron et al., 2005). The first clinical reports of unusual reactions to sensory stimuli date back to Kanner's report from 1943 (Kanner, 1943).

Sensory processing

Sensory processing is a neurobiological process of organizing incoming sensory stimuli from inside the body or the environment. When a person perceives information or stimuli, they are forwarded to a certain cortical structure where reception, modulation, integration, and the organization of sensory stimuli is carried out, such as behavioral responses to sensory input (Miller et al., 2000).

In 1997, Dunn proposed and posited four forms of sensory processing resulting from interactions between threshold types (high or low) and response types:

1) weak registration or low registration - passive behavioral responses with tall neurological threshold. Individual inside this one doesn’t perceive patterns of the same intensity information environment and it doesn't seem like there is the need to satisfy own answer (passive). One of

the examples of this behavior is the unconsciousness of a child that his face or hands are dirty (Pérez-Fonseca and et al., 2019).

2) sensitivity to sensory stimuli (sensory sensitivity) - passive behavioral reaction with a low neurological threshold. Kids are able to perceive feelings despite the fact that they include small quantity or intensity information, becoming a simple kind of " radar " when disclosures information, but they do not acquire it active role to oppose her threshold, an example that clearly describes this one pattern is a distraction which occurs in noisy environments.

3) sensory search - active behavioral reactions with a high neurological threshold. Examples of this behavior are: continuously searching for movement, appearing unaware of danger, constantly searching or making noise, crushing subjects, excessively touching or hugging others, and carrying inedible objects in the mouth (Pérez-Fonseca et al., 2019).

4) sensory avoidance (avoidance feeling) - Sensory input bothers a child, triggering an active response - characterized by sensory avoidance (avoidance feeling) and behaviors with a low neurological threshold (Dunn, 1997, DeBoth et al., 2017).

Sensory systems

We get information about ourselves, the body, and the environment that surrounds us through the senses/modalities (Biel and Peske, 2007). In humans, we distinguish seven senses: the sense of touch (includes the feeling of pressure, pain, vibration, temperature), the sense of balance and movement, the vestibular sense (which helps us maintain stability and orientation in space), the proprioceptive sense (which allows us to we consciously feel that we position parts of the body in relation to others and by the extent of movement of different parts of the body), and the senses of hearing (auditory), sight (visual), taste and smell (oral-gustatory and olfactory) (Ayers, 2002). Once upon a time, we used to say that the senses are "food for the brain" because they provide energy and control of the body and mind. Humans naturally seek sensations that improve brain organization, so children with autism often seek visual stimulation, alternating light, rotating objects, a tip or a sheet of paper in the front eyes, activating optokinetic nystagmus that stimulates the vestibular core (Thye et al., 2018). In addition to the above, children with autism often seek strong proprioceptor stimuli for strong pressure - they drag their hands in various cavities in space - under pillows, mats, and mattresses. In children with autism, they are present and seek vestibular stimulation such as rocking, swinging the head down so that it hangs upside down while lying down, or avoiding experiencing vestibular inputs, for example, fear of uneven, soft ground, uncertainty on stairs (Thye et al., 2018). Children with

autism differ from other children precisely in their sensory experience (Baio et al., 2018). They have a different sensory profile from typically developed children, which is reflected in their inadequacy of response to certain sounds, sensitivity to the taste of certain foods, and often insensitivity to pain compared to typically developed children and children with other developmental disabilities (Demirović and et al., 2018).

Objectives and hypotheses

The primary goal of this review, after searching and recording the relevant literature, is to examine the sensory processing of code in children with autism and children with typical development. Sensory processing was examined through sensory patterns and sensory systems. Considering the basic characteristics of autism and deviations from typical development and sensory processing, the first assumption is that children with autism will show differences in all sensory patterns and sensory systems. Based on this, the following hypothesis was defined:

1. Hypothesis I: Children with autism manifestt differences in all sensory patterns and systems.

The next assumption is that the differences in sensory patterns and sensory systems between children with autism and children with typical development indicate that children with autism will show greater problems in sensory processing. Based on that, the following hypothesis was defined:

1. Hypothesis II: Children with autism will show greater problems or greater concerns within sensory processing than children with typical development.

