

Research Paper

Sensory Processing in the Children Aged Under 14 Years



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Citation Shahbazi M, Alizadeh Zarei M, Shahbazi F, Mirzakhani N. Sensory Processing in the Children Aged Under 14 Years. *Iranian Rehabilitation Journal*. 2023; 21(2):239-250. <http://dx.doi.org/10.32598/irj.21.2.1568.1>

doi <http://dx.doi.org/10.32598/irj.21.2.1568.1>

**Article info:**

Received: 21 Sep 2021

Accepted: 22 Nov 2021

Available Online: 01 Jun 2023

Keywords:

Child, Sensation, Sensory processing, Sensory profile-2

ABSTRACT

Objectives: Individuals should have good sensory processing ability to function appropriately and participate in daily activities. This investigation aimed to evaluate the sensory processing characteristics of children aged under 14 years.

Methods: This is a descriptive cross-sectional study. The study population comprised all children aged >14 years referred to child's developmental centers and elementary and middle schools in Tehran City, Iran. After considering the inclusion criteria, 1272 children were selected using multistage cluster sampling. The research tool was sensory profile-2, completed by children's caregivers and teachers. Their sensory processing characteristics were measured according to the cut-off scores of the separate questionnaires of Sensory profile-2 in the section, school, and quadrant factors.

Results: The research samples scored just like the majority of others on most sensory processing areas, with only two quadrants, one sensory section, and one school factor score indicating "less than others" or "more than others."

Discussion: According to the findings, a high sensory sensitivity leads to intolerance of children in schools. Also, the low level of sensory seeking in toddlers is associated with less than other scores in movement items.

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Highlights

- The research samples scored just like “the majority of others” in most areas of sensory processing.
- A high sensory sensitivity leads to intolerance in school children.
- Low sensory seeking leads to “less than others” scores in movement items.

Plain Language Summary

The results of this study show that children under 14 years of age are just like others in most areas of sensory processing (except for two quadrants, one sensory section and the school factor). So, determining the characteristics of children’s sensory processing allows occupational therapists to use their specialized knowledge in sensory interventions to perform sensory integration interventions and adapt activities and environments to enable the participation of these children in different areas of life.

Introduction

Sensory processing in individuals includes the reception of a physical stimulus, conversion of the stimulus into a neural impulse, perception, or the conscious experience of sensation [1]. This process is essential for learning, understanding, and movement. It also explains the interaction between an individual’s nervous activity and the context, central to the novel conception of well-being and can influence contribution [2].

Dunn proposed a model for sensory processing that identifies response patterns based on neurological thresholds and self-regulatory strategies. Based on this model, threshold areas of upper to below, and self-regulation varies from inactive to active. By intersecting these pair continuums, 4 models of sensation processing are created: Bystander, seeker, sensor, and avoider. The bystander pattern represents a composition of upper threshold and inactive approaches, and the seeker is a composition of upper threshold and active approaches. The sensor is a composition of below threshold with inactive approaches, and the avoider is a combination of below threshold with active approach [3].

Based on what was discussed, sensory processing is how our neurological system receives, interprets, and responds to neural inputs [4]. Each person has his or her way of responding, which is related to his or her genetics and culture [5]. Therefore, sensory processing is essential to human behavior [6]. People with sensory problems often have difficulty adjusting their responses to stimuli. In addition, emotional and motor problems result from sensory processing problems [7].

The association between sensory processing and problems in the activity of daily living, adaptive responses, communicative skills, and play has been studied, considering that sensory processing disorder in typical children is 5% to 10% [8]. However, many investigations have utilized participants by special requirements like autism spectrum disorder or attention deficit and hyperactivity disorder [9-11]. This investigation aims to determine the sensory processing characteristics of a typical group of children aged under 14 years.

Materials and Methods

Study design

The study sample size (n=1272) was estimated from the study entitled “cultural adaptation and psychometric characteristic of the Persian version of the Sensory profile-2.” Determining the sample size in psychometric research is such that the number of samples should be at least 5 to 10 times the number of study items [12]. Participants in this study were enrolled utilizing multistage sampling, and information was gathered via the paper questionnaire method.

