

Sensory Modulation Deficiencies of Children With Allergic Rhinitis

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Allergic rhinitis (AR) is a common chronic condition. Recent studies raise the possible relationship between allergic conditions and sensory modulation disorders, mainly expressed in sensory hypersensitivity. This study aimed to evaluate sensory modulation abilities of children with AR and to assess whether these abilities have stronger expression in specific sensory systems, compared to healthy peers. Twenty-eight children with moderate/severe persistent AR and 28 healthy children, aged 4–11 years, participated in this study. Sensory modulation abilities were assessed using the Short Sensory Profile (SSP). Children with rhinitis showed significantly worse sensory modulation abilities than did healthy controls, in most SSP sections. The highest percentage of children with rhinitis showed deficiencies in the Taste/Smell Sensitivity and Low Energy/Weak SSP sections. Among the AR group, these sections were found to be impacted by age and gender. Children with AR may suffer from sensory modulation deficiencies. Thus, multidisciplinary intervention programs for children with rhinitis are recommended focusing on treating the symptoms together with consideration of additional possible factors that may influence the child's daily function and well-being, as the ability to modulate sensations in daily environments.

Introduction

ALLERGIC RHINITIS (AR) IS A common chronic condition in the pediatric populations. Its prevalence increases from infancy through childhood and adolescence.¹ Characteristic symptoms include sneezing, pruritus, nasal congestion, and/or rhinorrhea.² The chronic nature of this condition and its profound physical and psychosocial complications greatly impact the child's functioning and quality of life.^{3,4}

Recent studies raise the possible relationship between allergic conditions and sensory modulation deficiencies (SMD).^{5–8} SMD is a dysfunction in the ability to regulate and organize the degree, intensity, and nature of response to sensory input in a graded and adaptive manner.⁹ Sensory modulation disorders are divided into 3 subtypes: (a) Sensory Over-Responsivity (SOR)—represents individuals who respond to sensation faster, with more intensity or for a longer duration. Behaviors of these individuals may range from active, negative, impulsive, or aggressive responses to passive withdrawal or avoidance of sensation. Their emotional responses include irritability, moodiness, inconsolability, or poor socialization. (b) Sensory Under-Responsivity

(SUR)—represents individuals who tend to disregard sensory stimuli in their environments. They are often described as having lack of inner drive to initiate exploration, withdrawn, inattentive, unmotivated, or self-absorbed. (c) Sensory Seeking/Craving (SS)—represents individuals who have an insatiable desire for sensation. They energetically engage in actions that add more intense sensations to their bodies.¹⁰

Among children with specific conditions, as atopic dermatitis, SMD was mostly expressed by sensory hypersensitivity, and may negatively impact their function and well-being.^{5–8} Thus, it is important to examine whether SMD also characterize children with other similar conditions, such as allergic rhinitis.

The purposes of the present study were: (a) to evaluate the sensory profile of children with rhinitis by comparing their sensory modulation abilities to those of healthy children, (b) to assess whether the ability of children with rhinitis to modulate sensations has stronger expression in specific sensory systems, (c) to examine the impacts of age and gender on child's sensory modulation abilities.

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Materials and Methods

Participants

Fifty-six children, aged 4–10.9 years, participated in this study. The study group consisted of 28 children (20 boys and 8 girls mean age was 9.13 ± 2.02 years) with moderate/severe persistent AR due to dust mite allergy. Children with exclusive house dust mite allergy sensitization were chosen since they have constant perennial antigen stimulation. The study group included children with no past medical history suggestive of asthma or atopic dermatitis, history of depression or autism. The patients were recruited from our outpatient allergy clinic. The diagnosis of moderate/severe persistent AR was made in accordance with the ARIA (*Allergic Rhinitis and its Impact on Asthma*) guidelines, referring to nasal symptoms >4 days a week for >4 weeks and 1 or more of the following items present: (1) sleep disturbance, (2) impairment of daily activities, leisure, and/or sport, (3) impairment of school or work, (4) troublesome symptoms. The control group included 28 healthy children, 14 boys and 14 girls, who did not suffer from allergies or other chronic diseases. Their mean age was 8.82 ± 2.03 years. The controls were recruited through an advertisement that was posted in several neighborhoods in the north of Israel. The advertisement invited children and parents to participate in a study about child's reactions to sensations. Children in both groups were recruited in 2 years, in different seasons. All children came from families with average-high socioeconomic status, except for 2 children with AR who came from families with low socioeconomic status. Among the study group, 68.2% of the fathers and 69.6% of the mothers had academic education. Among the controls, 56.3% of the fathers and 62.5% of the mothers had academic education.