METHOD

From December 2022 to May 2023 online databases for publications from areas of sensory processing and autism were searched including PubMed, Eric, Web of Science, Google Scholar, and Scopus. The search strategy involved a combination of keywords " autism ", " sensory processing " " sensory processing disorder ". By using the term " autism " we also included the population with a diagnosis of disorder from spectrum autism, autism, Asperger's syndrome, and PDD-NOS. The initial the search resulted in a total of 254 publications. In this one phase applied are criteria including

1) Publications contain keywords in the title (" autism ", " sensory processing ", „sensory processing disorder ")

2) Publications in English language

3) Publications are reviewed and published on the searched bases

In addition to the above, for inclusion in this review they have to satisfy the next criteria:

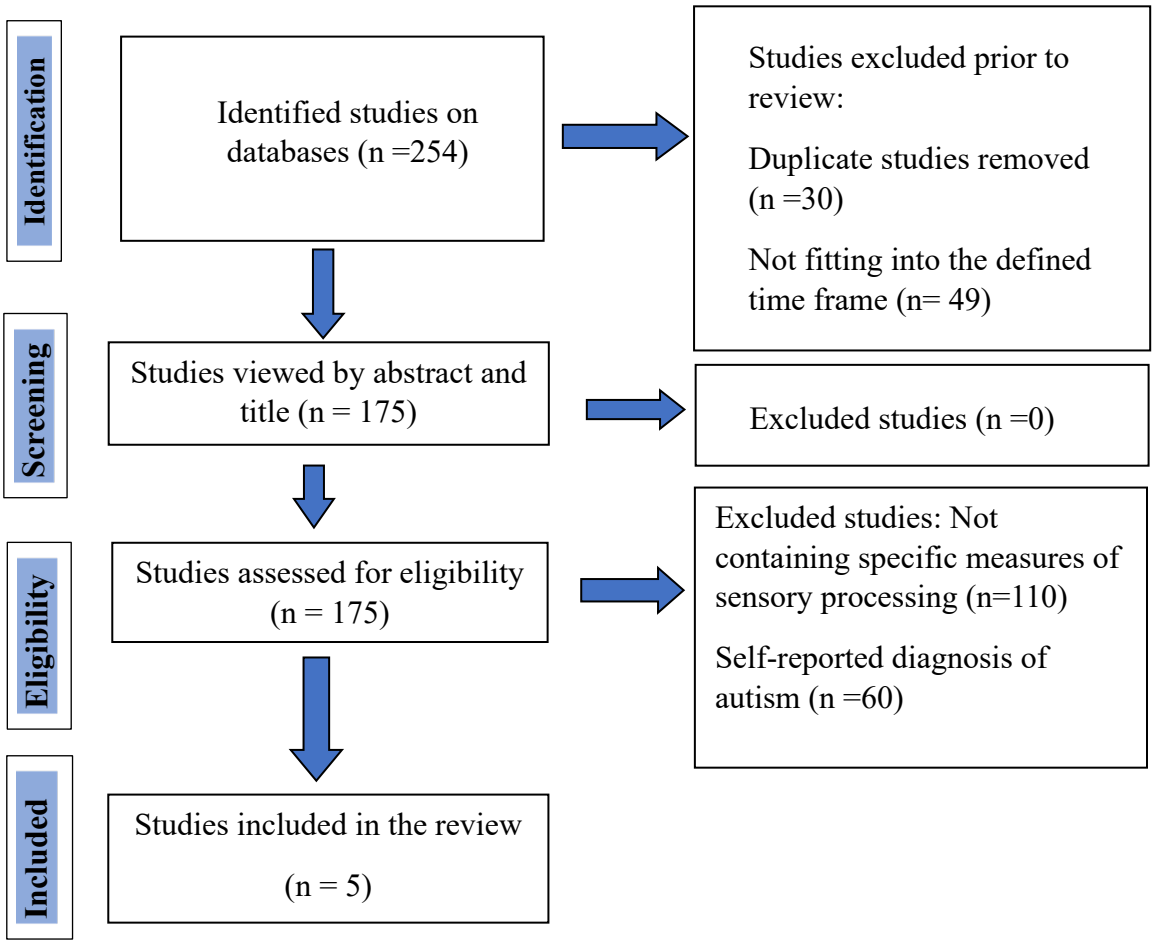
1) Publications are published in the period from January 2013 to May 2023 in the searched online databases data.

2) The population in the publications is diagnosed and/or to the end study have confirmed diagnosis of autism (disorder from spectrum autism, autism, Asperger's syndrome, PDD-NOS) or have a diagnosis reported by parents.

3) Publications contain measures of sensory processing

By applying these criteria, 110 publications were initially excluded because they did not contain concrete measures of sensory processing. 60 publications were excluded because the participants self-reported the autism diagnosis autism which was not further examined nor confirmed until the end of the research. Also, 30 duplicates were excluded and 49 publications which did not fit into the defined time frame (all 49 publications were published before 2013).

Figure 1. PRISMA Flow Diagram



RESULTS

Of the total of 5 publications included in this review, n=2 (Roknić, Vuković, 2021, Pérez et al., 2019) included only a group of participants with autism and a group of children with typical development, while the remaining n=3 included children with other developmental disabilities. The number included varies from a minimum of N=59 (Pérez et al., 2019) to a maximum N= 380 (Niedźwiecka et al., 2019). One publication includes n=1 participants with a gain range from 16–36 months, and the middle age participants 24.98 months (Niedźwiecka et al., 2019). The other four publications n=4 have a similar age range, shown in Table 1. Also, four publications of N=4 include female and male gender, while one study did not specify gender (Dellapiazza et al., 2021).