Study participants

The members in the present investigation were caregivers or teachers of children under 14 years old. Samples were recruited from Tehran City, Iran’s baby developmental centers, and primary and junior schools. The inclusion criteria were as follows: Caregivers of normal children under the age of 14 years who have been in contact with the child for at least 1 year (spent more than 11

hours a day with their child), teachers of the children for at least the past 4 or 6 months, and children without medical problems, such as a history of psychiatric or physical disorders or developmental delays. After informing them of the purpose and subject of the research and obtaining consent, subjects completed a questionnaire appropriate to the age and context of the child.

The study of sensory processing characteristics of normal children under 14 years was conducted for 1 year, from December 2018 to July 2019, in Tehran, the capital of Iran. In our study, 1272 normal children were selected using a multistage sampling method. After providing explanations and obtaining consent, the participants completed an appropriate questionnaire to age and context. Also, 160 infants and 272 toddlers were selected from baby developmental centers, and their caregivers completed the infant and toddler sensory profile-2. In addition, 612 children and 228 students were selected from primary and junior schools, and their caregivers and teachers completed the child, short, and school companion sensory profile-2.

Study measures

The sensory profile-2 assessment presents a standard approach for professionals to record children's sensory processing patterns. This test is a collection of judgment-based caregiver and teacher questionnaires as follows.

The infant sensory profile-2 includes 25 items to assess the sensory processing characteristics of infants 0 to 6 months old.

The toddler sensory profile-2 contains 54 items to assess the sensory processing characteristics of children aged 7 to 35 months.

The child sensory profile-2 contains 86 items to assess the sensory processing characteristics in children 3 to 14 years old.

The short sensory profile-2 contains 34 items to assess the sensory processing characteristics in children 3 to 14 years old. The items of this questionnaire are taken from the child sensory profile-2—designed to establish rapid data for evaluating and investigating projects.

The school companion sensory profile-2 requires teachers to fill in 44 items concerning their 3 to 14 years old students.

Sensory profile-2 questions are designed based on the child's sensory experiences in the context of home, school, and community. Caregivers and teachers provide valuable reports of children's responses to various sensory stimuli throughout the day. These data formulate assumptions regarding what can support or create barriers to the child's capacity to participate in daily life activities. Items on the sensory profile-2 rater questionnaires describe the sensory events. Generally, each questionnaire has several compositions of the sensory system, behavioral, sensory pattern, and school factor scores. These compositions are as follows:

- Sensory system scores: General, auditory, visual, touch, movement, body position, oral
- Behavioral scores: Behavioral, conduct, social-emotional, attentional
- Sensory pattern scores: Seeking, avoiding, sensitivity, registration
- School factor scores: Supports (school factor 1), awareness (school factor 2), tolerance (school factor 3), and availability (school factor 4)

Caregivers and teachers who interact with the child regularly complete the appropriate questionnaire based on the frequency of behaviors (almost always, frequently, half the time, occasionally, or seldom, with an option of does not apply). After the caregivers and teachers completed the questionnaires, the specialists rated them. Finally, by identifying the child's sensory processing pattern, hypotheses can be made about the relationship between sensory processing patterns and the child's performance in daily life.

The cut-off scores for the sensory profile-2 are based on the Mean \pm SD for each summary score. These scores provide a classification system to categorize a child's tendency for specific behaviors. This system consists of 5 categories that reflect specific groups of scores along the bell curve.

- Much less than others
- Less than others
- Just like the majority of others
- More than others
- Much more than others

The 5-category classification system compares the child to peers in the same age group. For these scores, “more than others” means that the child exhibits the behaviors listed in that group of items (i.e. sensory patterns, sensory systems, behaviors, and school factors) more often than expected. Similarly, “less than others” means that the child exhibits the behaviors listed in that group of items less frequently than expected.

