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Psychometric Evaluation of the Child Sensory Profile 2 (CSP2) Among Children with Dyslexia

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Abstract

Background: Sensory integration is a necessary skill for acquiring reading skills because it strongly depends on the rapid and strong relation between written and verbal symbols. There is no standardized test for Iranian children with dyslexia to investigate their sensory processing problems. Therefore, understanding the validity and reliability of the child sensory profile 2 (CSP2) would be essential for a detailed assessment of sensory impairments in dyslexic children.
Objectives: The current research aimed to establish the internal consistency, factor analysis, and convergent validity of the Persian version of CSP2 in children with dyslexia.
Methods: The sample of this study included 200 dyslexic children aged 6 to 12 years who were referred to learning disabilities centers in Qom from September 2019 to February 2020 by using the multistage sampling method. To collect data, the CSP2 questionnaire and the dyslexia test (NEMA) were used. The factor structure was assessed by confirmatory factor analysis. The internal consistency of the CSP2 was examined by using Cronbach's alpha. Convergent validity was assessed by examining the relationship between CSP2 and NEMA.
Results: Internal consistency was obtained as 0.89, 0.92, 0.77, and 0.94 for the four subscales of sensory processing, namely registration, seeking, sensitivity, and avoiding, respectively. The result of confirmatory factor analysis gained support for Dunn's four-factor model. Total scores of NEMA were correlated with the scores of CSP2 subscales (seeking, avoiding, sensitivity, and registration).
Conclusions: The Persian version of the Child Sensory Profile 2 is a valid (via confirmatory factor analysis and convergent validity) and reliable (via internal consistency) tool for assessing sensory processing in children with dyslexia.

Keywords: Child Sensory Profile 2 (CSP2), Dyslexia, Psychometric Properties

1. Background

Children learn through interaction with their surroundings (1). Nowadays, with the advancement of technology, children's interaction with the world around them is decreasing day by day, which would lead children to be deprived of the proper use of some of their physical senses. Due to the sensitivity of the subject, it is necessary to examine the role of different senses in learning and teaching. It is our body's senses that transmit information about the environment to the brain so that our world is known (2). The cause of some of the challenges related to academic performance is the issue of sensory processing. Therefore, we need to be aware of sensory systems and their relationships with problematic classroom behaviors (3). Ayres, an occupational therapist, and educational psychologist, believes that there is a close connection between learning and a child's sensory systems, sensory processing, and movement problems. According to her, in the developmental process of the child, sensory-motor skills play an important role in the academic skills in school (4).

In some people, sensory processing in the brain is not done properly, and sensory information such as touch, sound, and movement is misinterpreted every day. These mistakes in the interpretation of information can cause behavioral problems in response to environmental stimuli (5). Sensory processing disorder is a complex developmental disorder that can affect a person's life in childhood and adulthood (6). Sensory processing is how our neurological system receives, interprets, and responds to neural inputs. Individuals with sensory problems often have difficulty adjusting their responses to stimuli. They may use "self-stimulating" to counteract restrictions on stimuli and

"avoidance" to prevent overstimulation (7). People with sensory processing disorders may have an over-response or under-response to sensory stimuli, a strong or weak sensory desire, a tendency to gain intense sensory experiences, or a refusal to gain sensory experiences and difficulty in distinguishing senses (7). This disorder affects the activities of daily living, social, and educational life (8).

There is a growing concern about children with learning disabilities because they have great difficulty academic learning and other skills, despite being mentally gifted. Research findings show that, in all cultures, there are children who seem to have normal intelligence but have serious problems in learning the verbal language, acquiring reading or writing skills, or solving math problems (9). About 80% of students with learning disabilities have reading disabilities in decoding words, fundamental word recognition skills, or reading comprehension (10). Many people with dyslexia are smart at other things. For example, they may have high skills in math or space relations (9). The causes of dyslexia include weaknesses in the sensory channels. The results of some research show that dyslexic children are different from their typical peers in all sensory patterns (11).