Instruments

Allergy assessment. Sensitization restricted to house dust mite was established by performing skin prick reactivity to common inhaled allergens, in conjunction with positive and negative controls, 1 mg/mL histamine, and 0.9% w/v saline, respectively (ALK ABELLO Port Washington, NY, USA). The panel consisted of house dust mite (*dermatophagoides farine* and *pteronysinus*), mixed weeds (pigweed, lambs quarters, sagebrush, plantain, nettle, wall pellitory, cocklebur), mixed grass (Bermuda, Johnson, orchard, timothy), mixed trees (olive, cypress, pecan, oak, Acacia, cottonwood, Casuarina), mixed molds (*Cladosporium*, *Alternaria*, *Aspergillus*), dog, cat, and cockroach extracts. Reactions to the allergens were read after 15 min. Mean diameters were calculated as the mean of the widest diameter and the perpendicular diameter measured at its midpoint. Wheals with a mean diameter ≥ 3 mm than those of the negative control were considered positive reactions.¹¹

Sensory modulation assessment. The sensory modulation abilities were assessed using the Short Sensory Profile (SSP),¹² which is the shorter version of the Sensory Profile and found to be suitable for research and for screening sensory modulation disorders of children.¹³ The SSP is filled by the child's main caregiver. It measures the child's sensory modulation abilities as expressed in functional performance and in daily life. The SSP is comprised of the 38 items. The 7 sections of the SSP are Tactile Sensitivity (7 items); Taste/Smell

Sensitivity (4 items); Movement Sensitivity (3 items); Under-Responsive/Seeks Sensation (7 items); Auditory Filtering (6 items); Low Energy/Weak (6 items); and Visual/Auditory Sensitivity (5 items). Internal consistency of the sections within the scale ranged from 0.70 to 0.90.¹³ Internal validity correlations for the sections ranged from 0.25 to 0.76 and were all significant at $P < 0.01$. Initial studies of the validity of the SSP demonstrated discriminate validity of >95% in identifying children with and without sensory modulation difficulties. Items are scored on a five-point scale. Both section scores and a total score are recorded on the SSP. The possible range of raw scores on the total scale is 38 to 190, with higher scores (155–190) reflecting normal performance. A score of 142–154 reflects a probable difference in performance, while a score of 38–141 reflects a definite difference in performance.¹³

Procedure

After receiving approval from the ethics committee of Bnai-Zion Hospital, the parents of all children filled out a consent form approving their child's participation in the study. One of the parents, who accompanied the child, was asked to fill out the SSP. A home meeting was arranged with the parents of the control participants, who responded to the advertisement. The health status of the control participants was based on parent report. Parents of children who met the inclusion criteria were asked to complete the SSP.

Data analysis

A multivariate analysis of variance (MANOVA) with a general linear model was used to test the significance of differences between the groups in regard to each SSP section as well as the age and gender effects on SSP scores. *T*-test was performed to examine the differences between the groups in the total SSP score. Chi-square analyses examined whether differences exist in the percentage of children found in each of the SSP performance categories. Probabilities below 0.05 were considered significant.