Table 1. Number and age of participants in the included studies

Authors	**Participants**	**Age**
1. Alicja Niedźwiecka, Zuzanna Domasiewicz, Rafał Kawa, Przemysław Tomalski and Ewa Pisula	N = 380	From 16 to 36 months
2.Lauren M. Little, Evan Dean, Scott Tomchek and Winnie Dunn	N=239	From 3 to 14 years
3. Ana T. Roknića, Sanja P. Vuković	N=120	From 3 to 13 years and 10 months
4.Florine Dellapiazza, Cécile Michelon, Christelle Vernhet, Filippo Muratori, Nathalie Blan, Marie-Christine Picot Amaria Baghdadli	N=120	From 6 to 12 years
5. Rebeca A. Pérez, Germán E. Burguillos-Torres, Victoria G. Castillo-Velásquez, Natalia Moreno-Zuleta, Rosa I. Fonseca-Angulo, Cesar Blumtritt, and Rafael García-Jiménez	N=59	From 3 to 12 years

Autism measures: for diagnosis by a child psychiatrist and psychologist based on ICD-10 criteria (n=2), DSM-IV or DSM-V diagnosis by a psychiatrist or clinical psychologist in a recognized PSA specialist clinic (n=2), Diagnostic Autism Interview - Revised (ADI-R) (n=1), Autism Diagnostic Observation Schedule – Second Edition (ADOS-2) (n=1), Autism symptomatology was assessed using the SRS-2 (n=1), in one In the study, the diagnosis of autism was reported by the parents.

Sensory processing measures were used: Winnie Dunn Spanish version sensory profile test (n=1), sensory profile second edition (n=1), child sensory profile 2 (SPD-2) (n=2), infant/toddler sensory profile of children - Polish version (n=1).

Other measures used by the authors of the publications : for the connection between the sensory profile and attention problems, the Pearson or Spearman correlation coefficient (n=1), the Kolmogorov-Smirnov statistical test (n=1), the Shapiro-Wilk test (n= 1), for the reliability of the measuring instrument Cronbach's alpha coefficient (n=1), when checking the significance of the difference in the frequency of categories, the univariate chi-quadrant test (n=1) was used, to check the statistical significance of the obtained differences in scores, the Mann Whitney test was used (n=1), Kendall's tao coefficient (n=1), the median (Mdn) and interquadrantile range (IQR) (n=1) were used for the descriptive values of numerical variables, the Kruskal-Wallis test was used for the analysis of non-parametric parameters (n= 1), for statistics the Dun bin-Watson test was used for (n=1), attention problem CBCL (n=1), in case of significant results the Bonferroni correction was used (n=2), for multivariate analysis of covariance the model was used (MANCOVA) (n=1), to examine the main effect of chronological age (CA) (n=1), ROC analyzes to establish preliminary cut-off points for quadrant scores.

Table 2. Summary of the studies included in the review

Authors	Comparison groups	Participants (N)	Age range	Middle age	Sex/Gender	Measures of autism	Measures of sensory processing
1. Alicja Niedźwiecka, Zuzanna Domasiewicz, Rafał Kawa, Przemysław Tomalski and Ewa Pisula	ASD DD TD	N=380	16-36 months	24.98 months	ASD (M) =71 ASD (F) =25 DD (M) =30 DD (F) =12 TD (M) =124 TD (F) =118	Diagnosis placed by children's psychiatrist based on ICD-10 criteria	sensory profile of infants/toddlers – Polish version
2.Lauren M. Little, Evan Dean, Scott Tomchek and Winnie Dunn	ASD ADHD TD	N=239	3-14 year	not specified	ASD (M) =63 ASD (F) =14 ADHD (M) =61 ADHD (F) =17 TD(M) =63 TD (F) =21	The measures were not specified, the diagnosis was reported by the parents, and the data on the diagnosis was confirmed for 70% of the causes through record examinations	Child Sensory Profile 2 (SPD-2)
3. Ana T. Roknića, Sanja P. Vuković	ASD TD	N= 120	3-13 A year and 10 months	The respondents were divided into two groups, the younger	ASD (M) =40 ASD (F) =20 TD(M) =34 TD (F) =26	All subjects with autism were diagnosed by a child psychiatrist using ICD-10	Children's Sensory Profile 2 (SPD-2)

				group 57.42 months SD = 15.20 and the older group 124.98 months SD = 25.09		or DSM-IV and DSM-V criteria.	
4.Florine Dellapiazza, Cécile Michelon, Christelle Vernhet, Filippo Muratori, Nathalie Blan, Marie-Christine Picot Amaria Baghdadli	ASD ASD+ADHD ADHD TD	N=120 ASD= 43 ASD+ADHD= 18 ADHD = 28 TD=31	6-12 years	9.2 years	Not specified	Autism Diagnostic Interview - Revised (ADI-R) Autism Diagnostic Observation Schedule - Second Edition (ADOS-2)	Sensory profile
Rebeca A. Pérez, Germán E. Burguillos-Torres, Victoria G. Castillo-Velásquez, Natalia Moreno-Zuleta, Rosa I. Fonseca-Angulo, Cesar Blumtritt, and Rafael García-Jiménez	ASD TD	N=59	3-12 years	Not specified	ASD (M)=26 ASD (F)=5 TD (M)=17 TD (F)=11	Not specified, diagnosis confirmed by ASD neuropediatrician	Winnie Dunn's Sensory Profile Spanish Version