Undoubtedly, sensory integration is an essential skill in acquiring reading skills because it relies on the rapid and deep connection between visual (written) and auditory (verbal) symbols. Children with dyslexia have difficulty coordinating visual stimuli to verbal symbols. Recent findings on the effect of sensory integration on dyslexic children have shown that children with reading problems have poor performance in verbal, auditory, and visual processing, and multi-sensory integration disorders may be a significant aspect of developmental dyslexia dysfunction (12). Besides, other researchers have reached this conclusion in their research on children with dyslexia that dysfunctional children, like typical children, can use visual and sensory information to control their physical condition but have poorer performance in multi-sensory integration (11).

Research by researchers at the Massachusetts Institute of Technology shows that certain neurophysiological disorders lead to reading problems (dyslexia). The results of a study indicate that a disorder of rapid neural adaptation is the cause of dyslexia (13). On the other hand, the neurological factors that make it difficult for people with dyslexia to acquire fluent and accurate reading skills are still unknown, and although structural and functional brain abnormalities were reported concerning dyslexia within the school, differences in reading experience may be attributed to the problem of dyslexia (14).

The problems related to sensory processing in all people, especially children with disabilities such as dyslexia, can cause problems in executive functions (8). On the other hand, there is no standardized tool for dyslexic children to study sensory processing problems in Iran. Therefore, it is necessary to examine the different parameters of validity and reliability of the child sensory profile 2 (CSP2) among dyslexic children to provide a timely and appropriate diagnosis for this group of children.

2. Objectives

The validity and reliability of the CSP2 have been assessed in various categories of children such as autism spectrum disorder, learning disability, and typical individuals (15). In this study, we prospectively studied the internal consistency, factor analysis, and convergent validity of the Persian version of CSP2 in children with dyslexia.

3. Methods

3.1. Study Design

This was psychometric research. The study proposal was approved by the Faculty of Rehabilitation, Shahid Beheshti University of Medical Sciences. Then, we obtained ethical approval from the related committee with code IR.SBMU.RETECH.REC.1399.894.

3.2. Participants

For determining the construct validity and internal reliability of CSP2, a multistage sampling method was used. The participants in the present psychometric testing study were caregivers of children aged six to 12 years. Participants were enrolled from the learning disabilities centers of Qom, Iran, from September 2019 to February 2020.

The inclusion criteria in this study were as follows:

- Respondents who were caregivers of dyslexic children aged six to 12 years spending more than 11 hours a day with a child for at least a year,

- Children who are suspected of learning disabilities by their teachers are referred to learning disability centers with a diagnosis of dyslexiaChildren who had no sensory problems such as blindness, deafness, intellectual disability, and autism spectrum disorder.

The exclusion criteria were as follows:

- An unwillingness of caregivers to respond to the CSP2 at any stage of research and

- An incomplete test

A written information sheet was provided to ensure that the participants received sufficient details on the administration of research. Caregivers who agreed to participate signed the consent form and completed the Persian version of the CSP2. The number of participants was 200

caregivers for measuring factor analysis, convergent validity, and internal consistency.

3.3. Procedure

Four phases were used to collect data, including:

Phase 1: Referring to the Research Unit of the General Department of Education of Qom province,

Phase 2: Referring to the research units of education districts (districts 1 to 4 and non-governmental centers),

Phase 3: Selecting students with reading disorders (dyslexia) among all referring students, and

Phase 4: Collecting statistical data using CSP2 and dyslexia test (NEMA).

3.4. Instruments

3.4.1. Child Sensory Profile 2 (CSP2)

The CSP2 has 86 items filled in by a caregiver for measuring the characteristics of a child's sensory processing. The four subscales of Dunn's sensory processing framework were measured by the questionnaire: seeking, avoiding, sensitivity, and registration. Moreover, this tool can assess six different systems in sensation from auditory and visual sense to touch and movement, as well as body position and oral sensory system. It also has a behavioral part that focuses on three main categories, including attention, emotion, social skills, and child's conduct. Parents who have regular contact with the child complete the questionnaire by reporting the frequency at which the behaviors occur (almost always, frequently, half the time, occasionally, or almost never, with an option of does not apply for use where necessary). The psychometric study done by Dunn showed 0.60-0.90 alpha scores for the internal validity of the CSP2. In this study, 697 children (3-14-years-old) participated, and the test-retest reliability was 0.87 - 0.97 (16). The psychometric properties of the Persian version of this test in Iran were studied by Shahbazi, and after calculating the item impact with values higher than 1.5, the content validity ratio was more than 0.42 and the content validity index was higher than 0.79 and all items of sensory profile 2 enumerated (15).