There is one exception to the 5-category classification system, with very young babies, it is hard to determine what they will make adjustments for and which behaviors might persist longer than expected. The classification system for infants (birth to 6 months) provides scores according to the five categories with the recommendation for decisions to be classified as either:

- Expected performance (i.e. responds just like the majority of others)
- Consult and follow-up (i.e. responds more or less than others)

The sensory profile-2 standardized study was performed from 2012 to 2013 and included the evaluation of 1791 children (under 14 years) for the standardization sample. The measure demonstrates strong psychometric properties in English [13]. A study on the translation and psychometric characteristics of the Persian version of this test was conducted by Shahbazi et al. [14].

Data analysis

SPSS software, version 22 was used for data analyses. First, the demographic features of the research samples were evaluated. Next, their sensory processing characteristics were measured according to the cut-off scores of the separate questionnaires of Sensory profile-2 in the quadrant, section, and school factors.

Results

Table 1 presents the frequency and percentage of demographic characteristics of the participants in the present study.

The research samples scored just like the majority of others in most areas of sensory processing (Table 2-6), with only two quadrants (the seeking quadrant of the toddler sensory profile-2 and the sensitivity quadrant of the child, and the school companion sensory profile-2), one school factor (the school factor 3 of the school companion sensory profile-2), and one sensory section (the move-

ment sensory sections of the toddler sensory profile-2) score indicated less than others or more than others.

Discussion

This research demonstrated the sensory processing characteristics in normal children under 14 years. Our study used the classification system and Dunn’s sensory processing framework to interpret the obtained data [13].

Classification system

The cut-off scores for each summary score are based on the bell curve. See Figure 1 for a graphic representation of the classification system.

“Just like the majority of others,” scores include scores that range from 1 SD below the mean (-1 SD) to 1 SD above the mean (+1 SD). Summary raw score totals that fall within this range indicate sensory processing patterns of the majority of the normative sample.

“More than others” scores include scores between +1 SD and +2 SD. Summary raw score totals that fall within this range indicate that the individual engages in the behaviors of more than about 84% of the normative sample.

“Much more than others” scores include scores above +2 SD. Summary raw score totals that fall within this range indicate that the individual engages in the behaviors of more than about 98% of the normative sample.

“Less than others” scores include scores between -1 SD and -2 SD. Summary raw score totals within this range indicate that the individual engages in behaviors less than 84% of the normative sample.

“Much less than others” scores include scores below -2 SD. Summary raw score totals within this range indicate that the individual engages in behaviors less than 98% of the normative sample.

Dunn’s sensory processing framework for interpretation

Sensory profile-2 is designed based on the 4-factor model of sensory processing. This framework has two core constructs: Thresholds and self-regulation (Figure 2). When these two constructs intersect, they yield four patterns of sensory processing: Seeking, avoiding, sensitivity, and registration [15].

Table 1. Demographic data of the study subjects (n=1272)

Characteristic		Mean±SD/(%)				
		ISP2	TSP2	CSP2	SCSP2	SSP2
Age (m/y) ^a		4.5±1.5 ^a	13.6±3.4 ^a	11.6±2.3	11.5±2.2	11.4±2.4
Sex	Male	49.4	53.3	46.6	56.6	47.8
	Female	50.6	46.7	53.4	43.4	52.2
Maternal education level	No high school diploma	15.6	7.0	4.2	-	5.0
	High school graduate	36.2	23.9	18.8	-	23.9
	Some college or technical school	6.9	9.9	4.5	-	7.2
	≥ Four-year degree	41.3	59.2	72.5	-	63.9
Paternal education level	No high school diploma	19.4	4.0	1.9	-	2.2
	High school graduate	36.8	18.8	24.1	-	21.1
	Some college or technical school	4.4	3.7	2.3	-	3.4
	≥ Four-year degree	39.4	73.5	71.7	-	73.3
The child born in relation to siblings	Only child	48.8	54.8	39.1	-	41.7
	1 st	36.2	39.7	51.2	-	50.0
	2 nd	12.3	3.7	6.2	-	5.4
	Other	2.7	1.8	3.5	-	2.9
Who completed the forms?	Mother	96.9	95.6	94.0	-	91.1
	Father	3.1	4.4	6.0	-	8.9
	Teacher	-	-	-	100	-
Frequency of contact with this student	1 d/w	-	-	-	38.5	-
	2 d/w	-	-	-	9.2	-
	3 to 4 d/w	-	-	-	2.3	-
	Daily	-	-	-	50.0	-
Years have you had contact with this student	≤6 m	-	-	-	86.8	-
	7 m-1 y	-	-	-	10.1	-
	≥1 y	-	-	-	3.1	-
Total		160	272	432	228	180