Sensory processing in children with autism and children with typical development

Niedźwiecka et al., (2020) in their research as one of the main goals had to examine sensory processing in three groups: children with autism, children with other developmental difficulties and children with typical development. The authors used the Infant/Toddler Sensory Profile-Polish Version (ITSP), providing new insight into the universal diagnostic utility of this instrument. Higher scores on the ITSP reflect typical functioning or less significant symptoms, while lower scores reflect more severe symptoms. To make the examination of overall sensory patterns more complete and clear, the authors compared modality-specific patterns, which included visual, auditory, vestibular, tactile, and oral processing. Questionnaires were filled in by the primary caregiver/parent at home or daycare centers, early intervention centers, and clinics throughout Poland. The groups of children differed in age, with typically developing children being younger on average than the group of children with autism. There were also certain differences in the number of boys and girls in the group of children with autism, boys were more numerous than girls within this group, and in the group of children with typical development, there were no significant differences in the number. Through the ITSP, the authors in their research obtained significant differences in the results of children with autism and

children with typical development. ITSP regardless of the young age of the group and the average age of diagnosis and the great heterogeneity within the studied groups, ITSP results differed in all three quadrants (sensory sensitivity, sensory avoidance, low registration), there were no significant differences in the fourth quadrant (sensory seeking). Significant a main effect of the group was found in the low registration quadrant. A planned comparison revealed a significant difference between children with autism and typically developing children. Children with autism had lower scores than typical children, indicating that they were more hypersensitive. Also, the sensory sensitivity quadrant reveals a significant difference, children with autism had lower scores indicating that they were more sensitive to sensory stimulation compared to typical children. And a significant main effect of the group was found in the sensory avoidance quadrant, children with autism had lower scores than the group of typically developing children, indicating that they have a greater tendency to avoid stimulation. When asked about the fourth quadrant (sensation seeking), there was no significant main effect of group on sensation seeking, and a planned comparison revealed no significant differences between children with autism and typically developing children. When it comes to the results, it is important to mention that children with autism differed from children with typical development in sensory symptoms in all sensory systems (auditory, visual, tactile, vestibular, and oral), as well as in general difficulties (reactions to routine changes, avoiding play with others and withdrawing). Specifically, the group of children with autism showed more severe symptoms of sensory processing than typical children, especially in terms of auditory processing (refers to responses to things they hear), that is, children with autism showed lower results on the ITSP subscales (especially in the part which concerns the auditory processing item). This result was expected, as higher scores reflect typical functioning (Niedźwiecka et al., 2020).

Also, research conducted by the authors Little et al., 2018, whose goal was to examine sensory processing in children with autism, ADHD, and typically developing children using the Child Sensory Profile 2 (SPD-2) test, brings similar results. The authors used multivariate analysis of covariance (MANCOVA) for statistical analysis to examine differences in sensory processing patterns (avoidance, sensitivity, registration, seeking) between diagnostic groups. They also used a separate MANCOVA model to examine differences in sensory systems (auditory, visual, tactile, motor, body position, oral) and behaviors between diagnostic groups. The results of the first MANCOVA model showed differences in sensory processing patterns (avoidance, sensitivity, registration, seeking) between the group of children with autism and the group of

typically developing children. Post hoc comparisons revealed that the group of typically developing children scored significantly lower (lower scores reflecting typical functioning or less significant symptoms) compared to the group of children with autism on avoidance, sensitivity, registration, and seeking, while the group of children with autism showed higher scores (higher scores reflect a more severe symptom). Higher scores on the avoidance quadrant indicate that children with autism have a greater tendency to avoid stimulation, higher scores on the sensory sensitivity quadrant indicate that they were more sensitive to sensory stimulation than typical children, higher scores on the low regulation quadrant indicate that were more hypersensitive/hyposensitive, and higher results on the search quadrant refer to e.g. to the fact that the child is fascinated by certain textures, such as the continuous rubbing of a certain material. A follow-up MANCOVA model testing diagnostic group differences in sensory systems (auditory, visual, tactile, oral, movement, body position) and behavior was significant. Notable differences existed in oral processing, children with autism showed the highest mean score compared to children with typical development. The authors emphasize that feeding difficulties in children with autism likely reflect oral sensitivity as well as oral seeking (eg, preference for crunchy foods) (Little et al., 2018). Compared to children with typical development, children with autism had higher results in the tactile and auditory system, while there were no significant differences between these two groups in the visual system. Children with autism showed visual processing scores similar to typically developing children, with increased scores in auditory processing. Visual processing items reflect distractibility (e.g., the child enjoys looking at visual details in objects, watching people as they move around the room), while auditory processing items primarily reflect sensitivity (e.g., the child is distracted when there is a lot of noise around, or e.g., the child hands over ears to protect them from sound). The authors also emphasize that the current findings of their study may also reflect how children with autism use visual processing, as opposed to auditory processing, as a strategy for interacting with their environment (Little et al., 2018).

