Int J Sport Stud Hlth. 2018 April; 1(2):e74071. doi: 10.5812/intjssh.74071.

Published online 2018 April 30. **Research Article**

The Relationship Between Executive Functions and Sensory Processing with Emotional Recognition in Autism Spectrum Disorder

Felora Erfanian,[1] Hadi Hashemi Razini,[2,*] and Maryam Ramshini[1]

[1]Department of Psychology and Exceptional Children Education, Faculty of Human Sciences, Islamic Azad University, Science and Research Branch, Tehran, Iran
[2]Department of Psychology, Faculty of Psychology and Educational Sciences, Kharazmi University, Tehran, Iran

[*]*Corresponding author*: Hadi Hashemi Razini, Department of Psychology, Faculty of Psychology and Educational Sciences, Kharazmi University, Tehran, Iran. Tel: +98-9125338736, E-mail: hadihashemi@khu.ac.ir

Received 2018 March 01; **Accepted** 2018 April 26.

Abstract

Objectives: Considering attention capacity along with cognitive and emotional problems of autistic children has been of utmost interest among researchers in recent years. Hence, the aim of the study was to investigate the relationship between executive functions, emotional recognition and sensory processing in autistic children.
Methods: The study was correlational. 82 children with autism spectrum disorder with ages ranging from 6 - 11 years were chosen based on convenience sampling in Tehran. The modified Benton face recognition test, short sensory profile and executive functions questionnaires (Brief) of parent form were administered in order to measure the variables. Pearson correlation and multiple regressions were used to analyze the data at a significance level of $P \leq 0.05$.
Results: The results suggested that there was a positive relationship between the executive functions and emotional recognition, while a negative relationship was found between the sensory processing and emotional recognition in autistic children. Regression analyses revealed that emotional recognition could be predicted through the components of executive functioning and sensory processing.
Conclusions: It was concluded that, emotional functions and sensory processing modification can help reducing emotional problems and emotional recognition of children with autism spectrum.

Keywords: Emotions, Attention, Autism Spectrum Disorder

1. Background

Autism spectrum disorders (ASD) are referred to neurodevelopmental disorder that result in severe deficiencies in social communication and the occurrence of restricted repetitive behaviors and interests (stereotypical behaviors) in the affected population. A median prevalence of 17 per 10000 has been reported for autism spectrum worldwide (1). Patients with autism spectrum disorder exhibit undesirable behaviors such as stereotyped movements, aggression, and self-harming behaviors. They also have difficulty in understanding and using social rules and behaviors, interactive gestures, nonverbal behaviors, and motor coordination (2, 3). Low or high sensitivity to auditory, olfactory, tactile and visual stimuli is often reported in children with autism. This disorder is pervasive and affects all the aspects of a child's development; therefore, the assessment should include all the aspects of performance in autistic children including social skills, movement, language, daily life skills, playing, executive functions, social recognition, and academic skills. The results of studies show that one of the areas affected by autism spectrum disorder is executive function. Executive functions include the child's ability to respond, plan, and organize, use working memory, problem solving, goal setting, and to do curriculum activities (4). The deficiencies of executive functions in children with autism may be accompanied by deficits such as cognitive impairment and inappropriate responses to social situations. Children with autism spectrum disorders also have difficulty in sensory processing, and therefore show abnormal responses to sensory stimuli (5).

Sensory processing is the way that nervous system receives, organizes and interprets the sensory information. It is also considered as an intrinsic process of the nervous system, which informs the individual how to respond to the situation based on the sensory information obtained from the surroundings (6).

When processing problems occur in one or more sensory systems, problems such as apraxia, verbal problems,

delay in eye and hand coordination, excessive eating, sounds and touch intolerance, and collaborative problems occur. Sensory processing disorders can lead to problems in many areas of life, such as doing daily life activities, self-esteem and coping, social and play skills (7). The unique sensory processing pattern in children with autism is associated with attention deficit disorder, arousal level, and interaction with others (5). The ability to recognize emotions is an important part of the non-verbal communication system and an essential skill for successful adjustment and manipulation of the environment, and an essential and fundamental skill in establishing successful relationships. An unusual recognition of emotional states on the face is a critical factor in a weak relationship and negative changes in competing behavior. Based on the above-mentioned reasons, the perception and recognition of others' emotions are considered as an important factor in social interactions. Therefore, any defect in this ability affects the quality of communication, which is observed in autistic children and complicates their communication problems (8, 9).