Abbreviations: ISP2: Infant sensory profile-2; TSP2: Toddler sensory profile-2; CSP2: Child sensory profile-2; SCSP2: School companion sensory profile-2; SSP2: Short sensory profile-2. Y: Year; D: Day; W: Week.

^aAge reported in months for infant sensory profile 2 and toddler sensory profile 2 forms.

Note: Some spaces in this table are empty because the teachers complete the school companion sensory profile 2, and the child's caregivers complete other questionnaires of this tool.

Table 2. Sensory processing in general population of infant sensory profile 2

Sensory Processing Areas	Much Less Than Others	Less Than Others	Just Like the Majority of Others	More Than Others	Much More Than Others
Sensory sections					
Total score			✓		

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According to what was mentioned above, the occupational therapists completed the Toddler Sensory profile-2. We noted that the research samples' scores indicated that they process sensory information like other children at their age. They seek less movement information than other children their age. Regarding this finding, it can be explained that in recent years, due to the small living environment, lack of suitable spaces for play and sports for children, their excessive tendency to use computer games and watch TV, and low parental awareness, the tendency to seek movement activity in them has decreased [16, 17].

The occupational therapists completed the child sensory profile-2 and the school companion sensory profile-2. These two questionnaires illustrate how to collaborate between home and school to maximize each child's participation potential. The research scores indicate that they are just like most others for most things, although they are sensitive to some sensations. The teachers said they are more sensitive and less flexible than their peers

in certain situations. They also had a different score on school factor 3, which suggests they are more intolerant than other children their age.

Behavior consistent with a sensitivity pattern represents low thresholds and a tendency to act passively concerning those thresholds being met (i.e. reacting after the fact to overwhelming stimuli). The sensitivity items are written to show the amount that a child responds to sensory input, so children who have more than others sensitivity scores react more quickly and more intensely than others [18]. Parents and teachers may report that these children appear distractible or hyperactive. These children might be cautious about proceeding in some situations because they are overwhelmed or might become upset with others who interrupt them. The rationale for using Dunn's Sensory Processing Framework is that the child is aware of every available stimulus without the commensurate ability to habituate to these stimuli. People with a more than others sensitivity pattern react more quickly to stimuli in the environment, even stimuli others do not detect.

Table 3. Sensory processing in general population of toddler sensory profile 2

Sensory Processing Areas	Much Less Than Others	Less Than Others	Just Like the Majority of Others	More Than Others	Much More Than Others
Quadrants	Seeking	✓			
	Avoiding			✓	
	Sensitivity			✓	
	Registration			✓	
Sensory and behavioral sections	General			✓	
	Auditory			✓	
	Visual			✓	
	Touch			✓	
	Movement		✓		
	Oral			✓	
	Behavioral			✓	

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Table 4. Sensory processing in general population of child sensory profile 2

Sensory Processing Areas		Much Less Than Others	Less Than Others	Just Like the Majority of Others	More Than Others	Much More Than Others
Quadrants	Seeking			✓		
	Avoiding			✓		
	Sensitivity			✓		
	Registration			✓		
Sensory sections	Auditory			✓		
	Visual			✓		
	Touch			✓		
	Movement			✓		
	Body position			✓		
	Oral			✓		
Behavioral sections	Conduct			✓		
	Social-emotional			✓		
	Attentional			✓		

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For example, a child with a “more than others” sensitivity pattern may detect a change in how the teacher organizes her desk or may notice students in a distant hallway at school. This child may be the first to find a lump in the potatoes and may comment on it in a musical piece. The detailed orientation of children with more sensitivity than others makes them well-suited to find, correct, and edit errors. It may also cause them to be paralyzed by wanting everything to be perfect. Families and teachers must manage this child’s input [13, 19].