Results

Differences in SSP scores between groups

According to multivariate analysis of variance (MANOVA), a significant statistical difference was found in the mean scores of the 7 sections of the SSP between children with rhinitis and controls ($F(7,48) = 3.67$, $P = 0.003$). ANOVAs revealed that the children with rhinitis had significantly lower mean scores of each SSP section as compared to the control group (lower scores reflect abnormal sensory modulation abilities) (Table 1 and Fig. 1). A similar result was found in regard to the SSP total score (153.35 ± 18.58 vs. 173.96 ± 15.49 ; $t = 4.5$, $P \leq 0.0001$).

The percentage of children in each category of sensory modulation in each group was calculated according to the SSP (typical performance, probable difference, or definite difference in performance). As presented in Table 2, chi-square analyses yielded significant differences between groups in most SSP sections. A higher percentage of children in the control group received scores indicating typical sensory performance, while a higher percentage of children with rhinitis received scores reflecting probable or definite

TABLE 1. COMPARISON OF SSP SUM SCORES IN BOTH GROUPS

SSP sections	Rhinitis (n = 28)			Controls (n = 28)			F	η^2
	Mean	SD	Range	Mean	SD	Range		
Tactile sensitivity	29.93	3.78	35–23	31.43	3.07	35–24	4.15*	0.074
Taste/smell sensitivity	14.21	4.58	20–4	18.04	2.87	20–7	22.05***	0.298
Movement sensitivity	12.14	2.92	15–5	13.89	1.61	15–7	6.67*	0.114
Under-responsive/seek	27.12	5.22	35–16	31.93	3.01	35–24	16.71***	0.243
Auditory filtering	23.68	4.48	30–10	27.14	3.02	30–19	12.71**	0.196
Low energy/weak	24.64	4.52	30–16	28.25	2.74	30–18	14.18***	0.214
Visual/auditory sensitivity	21.64	3.03	25–14	23.28	2.17	25–16	4.84*	0.085

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

Abbreviations: SD, standard deviation; SSP, Short Sensory Profile.

differences in sensory performance. Among children with rhinitis, the highest percentage found in the “definite difference” was in the Taste/Smell Sensitivity section, Low Energy/Weak and Under-Responsive/Seek.

Gender effect on SSP scores

Significant difference was found between genders in the Taste/Smell Sensitivity section. Girls in general showed lower mean score (15.04 ± 4.79) than the boys (16.82 ± 3.78) ($F(1,56) = 8.3$, $P = 0.006$, $\eta^2 = 0.14$). Girls with rhinitis had the lowest scores (mean 11.12 ± 4.19) found in the “definite difference” range, compared to the other groups. This scores were significantly different from the score of the girls in the control group (mean 17.28 ± 3.56) that was found in the “typical performance” range ($t = 3.49$, $P = 0.004$) and from the score of the boys with rhinitis (mean 15.45 ± 4.22) that was also found in the “typical performance” range ($t = 2.45$, $P = 0.021$) (see Table 3).

Age effect on SSP scores

All children were divided into 2 age groups: 4–7 years; 8–10.9 years. The older children showed significantly lower score (mean 28.91 ± 4.85) than the younger children (mean

32.2 ± 2.44) in the Under-Responsive/Seek Sensation section. However, both scores are found in the typical performance range. When comparing the control and the study groups, older children with rhinitis had the lowest scores (mean 26.5 ± 5.13) and the youngest healthy children had the higher score (mean 34.16 ± 0.98). Yet, the group $\times$ age interaction was not found to be significant in any of the SSP sections.

Discussion

Previous reports noted that sensory hypersensitivity may characterize children with atopic diseases as atopic dermatitis (AD). The present study aimed to elaborate the knowledge about sensory profile of children with another atopic condition—allergic rhinitis.