In the research of Roknić and Vuković, (2021), whose goal was to determine the patterns of sensory processing in a group of children with typical development and a group of children with autism, the results indicate that there is a significant difference in the scores of sensory processing as a whole in relation to the group of respondents. The authors used the Child Sensory Profile 2 (SPD2). Each subscale of this test contains a different number of affirmative sentences for which it is necessary to mark the extent to which their statement applies to the child being assessed. Based on the obtained raw scores, there is a possibility of classification

into 4 quadrants: Seeking, Avoiding, Sensitivity, and Registration. For each of the 4 mentioned quadrants, it is possible to add up the raw scores and then indicates whether the total score of the given quadrant belongs to the group "Much less than others", "Less than others", "Like most others", "More than others" and "Much more than others". In this study, only raw data from the subscales and the scale as a whole were used. And to verify the statistical significance of the obtained differences in scores, they used the Mann-Whitney test, which in this research indicated that there is a significant difference in the scores of sensory processing as a whole in relation to the group of respondents. On all nine subscales, auditory processing (e.g. reacts strongly to unexpected or loud sounds, e.g. sirens, dog barking, hair dryer, holds hands over ears to protect them from sound), visual processing (e.g. prefers bright colors or patterns on clothing, enjoys looking at visual details of objects), tactile processing (e.g. rubs or scratches touched body part, seems unaware of pain and temperature changes), movement processing (e.g. takes risks of moving or climbing that are not safe, seeks opportunities to fall without regard for one's own safety, deliberately falls), body position processing (e.g. moves stiffly, gets tired easily, especially when standing or holding the body in one position), oral-sensory processing (eats only certain tastes, e.g. sweet, salty, restricts himself to certain food textures, is a picky eater, especially about food textures, smells non-food objects), sensory processing behavior (e.g, has tantrums, seems to enjoy falling, resists my or second eye contact), social-emotional reactions related to sensory processing (e.g. has strong emotional outbursts when unable to complete a task, struggles to interpret body language or facial expression, gets frustrated easily), attention in sensory processing reactions (e.g, struggles to pay attention, looks away from tasks to notice all actions in the room), there is a significant difference in sensory processing patterns with respect to group membership. Subjects with autism scored significantly higher than subjects with typical development, both globally and on all subscales, which means that subjects with typical development achieve lower sensory processing scores than subjects with autism. Thus, they show fewer problems in sensory processing. Children with autism had more difficulties when processing sensory information within all sensory systems compared to a group of children with typical development, and the authors emphasize tactile processing as the area in which children with autism showed the greatest difficulties in sensory processing, followed by olfactory and auditory, and the least common difficulties were manifested in the domain of visual processing (Roknić, Vuković, 2021).

The findings of the study by Dellaplazza et al., (2020), whose first goal was to compare sensory processing in 4 groups of children: with autism, autism and ADHD, only ADHD and typically

developing children show similar results as previous research. In their research, the authors confirm the stated hypothesis that atypical sensory processing occurs more often in children with autism compared to a group of children with typical development. All this is confirmed by the results obtained through the sensory profile test, more than half of the subjects showed atypical sensory processing compared to the group of children with typical development. Lower sensory profile scores imply greater sensory processing difficulties. Atypical results in this study are defined with probable and definite differences as scores over 1 to 2 standard deviations from the norm (less and much less than others). When it comes to sensory systems, children with autism showed significantly more atypical sensory processing compared to children with typical development, with an emphasis on a high percentage of atypical auditory and tactile processing, while a smaller percentage was within visual and vestibular processing. Also, in this research, there were no significant differences when it comes to oral processing, children with typical development showed similar results as children with autism. When it comes to the results obtained on the investigated quadrants, significant inter-group differences were in the sensation avoidance quadrant ("My child avoids wiping his face."), children with autism had lower results compared to typical children, which indicates a greater tendency to avoid stimulation. The authors state that it is possible that children with autism resort more to avoidance behavioral strategies to manage their hyperactivity to sensory stimulation. Children with autism also had significant differences on the sensory sensitivity quadrant (e.g, "My child is distracted and/or finds it difficult to eat in a noisy environment."). Differences in the results obtained for the registration and search quadrants between the two groups were present, but not as significant as the results of the two previously mentioned quadrants (Dellapiazza et al., 2020).