Children with a “more than others” sensitivity pattern score will benefit from numerous structured patterns of

sensory activities throughout daily life. With more sensory input structure, these children can notice all over daily life activities and continue them for a more extended time. Intervention planning involves eliminating distractors and adding supports to maintain focus. Creating organizational systems can be helpful. Calmness, repetition, familiarity, and consistency are tasks that support success for people with sensory sensitivity. The overall goal is to provide the child with the correct level of sensory experiences that help the child to continue a task while minimizing potential overwhelming extra input [13, 20, 21].

Table 5. Sensory processing in general population of short sensory profile 2

Sensory Processing Areas		Much Less Than Others	Less Than Others	Just Like the Majority of Others	More Than Others	Much More Than Others
Quadrants	Seeking			✓		
	Avoiding			✓		
	Sensitivity			✓		
	Registration			✓		
Sensory and behavioral sections	Sensory			✓		
	Behavioral			✓		

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Table 6. Sensory processing in general population of school companion sensory profile 2

Sensory Processing Areas	Much Less Than Others	Less Than Others	Just Like the Majority of Others	More Than Others	Much More Than Others
Quadrants	Seeking		✓		
	Avoiding		✓		
	Sensitivity				✓
	Registration			✓	
Sensory sections	Auditory		✓		
	Visual		✓		
	Touch		✓		
	Movement		✓		
	Behavioral		✓		
School factors	School factor 1		✓		
	School factor 2		✓		
	School factor 3				✓
	School factor 4			✓	

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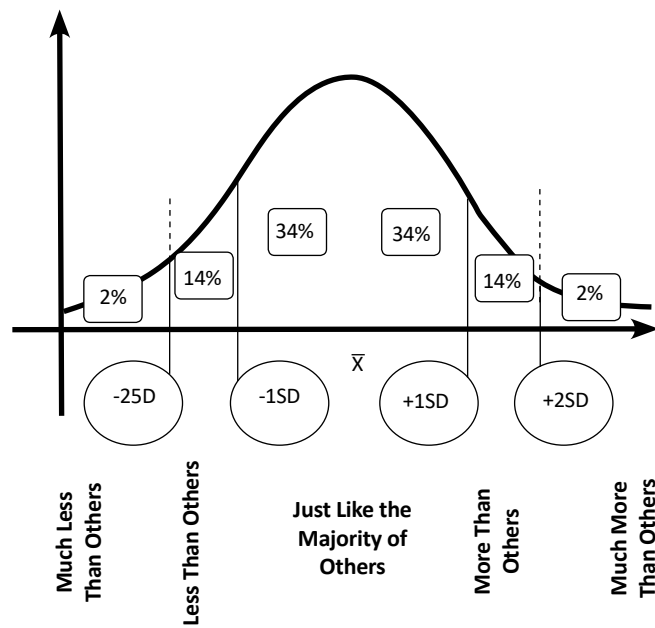