According to one study, weakness in sensory processing limited the participation of children with autism in activities (10). Furthermore, Hoyland et al. showed that autistic children not only perform weaker in the recognition of neutral face expression and female gender identity, but also their reaction time to male images was stronger (11). It was also shown in a study that autistic children had a different pattern in all their senses except olfactory as compared to healthy children (12).

Hilton et al. (2010) asserted that different patterns of sensory processing in children with autism are a major contributor to the social participation of these children (13). Based on the existing evidence and deficiencies in three areas of executive function, sensory processing, and emotional recognition in children with autism spectrum disorder, this research attempts to answer the question whether or not there is a relationship between executive functions, sensory processing and emotional recognition in autistic children.

2. Methods

The study was correlational. 82 children with autism spectrum disorder with ages ranging from 6 - 11 years were chosen from the autism children charity foundation, autistic children's Mita center and Ayin Mehrvarzi school based on convenience sampling in the year of 2017 in Tehran. The modified Benton face recognition Test, short sensory profile and executive functions questionnaires (Brief) of parent form were administered in order to measure the variables. The inclusion criteria were age, suffering from an autism disorder with level 1 based on the opinion of the center's authorities and medical records.

Behavior rating inventory executive function (BRIEF) parent form was used to evaluate the executive functions' level in children. The questionnaire consisted of 86 items. Among the skills related to executive performance, working memory (active memory), change (cognitive flexibility), emotion control, inhibition, initiating, planning / organizing, organizing materials and supervision were considered. Parents were asked to respond the phrases with regard to the problematic nature of the child's behavior during the last 6 months in each of the behaviors. For this questionnaire, the internal consistency coefficients using the Cronbach's alpha coefficient were estimated between 0.70 - 0.80 and for the re-test reliability, the correlation coefficients has been reported ranging from 0.78 - 0.90 after four and a half week interval (14).

Short sensory profile (SSP) was also used to measure the child's sensory processing models, answered by the child care givers which is applicable to children with the age of 3 to 10 years. The test has a high degree of clarity to detect abnormal sensory processing. Seven parts of the test that have been identified in normal samples include touch sensitivity (7 items), taste / olfactory sensitivity (4 items), motor sensitivity (3 items), emotion seeking (7 items), audio information filtering (6 items), weakness / low energy (6 items) and auditory and visual sensitivity (5 items). Items on this test are scored on a 5-point Likert scale and the score range is between 38 and 190. This test significantly differentiates between the sensory processing abilities of ordinary children and children with developmental disabilities and different etiologies. The internal consistency of the different parts of this test has been reported in the range of 0.70 0.90. Cronbach's alpha coefficients of the test were also found in the range of 0.67 to 0.93 (15).

Benton face recognition test (revised version) was used to evaluate seven different images from different people in every state of joy, sadness, anger and fear. The child had to choose from the four choices of happiness, grief, anger and fear. The test consisted of 28 different face's expressions from different people. All the faces are presented in full and front view and the children were asked to choose the emotional states appropriate to the target's face. The reliability of the test was also calculated by Cronbach's alpha and split-half. The results of the analysis showed that the reliability coefficient of the test based on the Cronbach's alpha was 0.98 and the correlation between the two halves of the sub-scales of happiness, sadness, fear and anger were respectively, 0.91, 0.77, 0.90 and 0.52. Pearson correlation and multiple regressions were used to analyze the data at a significance level of $P \leq 0.05$.

3. Results

The descriptive data are shown in Tables 1 and 2.