According to the results, children with rhinitis showed significantly worse sensory modulation abilities than did healthy controls, mostly manifested in higher sensory sensitivity in all sensory modalities as well as in sensory seeking tendencies. The high sensory sensitivity of children with rhinitis was mostly emphasized in the Taste/Smell section of the SSP. When examining the specific items in the Taste/Smell Sensitivity section, children with rhinitis were found to limit themselves to certain tastes, particular food textures/temperatures, and behave as picky eaters. It may be assumed

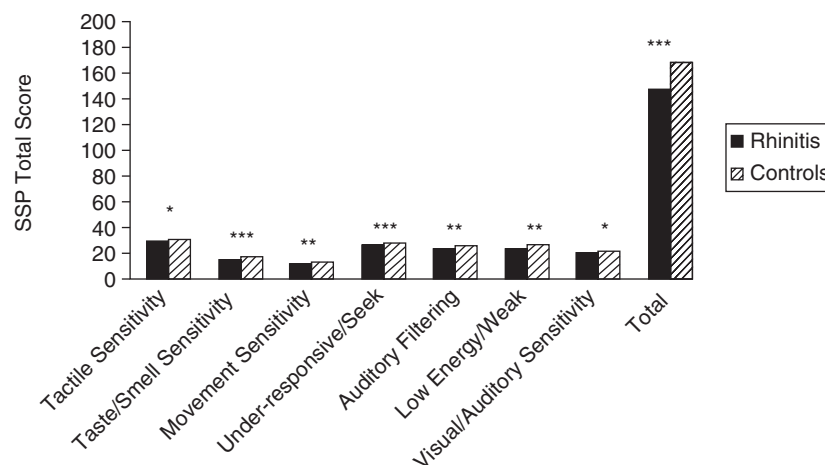


FIG. 1. Comparison of sum scores of all Short Sensory Profile (SSP) sections of both groups.

* $P \leq 0.05$ ** $P \leq 0.01$ *** $P \leq 0.001$

TABLE 2. THE PERCENTAGE OF CHILDREN FROM EACH GROUP IN EACH SENSORY LEVEL OF PERFORMANCE

SSP sections	<i>Typical performance</i>		<i>Probable difference</i>		<i>Definite difference</i>		χ^2
	<i>Rhinitis</i>	<i>Controls</i>	<i>Rhinitis</i>	<i>Controls</i>	<i>Rhinitis</i>	<i>Controls</i>	
Tactile sensitivity	60.7	75	14.3	14.3	25	10.7	2.02
Taste/smell sensitivity	46.4	89.3	25	7.1	28.6	3.6	12.01**
Movement sensitivity	53.6	92.9	21.4	3.6	25	3.6	11.02**
Under-responsive/seek	50	89.3	21.4	10.7	28.6	0	12.1**
Auditory filtering	60.7	89.3	25	7.1	14.3	3.6	6.1*
Low energy/weak	50	89.3	17.9	3.6	32.1	7.1	10.22**
Visual/auditory sensitivity	85.7	96.4	10.7	3.6	3.6	0	2.17
Total	57.1	89.3	7.1	7.1	35.7	3.6	9.34**

* $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

Abbreviation: SSP, Short Sensory Profile.

that since these children have limited variability of smells and taste, they limit themselves to specific tastes, textures, and temperatures of food, which they do sense relatively better. Previous studies explain that the increased presence of unregulated nerve growth factor (NGF) in rhinitis in the nasal mucosa may be implicated in neural hyperresponsiveness. O'Hanlon et al.⁸ examined the correlation between nasal sensitivity in patients with AR and level of neuronal markers, sensory and autonomic neuropeptides, the capsaicin/heat receptor TRPV1, and nerve growth factor (NGF). These researchers concluded that the increased number and specific phenotypical changes of sensory nerves may play a role in nasal hypersensitivity and provide new targets for the treatment of rhinitis. This strengthens the work of Sarin et al.¹⁴ Other studies refer separately to active phases of AR versus a non-symptomatic period.^{15,16} Sanico et al.¹⁵ claimed that the responsiveness of the neural apparatus of the nose is significantly greater in patients with active AR. It should be mentioned that in the present study, which refers to the pediatric age group, differentiating hyposmia from anosmia, and chronic from transient anosmia, is difficult. Endoscopic examination for neuroendothelial damage may be helpful, although not included in this study. In addition, anosmia due to AR is most responsive to topical corticosteroids. It is

recommended to further examine whether nasal corticosteroids, which improve hyposmia, impact the sensory sensitivity in children with rhinitis.