Figure 1. The normal curve and the sensory profile 2 classification system

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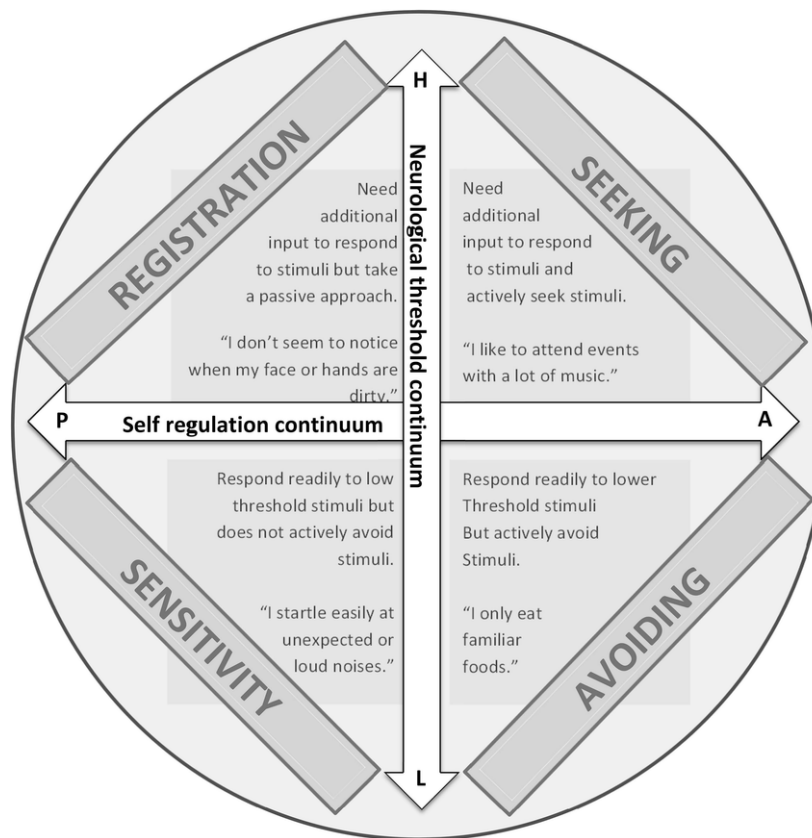


Figure 2. Dunn's sensory processing framework

School factor 3 demonstrates the student's range of sensory input tolerance. From a sensory processing point of view, school factor 3 includes avoiding and sensitivity patterns. These sensory processing patterns are low threshold patterns, suggesting that the student notices sensory input very quickly. With avoiding, the student is more likely to move away from stimuli, while with sensitivity, the student is more likely to react to stimuli with annoyance or frustration [22, 23]. From the teacher's point of view, these students may be seen as less tolerant and overly reactive. Students with unexpected school factor 3 scores need a controlled learning environment [13].

The most important thing to remember when planning interventions for students who have unexpected school factor 3 scores is that they will need reductions in stimuli within the learning environment to participate strongly. As the relevant service professional supporting the educational experience, examine the school factor 3 scores and the avoiding and sensitivity quadrant scores (the sensory processing patterns that comprise school factor 3) to determine what likely interferes with the students learning. When the avoiding pattern predominates (i.e. avoiding items are out of expected ranges), skilled observa-

tion provides additional information about what sensory inputs are most aversive for the student. For example, the student may hold his ears during small group work. A therapist might collaborate with the teacher about alternative places for this student's group to create a more isolated workspace (e.g. part of the room or the library for work time). When the sensitivity pattern predominates (i.e. sensitivity items are out of expected ranges), the therapist identifies what stimuli the student reacts to during the learning activities and helps the teacher adjust accordingly. The overall purpose is to know strategies the teacher can use to diminish the number and types of sensory inputs available to these students during critical learning periods [13, 24].

Clinical application

These findings present a unique way to determine how sensory processing can contribute to or interfere with participation. When combined with other information about the child in context, professionals can plan effective interventions such as sensory diet to support children, families, and educators as they interact with each other throughout the day.

Conclusion

Evidence shows that sense is the basis for cognition and metacognition. The learning model presented by William and Shellenberger shows how sensory processing affects metacognition processes, academic achievement, and behavior [25]. Therefore, determining the characteristics of children's sensory processing allows occupational therapists to use their specialized knowledge in sensory interventions to perform sensory integration interventions and adapt activities and environments to enable the participation of these children in different areas of life.

Ethical Considerations

Compliance with ethical guidelines

The study protocol was approved by the Moral Committee of the School of Rehabilitation of [Shahid Beheshti University of Medical Sciences](#) (Code: IR.SBMU.RE-TECH.REC.1399.1328).

Funding

This study was supported financially by [Shahid Beheshti University of Medical Sciences](#).

Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

We express our gratitude to parents and teachers of children, who had directly participated in the present study.

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