3.4.2. Dyslexia Test (NEMA)

This test was created and standardized by Karami and Nouri in 2014. A total of 1,614 primary school students from Tabriz, Sanandaj, and Tehran were evaluated using the reading and dyslexia test (NEMA). The study sample was selected by stratified random sampling among students from the three cities (Tehran: n = 600, Sanandaj: n = 500, Tabriz: n = 500). The overall Cronbach's alpha values for tests with high-frequency words, medium-frequency words, low-frequency words, word string, the test of rhyme, calling pictures 1, 2, text comprehension, word understanding, elimination of sounds, pseudowords, and reading fake words were 0.97, 0.98, 0.98, 0.95, 0.89, 0.67, 0.68, 0.48, 0.71, 0.95, and 0.97, respectively. Also, the results of factor analysis showed that the NEMA test included two major components. The first factor included vocabulary tests with high-frequency and medium-frequency words, word understanding, elimination of sounds, pseudowords, and reading fake words. The second factor included low-frequency words, rhymes, calling pictures of 1, 2, text comprehension, and signs test (17).

3.4.3. Internal Consistency

The internal consistency shows the correlation among the items of a questionnaire and is known to be a reliability term. It is usually measured by statistical methods such as split-half and Cronbach's alpha or sometimes Kuder Richardson$_{20}$ and Kuder Richardson$_{21}$ coefficients (18). For examining the CSP2's internal consistency, Cronbach's alpha was used, which ranges between zero and one. A zero value means no consistency, while the one score shows full consistency (19).

3.4.4. Construct Validity: Convergence

Construct validity is a measure of how meaningful a scale is in practical use or a determination of whether a scale measures what it purports to measure (20). The Pearson correlation coefficient between CSP2 and NEMA was used to calculate the convergent validity of CSP2.

3.4.5. Confirmatory Factor Analysis

For assessing the fit between a models' Hypothetical modeland what was gathered from participants in the study, we can use confirmatory factor analysis. In the current study, a wide range of fit indices such as chi-square, ration of chi-square to a degree of freedom, comparative fit index (CFI), the goodness of fit index (GFI), the root-mean-square error of approximation (RMSEA), normal fit index (NFI), Tucker-Lewis's index (TLI), and Akaike information criterion (AIC) were applied (21).

All data analyses were conducted using SPSS version 22 software, except for CFA, which was conducted using LISREL version 8.80.

4. Results

Table 1 displays the demographic characteristics of the participants. In total, 200 caregivers of children (93 boys and 107 girls; mean age: 8.39; age range: 6 - 12) completed these questionnaires. The frequencies based on the grade of the participants were as follows: The highest frequency

was related to the first grade (79 people, 39.5%), and the lowest frequency was related to the sixth grade (five people, 2.5%).

Table 1. Demographic Characteristics of Children with Dyslexia

Variables	No. (%)
Gender	
Girl	107 (53.5)
Boy	93 (46.5)
Age	
6	9 (4.5)
7	62 (31.0)
8	51 (25.5)
9	36 (18.0)
10	13 (6.5)
11	20 (10.00)
12	9 (4.5)
Grade	
First	79 (39.5)
Second	45 (22.5)
Third	39 (19.5)
Forth	16 (8.0)
Fifth	16 (8.0)
Sixth	5 (2.5)
Father's education	
Lower than diploma	92 (46.0)
Above the diploma	108 (54.0)
Mother's education	
Lower than diploma	67 (33.5)
Above the diploma	133 (66.5)
Father's job	
Self-employed	101 (50.5)
Employee	80 (40.0)
Manual worker	12 (6.0)
Unemployed	7 (3.5)
Mother's job	
Housewife	153 (76.5)
Employee	47 (23.5)

We used Cronbach's alpha for examining the internal consistency of sensory pattern (avoiding, seeking, sensitivity, and registration), sensory area (auditory, visual, touch, movement, body position, and oral), and behavioral area (conduct, social-emotional, and attentional) based on CSP2 in dyslexia children (Table 2).