In their research, Pérez et al. (2019) had the main goal of determining and comparing the sensory profile of a sample of children between 3 and 12 years old with autism and children with typical development through the Winnie Dunn Sensory Profile. In order to fulfill the aim of the research, the sensory profile of Winnie Dunn's Spanish version was applied to 59 participants (28 with typical development, 31 with autism), this questionnaire is divided into three parts that assess; the sensory system (visual, auditory, oral, proprioceptive and vestibular) along with sensory patterns (seeking, avoidance, low registration, and sensitivity) and behavior (behavior, attention and social emotions). Regarding the sensory processing patterns evaluated through the Winnie Dunn Sensory Profile, the search pattern observed that 45.2% of the autism group were within the more than others/much more than others response category. This means

that children with autism can search for sensory information so much that it interferes with participation, while 64.3% of the group of children with typical development is in the same category as most of the others, which means that they use different sensory stimuli to gather information necessary for active participation. Regarding the avoidance pattern, 54.8% of children with autism were confirmed to be within the score more than others/much more than others, indicating that they may be overwhelmed by sensory information to the extent that it interferes with their participation. As for typically developing children, 60.7% are in the same category as most others. In the pattern of sensitivity within the obtained results, it was shown that 64.5% of the group with autism is within the score more than the others/much more than the others, which indicates that they can be disturbed by unorganized sensory information. On the other hand, 89.3% of children with typical development fall into the category "like most others", that is, they detect sensory stimuli that allow them to participate. On the registration form, both the autism group and the typically developing group were rated within the same category as most others, meaning they perceived the amount of stimuli sufficient to participate properly. Results and comparisons revealed that there were significant differences between the group with autism and the group of typically developing children. In each of the evaluated forms, the group of children with autism shows a trend of higher values compared to the measurement of the group of children with typical development. At the level of auditory sensory processing, 74.2% of children with autism and 64.3% of children with typical development are in the response category like most others, when it comes to visual processing 48.4% of the group with autism and 42.9% of children with typical development development are in the same category as most others. However, 53.5% of typically developing children and 38.7% with autism are in the less than other/much less than other category, indicating that they are below the response threshold set by Dunn. In tactile sensory processing, 51.7% of children with autism are in more than the others/much more than the second category, with this high threshold it can be determined that there is a greater tactile defensive ability that intrudes into their behavior, while a group of typically developing children 67 .9% in this category as well as most of the others. Otherwise, in both groups, they are in the same category as most others at the level of the vestibular, proprioceptive, and gustatory systems. Regarding sensory processing systems assessed through the Winnie Dunn Sensory Profile, results and comparisons revealed that there were significant differences between the group of children with autism and the group of typically developing children in each of the systems except the visual system (Pérez et al., 2019).

DISCUSSION

During the literature search, different data on the frequency of sensory processing difficulties in children with autism are observed. In one study, it was stated that 69% of children with autism have sensory processing difficulties (Baranek et al., 2006). Other authors state that the problem of sensory processing in preschool children is present in as many as 95% of children with autism (Tomchek, Dunn, 2007). Two more studies point out that more than 90% of children with autism exhibit some form of sensory dysfunction (Kilroy et al., 2019). Some sensory symptoms were even recorded in six-month-old children diagnosed with autism (Estes et al., 2015). Research by Tomchek and Dunn (2007) found that 95% of autistic children have some amount of sensory processing variation. This review includes 5 studies that contained some of the key words in their title and were published within a ten-year time frame. Two hypotheses were put forward. Hypothesis I was partially confirmed, because there are different results among the authors and their research. The authors (Niedzwiecka et al., 2020 and Litlle et al., 2018) state in their research that children with autism had worse results in sensory patterns/quadrants (avoidance, sensory sensitivity, low registration,) compared to typical children. Sensory avoidance refers to the fact that the child is bothered by sensory input, e.g. hair dryer, its sound causes different behavioral reactions in children, such as children cover their ears, which may indicate that children with autism are more hypersensitive than typical children. Also sensory sensitivity, children are able to perceive sensations despite the fact that they involve a small amount or intensity of information, e.g. the child has a hard time completing a task when the music or TV is left on, or the child can be bothered by wearing certain clothes, which is also a sign of hypersensitivity. On the other hand we have low registration, children within this pattern do not perceive the same intensity of environmental information and do not seem to have a need to satisfy their response e.g. especially enjoying unusual, strange sounds, or the child likes to make noise for fun or shows unawareness that his hands are dirty, these behaviors can be an indicator of hyposensitivity. When it comes to the fourth quadrant (search), the authors do not highlight the search quadrant as a quadrant with significantly achieved results, especially in the research (Niedzwiecka et al., 2020) where children with autism will achieve almost the same results as children with typical development . Also, the research by Dellapiazza et al. (2020) brings similar results when it comes to the results on the quadrants, as well as the research by Little et al. (2018). Significant between-group differences were in the sensation avoidance quadrant ("My child avoids wiping his face."), children with autism had lower scores compared to typical children, indicating a greater tendency to avoid stimulation, just as in the research of Niedźwiecka et al. (2020). Children who avoid patterns can easily become overwhelmed,