Table 1. Frequency Distribution by Age and Gender

Variable	Frequency	Frequency Percentage
Age		
6 - 7	14	17.1
8 - 9	35	42.7
10 - 11	33	40.2
Gender		
Female	22	26.8
Male	60	73.2
Total	82	100

Table 2. Descriptive Indices of Executive Functions, Sensory Processing and Emotional Recognition

Construct	Mean ± SD	Skewness	Kurtosis
Executive			
Working memory	21.85 ± 5.14	0.06	-0.57
Shifting	18.18 ± 4.50	0.63	0.02
Emotion control	20.78 ± 3.81	0.31	-0.49
Inhibition	19.57 ± 4.34	0.15	-0.34
Initiating	19.59 ± 4.13	0.61	-0.23
Planning	17.42 ± 3.65	0.65	-0.37
Organizations of materials	17.79 ± 3.77	0.15	-0.65
Monitoring	17.78 ± 3.78	0.26	-0.63
Sensory processing			
Touch sensitivity	24.92 ± 6.97	-0.50	-0.43
Auditory/visual sensitivity	14.15 ± 3.71	0.14	-1.21
Emotion seeking	21.19 ± 5.87	-0.36	-0.69
Auditory information filter	20.30 ± 6.89	-0.16	-1.35
Auditory/visual sensitivity	17.40 ± 4.65	-0.08	01.86
Weakness	21.71 ± 5.33	-0.33	-0.34
Motor sensitivity	11.50 ± 2.22	-0.11	-0.81
Emotional recognition	19.90 ± 7.84	-0.84	-0.50

Pearson correlation test (seen as the correlation matrix in Table 3) suggested that there was a pairwise relationship between the components of executive functions and emotional recognition; for example, the relationship between Emotional recognition with working memory was 0.24. The rest is as follows: emotion control (P = 0.33), initiation (P = 0.39), planning (P = 0.26), organizing (P = 0.23) and monitoring (P = 0.42) which were all significant at significance level of $P \leq 0.01$. However, It was shown that the relationship between the emotional recognition, shifting (P = 0.17) and inhibition (P = 0.15) were not significant.

In order to evaluate the predictive value of each of the components of executive functions in the prediction of emotional recognition, multiple regression test was used (See Table 4).

The results indicated that the components of executive functions predicted 23% of the variance of emotion recognition. The value of F = 2.72 also indicated that this value was significant at $P \leq 0.001$.

As shown in Table 5, the beta value of each of the components of executive functions in the prediction of emotional recognition is reported.

Based on the findings of coefficients and the T-statistic of the predictive variables, the emotional recognition can be predicted with a beta coefficient of 0.17 for shifting, 0.11 for emotional control, 0.26 for initiating and 0.29 for monitoring.

The correlation matrix of Table 6, suggested that there was a pairwise relationship between sensory processing and emotional recognition components; as shown, the relationship between face recognition and touch sensitivity equals -0.27. The results for other variables are as follows: olfactory/taste sensitivity (-0.38), emotion seeking (-28.2), auditory information filter (-29.2), and auditory/visual sensitivity (-0.34) which were significant at 0.01. It can be stated that the scores of facial recognition decrease and vice versa by increasing the scores of emotional processing. Also, according to the Table, the relationship between the emotional recognition, weakness (-0.13) and motor sensitivity (-0.19) was not significant.

Multiple regression test was used to evaluate the predictive value of each of the sensory processing's components in the prediction of emotional recognition as reported in Table 7.

The results of the Table above show that the sensory processing can predict the variance of recognition by 29% and the value of F = -2.41 also indicated that this value was significant at the level of 0.001.

Based on the coefficients and the T-statistic of the predictive variables, seen in Table 8, the emotional recognition can be predicted with a beta coefficient of -0.14 for touch sensitivity, -0.29 for taste/olfactory sensitivity, -0.12 for emotion seeking, -0.10 for auditory information filter and -0.18 for olfactory/visual sensitivity. It can be concluded that they have positive predictive power for emotional recognition at the level of 0.001.

4. Discussion

Given the importnace of emotional functions and sensory processing in children with autism spectrum disorder, the relationship of executive functions, emotional recognition and sensory processing was studied in autistic children. The results sugested that there was a pairwise

Table 3. Relationship Between Executive Functions and Emotional Recognition[a]

Number	Variable	1	2	3	4	5	6	7	8	9
1	Working memory	1								
2	Shifting	0.52[b]	1							
3	Emotion control	0.50[b]	0.55[b]	1						
4	Inhibition	0.49[b]	0.64[b]	0.32[b]	1					
5	Initiating	0.37[b]	0.45[b]	0.47[b]	0.38[b]	1				
6	Planning	0.52[b]	0.57[b]	0.58[b]	0.51[b]	0.51[b]	1			
7	Organizing	0.46[b]	0.27[b]	0.42[b]	0.32[b]	0.33[b]	0.44[b]	1		
8	Monitoring	0.53[b]	0.34[b]	0.58[b]	0.28[b]	0.46[b]	0.55[b]	0.53[b]	1	
9	Emotional recognition	0.24[b]	0.17	0.33[b]	0.15	0.39[b]	0.26[b]	0.23[b]	0.42[b]	1

[a] P < 0.05.
[b] P < 0.01.