Table 2. Values of Internal Consistency Coefficient Alphas for CSP2 in Dyslexia Children

Area	Boy	Girl	Total
Avoiding	0.90	0.85	0.88
Seeking	0.90	0.91	0.90
Sensitivity	0.87	0.84	0.85
Registration	0.93	0.85	0.90
Auditory	0.66	0.69	0.67
Visual	0.58	0.61	0.60
Touch	0.84	0.73	0.79
Movement	0.80	0.80	0.80
Body position	0.86	0.84	0.85
Oral	0.89	0.83	0.86
Conduct	0.85	0.82	0.84
Socio-emotional	0.93	0.88	0.91
Attentional	0.91	0.85	0.88
			0.96

Table 3 represents the correlation between the CSP2 and NEMA. As can be seen in the table, the sensory avoiding quadrant had a highly inverse and meaningful relationship with NEMA (r = -0.678), so that with increasing sensory avoiding, the NEMA score decreased, and the child showed to suffer from severe dyslexia. Pearson correlation coefficients in sensory registration, sensory sensitivity, and sensory seeking quadrants were at a moderate level of correlation with dyslexia (r = -0.491, -0.334, and -0.379, respectively). The above coefficients indicated that dyslexic children showed different patterns in the field of sensory processing.

Table 3. Relationship Between CSP2 and NEMA

CSP2	NEMA	
	Pearson Correlation Coefficient	Significance Level (P < 0.05)
Quadrant		
Seeking	-0.379	0.034
Avoiding	-0.678	0.012
Sensitivity	-0.334	0.045
Registration	-0.491	0.051

To evaluate model fit, the chi-square statistic (χ^2) was used. Also, relative/normed chi-square (χ^2/df), goodness of fit index (GFI), comparative fit index (CFI), Tucker–Lewis index (TLI), root-mean-square error of approximation (RMSEA), and standardized root means square residual (SRMR) were used. Although the V2 statistic has been proven to

be more used to monitor the fit, it highly depends on the sample size, which could be a limitation. A good substitute for V2 is the relative/normed chi-square (χ^2/df). If this ratio shows scores lower than three, it means that the fit between the data and the theoretical model is great. Besides, GFI, CFI, and TLI > 0.95, RMSEA < 0.06, and SRMR < 0.08 are other values that show a good fit of data (22) (Table 4).

5. Discussion

For the first time, the present study examined the psychometric properties of the CSP2 questionnaire in children with dyslexia in Iran. In the current study, for assessing the internal consistency of the test's items, Cronbach's alpha coefficient was used. According to the findings, excellent internal consistency (α = 0.96) was obtained for the total CSP2 score. Cronbach's alphas of each of the quadrants of sensory processing were as follows: seeking 0.92, avoiding 0.94, sensitivity 0.77, and registration 0.89.

The research findings indicated that these coefficients were high for all quadrants, as well as the total score, so it can be said that both the total scale and all of its components have good reliability. In the initial study of sensory profile design 2, internal consistency was obtained as 0.92, 0.91, 0.89, and 0.89 for the four patterns of sensory processing, namely sensory recording, sensory retrieval, sensory sensitivity, and sensory avoidance, respectively (16). In addition, the present study results are in line with those of Anagnostopoulos and Griva (2012) that obtained the reliability of the Sensory Profile 2 questionnaire with Cronbach's alpha value, which was estimated to be in the range between 0.710 and 0.845 for the subscales (23). Movallali et al. (2017) reviewed the psychometric properties of the sensory profile questionnaire in Iran by using Cronbach's alpha. The internal consistency was obtained for the sensory registration, sensory seeking, sensory sensitivity, and sensory avoidance as 0.81, 0.88, 0.82, and 0.81, respectively (24).