stimuli that trigger avoidance responses can appear anywhere and at any time (Brown, 2010). Children with autism also had significant differences on the sensory sensitivity quadrant. Within this pattern, children are able to perceive sensations despite the fact that they involve a small amount or intensity of information. Unlike the previously mentioned research, in this research the differences in the results obtained for the quadrants of registration and search between the two groups were present, but not as significant as the results of the quadrants sensory avoidance and sensory sensitivity. But what is important to mention when it comes to the results of this research is that they confirm that atypical sensory processing is more common in children with autism than in children with typical development. Therefore, atypical sensory processing in children may be a nonspecific marker of multiple neurodevelopmental conditions (Dellapiazza et al., 2020). It should also be mentioned that the results of Niedzwiecka et al., (2020) are consistent with previous findings on sensory processing in children with autism obtained mainly from North American samples of similar age (Baranek et al., 2006, Ben-Sasson et al., 2009). In terms of Dunn's model for sensory processing (Dunn, 1997) Niedzwieck's results showed that young children with autism had low sensory thresholds for some types of stimuli and high thresholds for other types of stimuli, also their results showed that children with autism were more hyposensitive and hypersensitive, as confirmed by some of the previous research (Ausderau et al., 2016).

Unlike the previously mentioned research, the authors Pérez et al., (2019) state in their research that in each of the evaluated forms, the group of children with autism shows a trend of higher values compared to the measurement of the group of children with typical development. Regardless of the differences between the authors, the results show that children with autism were more hyposensitive and hypersensitive, and showed more active avoidance of stimulation, which indicates to us that children with autism show greater problems and greater concern when it comes to sensory processing. The above confirms hypothesis II. As in the mentioned studies, also a study done in the United States on a sample of 21 children with autism between the ages of 3 and 9, reported that there are significant differences between groups of children with autism and groups of typically developing children in each of the sensory patterns . These results coincide with the study by Linde et al. (2013) in the USA, which confirms that the results of children with autism are always superior (showing more sensory processing difficulties) in each of the sensory processing patterns compared to a group of typically developing children.

When it comes to sensory systems, we have similar results in terms of the existence of atypical sensory processing in children with autism compared to children with typical development,

only in some studies we have obtained a significant result for only some of the sensory systems, but what is certain is that children with children with autism show more difficulties in processing sensory information within the sensory systems than children with typical development. Research by Dellapiazza et al., (2020) when it comes to sensory systems shows that children with autism showed significantly more atypical sensory processing compared to children with typical development, with an emphasis on a high percentage of atypical auditory and tactile processing, which is similar to the results of Little et al., (2018) when it comes to these two sensory systems, while a smaller percentage was within visual and vestibular processing. Also, in research Dellapiazza et al., (2020) there were no significant differences when it comes to oral processing, typically developing children showed similar results to children with autism. The authors found that auditory sensory processing is the sensory dimension most affected in groups of children with autism, which is confirmed by other research (Sanz-Cervera et al., 2017). Case-Smith and Bryan (1999) observed that children with autism may exhibit sensitivity to auditory stimulation, leading them to overreact and withdraw.

Similar results were obtained in their research by Roknić and Vuković (2021), who point out that there are differences between subjects belonging to different groups, and the scores on each subscale are higher in subjects with autism than in subjects with typical development. This confirms that subjects with autism have more difficulties when processing sensory information within all sensory systems compared to subjects with typical development. These results are in line with many foreign and domestic researches that point out that sensory processing is much more difficult in people with autism (Đorđević et al., 2019, Kilroy et al., 2019, Taylor et al., 2020). Thus, Engel-Jeger et al. (Engel Yeger et al., 2015) point out that sensory processing difficulties are more common in people with developmental disorders and that the mentioned difficulties are manifested in all sensory systems. In contrast to the research of Dellapiazzo et al., (2020), Roknić and Vuković (2021) in their research highlight tactile perception as the area where the greatest difficulties in sensory processing are manifested, followed by auditory and auditory perception. This coincides with the study by Linde et al., (2013), which states that 60.1% of children with autism have changes in the tactile system. While children with autism rarely showed difficulties in the domain of visual perception, as in the research by Dellapiazza et al., (2020), Litlle et al., (2018). Also, the above coincides with research by Nadon et al., (2011) and Tomchek, Dunn, (2007), where children with autism have a typical result when it comes to visual perception. Pérez et al., (2019) in their research emphasize that there are differences in each of the sensory systems analyzed in children with autism and children with