Table 4. Summary of Regression Model, Variance Analysis and Statistical Regression Indices of Emotional Recognition

Model	SS	DF	MS	F	P	R	R^2	S.E
Regression	1143.62	8	142.95	2.72	0.001	0.48	0.23	7.25
Residual	3837.60	73	52.57					

Table 5. Regression Coefficients of Emotional Recognition of the Components of Executive Functions

Variables	B	Standard Error b	β	T
Working memory	0.06	0.21	0.04	6.11
Shifting	0.13	0.27	0.17[a]	9.05
Emotion control	0.21	0.31	0.11[a]	3.46
Inhibition	0.03	0.26	0.07	2.54
Initiating	0.49	0.24	0.26[a]	1.67
Planning	0.11	0.32	0.05	0.90
Organizing	0.03	0.27	0.06	0.55
Monitoring	0.60	0.31	0.29[a]	0.70

[a] P < 0.001.

Table 6. The Relationship Between Sensory Processing and Emotional Recognition[a]

Number	Variable	1	2	3	4	5	6	7	8
1	Touch sensitivity	1							
2	Olfactory/taste sensitivity	0.46[b]	1						
3	Emotion seeking	0.63[b]	0.52[b]	1					
4	Auditory information filter	0.55[b]	0.63[b]	0.79[b]	1				
5	Auditory/visual sensitivity	0.59[b]	0.54[b]	0.57[b]	0.61[b]	1			
6	Weakness	0.65[b]	0.40[b]	0.54[b]	0.42[b]	0.44[b]	1		
7	Motor sensitivity	0.34[b]	0.44[b]	0.53[b]	0.44[b]	0.49[b]	0.48[b]	1	
8	Face recognition	-0.27[b]	-0.38[b]	-0.28[b]	-0.29[b]	-0.34[b]	-0.13	-0.19	1

[a] P < 0.05.
[b] P < 0.01.

relationship between the components of executive functions and emotional recognition. In other words, by improving the emotion control, initiating, planning, organizing, and monitoring the amount of emotional recognition,working memory is enhanced. As indicated, the components of executive functions can predict 23% of the vari-

Table 7. Summary of Regression Model, Analysis of Variance and Regression Statistical Indices of Empirical Recognition

Model	SS	DF	MS	F	P	R	R^2	S.E
Regression	926.6052	7	132.29	2.41	0.0010	0.430	0.290	7.40
Residual	4055.17	74	54.80					

Table 8. Regression Coefficients of Emotional Recognition by Sensory Processing Components

Variables	B	Standard Error b	β	T
Touch sensitivity	-0.12	0.56	-0.14[a]	-0.68
Taste/olfactory sensitivity	-0.61	0.34	-0.29[a]	-1.02
Emotion seeking	-0.16	0.67	-0.12[a]	-0.61
Auditory information filter	-0.13	0.66	-0.10[a]	-0.52
Auditory/visual sensitivity	-0.12	0.80	-0.18[a]	-1.20
Weakness	-0.31	0.41	0.05	-0.08
Motor sensitivity	0.22	0.23	0.04	-0.09

[a] $P < 0.001$.

ance of emotion recognition. This finding is in line with the results of the research by Zingerevich, showing that children with autism disorder perform poorly in executive functions (4). Most neuropsychological studies of autism executive functions show that these individuals have difficulty in controlling the response inhibition and information processing. The deficiency in executive functions disturbs the sensory processing, leading to the emotion recognition disruption. However, the emotional recognition is not weak at all in its aspects. Autistic children are better at recognizing the emotion of happiness as compared to other emotions. Farran et al., demonstrated that those with autism show the fastest and most correct responses in the recognition of happiness (8). In explanation of this finding, it should be pointed out that teeth can be seen in the state of happiness and such a stimulus is very helpful in processing the above emotion in the autistic child and requires less attention and cognitive function and doesn't need subjective representation. Therefore, the recognition of happiness state is easier for them, because it does not require complicated cognitive function. However, emotions such as fear is an ambiguous emotion with no obvious sign on the individual's face, and the subjective representation is required and autistic children find it difficult to identify. Another explanation for this hypothesis is the fact that the autistic children's weakness in executive functions brings about other problems in initiating, creating and maintaining social relationships. When social interactions are reduced, these children are less likely to experience emotional state which itself decreases emotional states' recognition.