It should be mentioned that in the present study, children's hypersensitivity in smell/taste modalities was based on their parent's reports. It may strengthen the need to refer to parents' reports in the examinations of children with AR in order to identify sensory modulation disorders in these modalities as early as possible and supply an appropriate intervention that will refer to the child's nutrition as well as to child's environment factors that involve smell stimuli.

The findings of the present study support a previous report about similar sensory modulation patterns found in children with AD,⁷ and supports additional studies about the involvement of the peripheral and central nervous systems in modulating sensory input in patients with atopic conditions.⁸ This may suggest that sensory hypersensitivity is a common characteristic of allergies and should be taken into account in the treatment processes. Thus, it is recommended that physicians should refer to sensory modulation abilities when evaluating children with allergies. In case sensory modulation disorders are found, the child's parents should be encouraged to perform needed adaptations in the child's home environment (eg, enable the child to choose his/her

TABLE 3. COMPARISON OF SSP SUM SCORES BETWEEN GENDERS

SSP sections	<i>Rhinitis (n = 28)</i>				<i>Controls (n = 28)</i>			
	<i>Boys</i>		<i>Girls</i>		<i>Boys</i>		<i>Girls</i>	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Tactile sensitivity	30.55	3.41	28.37	4.44	31.76	2.83	31.07	3.36
Taste/smell sensitivity	15.45	4.22	11.12	4.18	18.78	1.81	17.28	3.56
Movement sensitivity	12.15	3.31	12.13	1.812	13.93	0.99	13.85	2.11
Under-responsive/seek	27.3	5.77	26.62	3.77	32.57	2.76	31.28	3.19
Auditory filtering	24.2	4.52	22.37	4.41	27.57	2.95	26.71	3.12
Low energy/weak	25.15	4.53	23.38	4.53	28.64	1.86	27.85	3.43
Visual/auditory sensitivity	21.65	3.23	21.62	2.66	23.85	1.41	22.71	2.67
Total SSP score	156.45	19.07	145.63	15.75	177.14	12.786	170.78	17.69

Abbreviations: SD, standard deviation; SSP, Short Sensory Profile.

favorite food but also gradually expose the child to different food textures, temperatures, and different food products; to involve the child in choosing the clothes in which he/she feels most comfortable; to use clothes made of pure cotton, etc.).

When examining gender effects on children's sensory profile, girls showed significantly lower score than the boys. However, the estimated effect size was <0.2 , showing that this difference has no practical significance. Yet, the number of children in each gender in the present study is relatively small. Gender may play a role in the pathophysiology of allergies, and boys are more susceptible to develop allergies.¹⁷ Thus, it is recommended to further study this point and to examine whether girls with allergies as rhinitis are more prone to show sensory hypersensitivity.

No significant group $\times$ age interaction was found. However, the relatively small sample size and the result according to which older children with rhinitis were more susceptible to present sensory under-responsiveness or seeking raises the need to further study age effects on child's sensory profile. This is strengthened by the literature that describes allergies as more severe in older children with stronger negative effects on life quality and well-being.¹⁸

In summary, the organization and modulation of sensory input provides the foundation for child's development and emotional regulation. The present study found that SMD are more frequent among children with rhinitis and highlights the need for multidisciplinary intervention programs for these children. These programs should focus on treating the symptoms and considering additional possible factors that may influence child's daily function and well-being, as child's ability to modulate sensations in daily environments. Information coming from parents to children with rhinitis, as by completing the sensory profile questionnaire, may contribute to the understanding of both parents' and medical practitioners of the child's abilities and needs.