typical development, except at the level of the visual system. They also point out that in tactile sensory processing, the largest percentage of children with autism show a greater tactile defensive ability, which is in accordance with the research of Roknić and Vuković, (2021). Research by Niedźwiecka et al., (2020) emphasizes that children with autism differed from children with typical development in terms of sensory symptoms in all sensory systems (auditory, visual, tactile, vestibular and oral), as well as in general difficulties (reactions to routine changes, avoiding playing with others and withdrawing). Specifically, the group of children with autism showed more severe symptoms of sensory processing than typical children, especially in terms of auditory processing (refers to responses to things they hear), which is in line with the research of Dellapiazza et al., (2020). And unlike all other research used in this paper, the research by Little et al., (2018) highlights notable differences in oral processing, children with autism showed the highest mean score compared to children with typical development. In children with autism, feeding difficulties, according to the authors, are likely indicative of both oral sensitivity and oral seeking behaviors, such as a preference for crunchy foods (Little et al., 2018). And we can say that these results are similar to the results of the study developed by Dunn, (1997) and Al-Heizan et al., (2015) where they also reported deficiencies in this system, specifically 54.1% of children with autism were assessed, parents are reported the intake of only some foods, while in the case of children with typical development, their food intake was wider. What is important to point out is that the results obtained during the examination of sensory patterns as well as the examination of the sensory processing system show that the majority of children with autism were hyper or hypo sensitive to sensory stimulation (e.g sound, light, crowd, touch, warm). This often causes children with autism to cover their ears, avoid or react negatively to brightly lit areas, or, on the other hand, crash into sofas and crave powerful bear hugs (Christopher, 2019). As we could see in the results presented in this review paper, the sensory systems can be hyposensitive, or can lead the person to experience disturbances such as tinnitus (persistent buzzing or ringing in the ears). Therefore, children/individuals with autism may find it difficult to process incoming sensory information correctly (Christopher, 2019). These sensory issues can be the underlying reason for behaviors such as rocking, turning, and waving. These problems are thought to stem from neurological dysfunction in the central nervous system – the brain, although the receptors for these senses are located in the peripheral nervous system (which includes everything except the brain and spinal cord) (Christopher, 2019). All of the above fully confirms hypothesis II, children with autism show greater problems and greater concerns in sensory processing compared to typical

children. This link between sensory processing and difficulties in the same, as well as behavior, behavioral responses, can be a driving force and an interesting topic for further research.

CONCLUSION

The conclusion of this review paper when it comes to the results of the presented research suggests that children with autism show significant differences in the patterns of sensory processing and sensory systems, the results of the group of children with autism were elevated compared to the group of children with typical development, but the results within all the mentioned studies were not the same for all sensory patterns and systems, which partially confirms hypothesis I. Differences within sensory systems exist between a group of children with autism and a group of children with typical development, but on the other hand, we have agreement and disagreement between authors when it comes to significant differences between systems. All the authors of the research in this review agree when it comes to the visual sensory system, that there were no significant results on the tests, children with autism had similar results as children with typical development. When it comes to vestibular and gustatory sensory systems, there are differences, but they were not as significant as in other systems. What we can conclude is that there are still different views of the authors and their research when it comes to the auditory and tactile sensory system. It should be pointed out that all the studies showed differences in these systems between the two examined groups, but in some studies these differences were significantly higher in one of these two systems compared to the other systems. Dellapiazza et al., (2020) highlight both the auditory and tactile sensory systems, with an emphasis on multi-sensory difficulties in the auditory sensory system, the research of these authors agrees with the research of Niedzwieck et al., (2020). While researching Roknić, Vuković (2021) and Pérez et al., (2019) highlight the tactile sensory system, as the system in which children with autism show the most atypical sensory processing. Research that was particularly interesting was the research by Little et al., (2018), whose results highlight both the tactile and auditory sensory systems in which children with autism had more atypical sensory processing compared to typical children. What was the main result of this research, which is the opposite compared to other research used in the paper, is the emphasis on a particularly significant result in the oral sensory system in children with autism compared to children with typical development. Children with autism showed increased difficulties in the oral sensory system. These findings suggest greater insight and possible difficulties in oral processing in children with autism, and as previous research has shown, feeding difficulties in children with

autism are well documented (Marí-Bauset et al., 2014) and likely reflect oral sensitivity, as well as oral seeking (e.g preference for crunchy foods) (Little et al., 2018).

All in all, we can conclude that difficulties in sensory processing are more present in children with autism, and that children with autism show more severe symptoms of sensory processing compared to typical children. That is, that there is a significant difference in sensory processing between children with autism and children with typical development. When we are aware of these differences and difficulties that children with autism face in sensory processing, we can respond adequately and provide them with appropriate support. Based on all of the above, we can conclude that children with autism often show specific patterns of sensory processing that can be significantly different from those of children with typical development. They may be hypersensitive to certain sensory stimuli, such as sound, light, smell or touch. This hypersensitivity can cause discomfort, anxiety or even physical pain in children with autism. On the other hand, some children with autism may have reduced sensitivity to sensory stimuli and therefore need more stimulation to achieve optimal sensory integration.

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