In the second part of results, it was found that Sensory processing can predict the emotional recognition of children in the autism spectrum. It was concluded that the scores of facial recognition decrease by increasing the scores of emotional processing. The results also show that the sensory processing can predict the variance of recognition by 29%. This finding is in line with some studies (8, 10, 13). In the explanation of this finding, it can be stated that sensory processing is a way through which the nervous system receives, organizes and interprets the sensory information. Optimum sensory processing enables the individual to respond in a manner consistent with environmental demands and participate meaningfully in everyday tasks. In this regard, a study showed that autistic children were capable of repairing their ability to recognize emotional states after short and intensive training methods (10).

When these children's social interactions decrease, they get less familiar with different emotional states and less cognitive and sensory consciousness toward emotions such as happiness, anger, fear, and sadness, and therefore the recognition of emotional states decreases. Another explanation to confirm this hypothesis is among the options related to sensory processing. There are five weak factors in children with autism including visual processing, touch processing, sensory processing associated with physical movement, sensory processing associated with tolerance and low muscular strength, and sensory sensitivity. When the visual processing is poor in these children, it can be difficult for them to recognize the recognition of emotional states. In fact, children with autism are incapable of extracting abstract and holistic concepts and detailing visual stimuli in their environment due to the weakness of central integration and this can justify the incorrect emotional recognition of the faces (16, 17). Due to considerable effects of life style (nutrition, exercise) on mental and psychological status of human (18-21), considering this factor for autistic children are highly recommended in future studies.

One of the study limitations was due to convenience

sampling method. Therefore, the generalization of the results to larger populations should be done with caution. Another limitation refers to the research tools, since a questionnaire was used to collect the data, it might have caused a bias in the individuals' self-reports. In subsequent studies, tools with more precision, such as clinical interview, storytelling can be administered instead of self-reporting tools.

Footnote

Conflict of Interest: Nothing to declare.