Additional studies should further examine the sensory profile of children with rhinitis, for example, after a period of treatment. It is also recommended to conduct studies regarding the sensory modulation abilities impacts on child's function and well-being among children with other allergies in order to enable child's optimal development and optimal function and participation in daily living activities.

References

1. Berger WE. Overview of allergic rhinitis. *Ann Allergy Asthma Immunol* 2003; 90(Suppl 3):7-12.
2. Skoner DP. Allergic rhinitis: definition, epidemiology, pathophysiology, detection and diagnosis. *J Allergy Clin Immunol* 2001; 108(Suppl):S2-S8.
3. Kalpaklioglu AF, Baççioğlu A. Evaluation of quality of life: impact of allergic rhinitis on asthma. *J Invest Allergol Clin Immunol*. 2008; 18(3):168-173.

4. Rabago D, Guerard E, Bukstein D. Nasal irrigation for chronic sinus symptoms in patients with allergic rhinitis, asthma, and nasal polyposis: a hypothesis generating study. *WMJ* 2008; 107(2):69-75.
5. Andrew D, Craig AD. Spinothalamic lamina I neurons selectively sensitive to histamine: a central neural pathway for itch. *Nat Neurosci* 2001; 4:72-77.
6. Krishna MT, Mavroleon G, Hogate ST. Essentials of allergy. London: Martin Dunitz Ltd, 2001.
7. Engel-Yeger B, Habib-Mazawi S, Parush S, Rozenman D, Kessel A, Shani-Adir A. The sensory profile of children with atopic dermatitis as determined by the sensory profile questionnaire. *J Am Acad Dermatol* 2007; 57(4):610-615.
8. O'Hanlon S, Facer P, Simpson KD, Sandhu G, Saleh HA, Anand P. Neuronal markers in allergic rhinitis: expression and correlation with sensory testing. *Laryngoscope* 2007; 117(9):1519-1527.
9. Wilbarger P, Wilbarger JL. Sensory defensiveness in children aged 2-12. An: Intervention Guide for Parents and Otter Caretakers. Santa Barbara, CA: Avanti Educational Programs, 1991.
10. Miller LJ, Anzalone ME, Lane SL, Cermak SA, Osten ET. Concept evolution in sensory integration: a proposed nosology for diagnosis. *Am J Occup Ther* 2007; 61:135-140.
11. Pepys J. Skin tests for immediate, type I allergic reactions. *Proc R Soc Med* 1972; 65:271-272.
12. McIntosh DN, Miller LJ, Shyu V. The Short Sensory Profile (SSP). In: Dunn W, ed. The Sensory Profile: Examiner's manual. San Antonio, TX: Psychological Corporation, 1999, pp. 59-83.
13. Dunn W. The Sensory Profile: Examiner's manual. San Antonio, TX: Psychological Corporation, 1999.
14. Sarin S, Undem B, Sanico A, Togias A. The role of the nervous system in rhinitis. *J Allergy Clin Immunol* 2006; 118(5):999-1016.
15. Sanico AM, Koliatsos VE, Stanis AM, Bienenstock J, Togias A. Neural hyperresponsiveness and nerve growth factor in allergic rhinitis. *Int Arch Allergy Immunol* 1999; 118(2-4):154-158.
16. Hinriksdóttir I, Murphy C, Bende M. Olfactory threshold after nasal allergen challenge. *ORL J Otorhinolaryngol Relat Spec* 1997; 59(1):36-38.
17. Dong GH, Ma YN, Ding HL, Jin J, Cao Y, Zhao YD, He QC. Housing characteristics, home environmental factors and respiratory health in 3945 pre-school children in China. *Int J Environ Health Res* 2008; 18(4):267-282.
18. Pastar Z, Lipozencic J, Ljubojevic S. Etiopathogenesis of atopic dermatitis-an overview: *Acta Dermatovenol Croat* 2005; 13(1):54-62.

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