According to our searches, the current study is the first that used CSP2 for people with dyslexia. The main CSP2 questionnaire consists of four areas. These areas include seeking, avoiding, sensitivity, and registration. According to the statistical analysis performed to check the confirmatory factor analysis in the present study, the first factor (avoiding) has 35 items, the second factor (seeking) includes 21 items, the third factor (registration) has 11 items, and the fourth factor (sensitivity) contains 13 items. All of these factors had the desired validity, and only six items (1, 2, 10, 16, 23, 24) were removed due to weak factor loads. Considering the value of the RMSEA index and other indicators, we concluded that the designed model, which is a confirmatory factor analysis model of the CSP2 questionnaire in dyslexia children, had a good fit, which is consistent with the results of a study by Dean et al. (25).

The outcomes of the current study demonstrated that sensory avoiding at a significance level of 0.05 had a meaningful role in explaining dyslexia in children. Children with sensory processing disorder of sensory avoiding have intense alertness to sensory stimuli such as sounds, smell, and touch due to their low stimulation threshold. Thus, they suffer from confusion in facing these sensory stimuli and show symptoms such as discomfort, avoidance, distraction, and anxiety (26). Moreover, there was another meaningful relationship between sensory sensitivity and NEMA at a significance level of 0.05, which is associated with symptoms such as introversion, shyness, anxiety, and depression (27). This indicates that there is a significant relationship between children's sensory processing patterns and their dyslexia, which is in line with Perrachione et al.'s study. Perrachione et al. indicated that reading skills in dyslexic children were related to the more extensive repetition-induced neural adaptation. These results illustrate that the dysfunction of sensory patterns can be assumed as a significant neurophysiological difference in children with dyslexia, which would address impaired reading development (13). Thus, the findings of the present study are consistent with the results of many studies in terms of the relationship between sensory processing and dyslexia (11, 12, 28, 29).

5.1. Limitations and Future Research

This study has some limitations: (1) The research community, which was limited to students with dyslexia, so the data obtained from this study cannot be generalized to other groups in society, and (2) The lack of cooperation of some parents to complete the CSP2.

The study population should not be limited to students with dyslexia, and to determine the psychometric properties of this questionnaire, other groups that need special education and rehabilitation services should be used in sampling. This questionnaire should also be assessed in the groups of writing disorder and math disorder students, and its results should be compared with the general population to determine which group has the most power of detection. In addition, it is recommended for the schools to use sensory integration skills in their educational curricula according to the individual sensory features of the students.

5.2. Conclusions

Sensory integration skills are the abilities that dyslexic students require to obtain reading skills because it strongly depends on the rapid and strong relation between written and verbal symbols. The best procedure is

Table 4. Factor Analysis Fit Indices of the Persian Version of CSP2 in Dyslexia Children

	χ^2 (df)	df	CFI	GFI	RMSEA	NFI	TLI
Model	6353.15	2.75	0.96	0.90	0.07	0.93	0.89

Abbreviations: df, degree of freedom; CFI, comparative fit index; GFI, goodness of fit index; RMSEA, root-mean-square error of approximation; NFI, normal fit index; TLI, Tucker-Lewis's index.

to assess their sensory processing rapidly and give appropriate interventions according to their sensory patterns. As our results showed, the CSP2 can be addressed as a valid and reliable test for sensory processing assessment in people with dyslexia among the Iranian population. It also can be a proper tool for measuring sensory the processing of this group in a precise way.

Footnotes

Authors' Contribution: All authors made significant contributions to the conception, design, acquisition, analysis, and interpretation of data.

Conflict of Interests: There is no conflict of interest.

Ethical Approval: All procedures performed in this study were in line with the standards of the Ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1399.894).

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Informed Consent: Oral and written consent was obtained from participants after giving sufficient details on the administration of the research.

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