References

1. National Academies of Sciences EAM, Thomas F B, Joel T W. *Mental disorders and disabilities among low-income children*. National Academies Press; 2015.
2. Craig F, Margari F, Legrottaglie AR, Palumbi R, de Giambattista C, Margari L. A review of executive function deficits in autism spectrum disorder and attention-deficit/hyperactivity disorder. *Neuropsychiatr Dis Treat*. 2016;**12**:1191–202. doi: 10.2147/NDT.S104620. [PubMed: 27274255]. [PubMed Central: PMC4869784].
3. O'Hearn K, Franconeri S, Wright C, Minshew N, Luna B. The development of individuation in autism. *J Exp Psychol Hum Percept Perform*. 2013;**39**(2):494–509. doi: 10.1037/a0029400. [PubMed: 22963232]. [PubMed Central: PMC3608798].
4. Zingerevich C, Patricia D LV. The contribution of executive functions to participation in school activities of children with high functioning autism spectrum disorder. *Res Autism Spectr Disord*. 2009;**3**(2):429–37. doi: 10.1016/j.rasd.2008.09.002.
5. Sanz-Cervera P, Pastor-Cerezuela G, Gonzalez-Sala F, Tarraga-Minguez R, Fernandez-Andres MI. Sensory Processing in Children with Autism Spectrum Disorder and/or Attention Deficit Hyperactivity Disorder in the Home and Classroom Contexts. *Front Psychol*. 2017;**8**:1772. doi: 10.3389/fpsyg.2017.01772. [PubMed: 29075217]. [PubMed Central: PMC5641858].
6. Devlin S, Healy O, Leader G, Hughes BM. Comparison of behavioral intervention and sensory-integration therapy in the treatment of challenging behavior. *J Autism Dev Disord*. 2011;**41**(10):1303–20. doi: 10.1007/s10803-010-1149-x. [PubMed: 21161577].
7. Cosbey J, Johnston SS, Dunn ML. Sensory processing disorders and social participation. *Am J Occup Ther*. 2010;**64**(3):462–73. [PubMed: 20608277].
8. Farran EK, Branson A, King BJ. Visual search for basic emotional expressions in autism; impaired processing of anger, fear and sadness, but a typical happy face advantage. *Res Autism Spectr Disord*. 2011;**5**(1):455–62. doi: 10.1016/j.rasd.2010.06.009.
9. Lartseva A, Dijkstra T, Buitelaar JK. Emotional language processing in autism spectrum disorders: a systematic review. *Front Hum Neurosci*. 2014;**8**:991. doi: 10.3389/fnhum.2014.00991. [PubMed: 25610383]. [PubMed Central: PMC4285104].
10. Kirby AV, Dickie VA, Baranek GT. Sensory experiences of children with autism spectrum disorder: in their own words. *Autism*. 2015;**19**(3):316–26. doi: 10.1177/1362361314520756. [PubMed: 24519585]. [PubMed Central: PMC4556130].
11. Hoyland AL, Naerland T, Engstrom M, Lydersen S, Andreassen OA. The relation between face-emotion recognition and social function in adolescents with autism spectrum disorders: A case control study. *PLoS One*. 2017;**12**(10). e0186124. doi: 10.1371/journal.pone.0186124. [PubMed: 29020059]. [PubMed Central: PMC5636137].
12. Matsushima K, Kato T. Social interaction and atypical sensory processing in children with autism spectrum disorders. *Hong Kong J Occup Ther*. 2013;**23**(2):89–96. doi: 10.1016/j.hkjot.2013.11.003.
13. Hilton CL, Harper JD, Kueker RH, Lang AR, Abbacchi AM, Todorov A, et al. Sensory responsiveness as a predictor of social severity in children with high functioning autism spectrum disorders. *J Autism Dev Disord*. 2010;**40**(8):937–45. doi: 10.1007/s10803-010-0944-8. [PubMed: 20108030].
14. Abdollahipour F, Alizadeh Zarei M, Akbar Fahimi M, Karamali Esmaeili S. [Study of face and content validity of the persian version of behavior rating inventory of executive function, preschool version]. *J Rehabil*. 2016;**17**(1):10–7. Persian. doi: 10.20286/jrehab-170110.
15. Tomchek SD, Dunn W. Sensory processing in children with and without autism: a comparative study using the short sensory profile. *Am J Occup Ther*. 2007;**61**(2):190–200. doi: 10.5014/ajot.61.2.190. [PubMed: 17436841].
16. Whyatt C, Craig C. Sensory-motor problems in Autism. *Front Integr Neurosci*. 2013;**7**:51. doi: 10.3389/fnint.2013.00051. [PubMed: 23882194]. [PubMed Central: PMC3714545].
17. Pfeiffer BA, Koenig K, Kinnealey M, Sheppard M, Henderson L. Effectiveness of sensory integration interventions in children with autism spectrum disorders: a pilot study. *Am J Occup Ther*. 2011;**65**(1):76–85. doi: 10.5014/ajot.2011.09205. [PubMed: 21309374]. [PubMed Central: PMC3708964].
18. Amini M, Mirmoezzi M, Salmanpour M, Khorshidi D. Eight weeks of aerobic exercises improves the quality of life in healthy aged sedentary men. *Int J Sport Stud Hlth*. 2018;**1**(1). doi: 10.5812/intjssh.67514.
19. Irandoust K, Taheri M. The effect of vitamin d supplement and indoor vs outdoor physical activity on depression of obese depressed women. *Asian J Sports Med*. 2017;**8**(3). doi: 10.5812/asjsm.13311.
20. Irandoust K, Taheri M. The effects of aquatic exercise on body composition and nonspecific low back pain in elderly males. *J Phys Ther Sci*. 2015;**27**(2):433–5. doi: 10.1589/jpts.27.433. [PubMed: 25729184]. [PubMed Central: PMC4339154].
21. Irandoust K, Taheri M, Neto GR, Lotfi L. Physical and physiological literacy feedback improves the exercise behavior in TOFI governors and chief executive officers. *J Exerc Physiol Online*. 2017;**20**(6):24–30.