



Effect of Perceptual-Motor activities on the Mirror Neurons Training, Behavioral Disorders and Social development in Children with High Functioning Autism

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Abstract

Background: Autism spectrum disorders (ASDs) are developmental conditions characterized by deficits in social interaction, motor performance, and obsessive/stereotyped patterns of behaviors. Although there is no reliable neurophysiological marker associated with ASDs, dysfunction of the parieto-frontal mirror neuron system has been suggested as a disturbance linked to the disorder.

Objective: The purpose of this applied and basic study was to investigate the effect of perceptual-motor training on the mirror neuron activity, behavioral disorders, and social development in children with high function autism.

Methods: The pretest-posttest randomized-group research design was used for this quasi- experimental research. Therefore, 12 children with high function autism (7-11 years) were selected from special school and then assigned into two groups (experimental and control). Social development, behavioral disorders, and mirror neurons activity were assessed at baseline (pre-intervention), week 8 (post-intervention). The experimental group received perceptual motor training three times per week for 8 week). Data was analyzed by independent t test, mixed 2*2*2*3 ANOVA, mix ANOVA 2*2 at the $p < 0.05$ significance.

Results: Results showed that perceptual motor training significantly reduced behavioral disorders ($p < 0.05$), and increased social development in the experimental group ($p < 0.05$). furthermore, there was a significant improve in MNs activity in experimental group compare with control group. ($p < 0.05$).

Conclusion: These results can affect the improvement of autistic children and it emphasized the role of motor skills in autistic children school schedule.

Introduction

Over the past two decades, a great deal of empirical evidence has been proposed which indicates that timely education can be most impactful on children. In this regard, there is a general agreement that childhood is a time when development processes and behavioral

characteristics undergo rapid changes and it is the most flexible time of people's lives (Payne and Isasscs, 2002). Since children with special needs or those who are exposed to the risk of disability are way more in need of a well-organized and enriched environment than ordinary children; thus, it is quite important to use intervention plans to provide such

an environment for them. One of these disorders is autism. This disorder disables the brain and prevents it from acting properly when it comes to social behaviors and communicative skills and it disturbs the functioning of the brain in terms of social interactions (Fooladgar et al., 2009). A disorder that affects the social aspect of one's life is the main core of autism. In fact, a defect in the observation/execution matching system or the mirror neuron system is a nervous mechanism that causes disorder and defects in social communication and cognition associated with autism (Rizzolati et al., 2010). In other words, these individuals have a problem with mirroring what others do (Brenier, 2007). A mirror neuron system is a nervous system in the gray matter and in the pre-motor part and it includes a series of neurons that reflects all of the activities in the environment like a mirror in the brain. Given the various functions of the mirror neurons and since most of these functions are damaged in autistic patients, an assumption which has been proposed is that the problems autistic children deal with in domains such as movement perception, language, imitation, empathy and social interaction are caused by malfunction of the mirror neurons (Brenier, 2007). The small number of studies which have focused on the relationship between the activity of these neurons and autism spectrum disorders have obtained different and conflicting results. Some of these results were indicative of a defect in the mirror neuron system of individuals with autism (Peter et al., 2012; Lindsay et al., 2005); whereas, others have rejected this

hypothesis (Raymaecker et al., 2009; Teng Fan et al., 2010 and Mirab Zadeh, 2001). Hence, these ambiguities put autistic children and their families in a special situation (Meirsschaut et al., 2010). The destructive effect of this disorder on the life of the autistic person on the one hand and the concerns specialists have about its out of hand prevalence on the other one, a number of researchers have studied the etiology of this disorder and examined various treatments in this field.

One of the important neurological processes resulted from the effect of this neuronal weakness is "perceptual inability". In the field of learning disabilities, the focus is on perceptual – motor processes (Catmur, 2013). From the perspective of dynamic systems, perceptual development and motor development are connected to one another and are not separated and all of the voluntary movements are connected with an element of cognition and perception. An autistic person deals with defects in terms of their sensory – motor connections and different parts of their brains that are responsible for processing emotions (mirror neuron system) are not properly connected. As a result, this person is not able to convert his/her emotions and feelings through suitable verbal and motor planning. Further, proper and purposeful physical activity can improve the physical health and motor behaviors of these children and contribute to the improvement of their social behaviors which is a requirement if they want to adopt to their surrounding world and various phenomena and lead them to acceptable and desirable social criteria (Aslankhani, 2000). In

addition, this method can prevent the consequences of leading inactive lives by these children and pave the way for their physical and behavioral health to be improved. Motor interventions are among methods that are both inexpensive and noninvasive and also, their positive impacts on autism disorders have been shown in a small number of studies that have focused on them (Afshari, 2012; Bahrami et al., 2012; Sabaghian et al., 2012; Maria et al., 2011 and Rebecca Ulrich, 2000). In this respect, the present study has aimed to determine the effectiveness of 24 sessions of perceptual – motor activities on the mirror neuron training, behavioral disorders and social development of 7 to 11-year old boys diagnosed with high functioning autism.

Method

Participants

After getting the necessary permission from the Exceptional Education Organization of Iran, the researcher visited exceptional schools related to behavioral disorders and studied the medical and educational files on the students and specified children in the age range of 7 to 11 years old diagnosed with high functioning autism. Following this, the researcher provided the parents of the selected children with the essential information about different stages of the study and the nature of the research. After getting all of the necessary information, parents signed a written consent and 12 of these children were selected using the convenience sampling method based on the criteria determined for entering the study which follow:

1. Diagnosis with high functioning autism

2. Lack of other nervous and behavioral disorders
3. No history of chronic physical problems
4. Achieving the mean intelligence score or higher

The qualified students took part in this research. These 12 children were again randomly divided into two groups of 6: a control group and an experimental group.

Research tools

The following tools have been used in this study: Social Communication Questionnaire (SCQ) to determine children's social development score, Gilliam Autism Rating Scale (GARS) to detect and assess the severity of autistic behaviors, Achenbach's Child Behavior Checklist (CBCL) to assess children's behavioral disorders, Raven's Child Intelligence Colored Test – Raven's Colored Progressive Test (RCPM) to assess children's IQ score (Raven and Summers, 1986) and 64-channel EB PLUS amplifier to record the brain waves (mu frequency).

Method of execution

Before and after the interventions, children's parents or educators were asked to fill out the behavioral disorders and social development questionnaires in relation to their children. In addition, the EEG test was done on the children from both the control and the experimental group so that their mu wave activity would be recorded with the sampling rate of 256 HZ at a frequency of 8 to 13 HZ and their mirror neuron activity would be examined. The reference electrodes for

recording the activity in this research were CZ, C3 and C4. The mu waves were recorded at three different modes. The assignments were as follows:

1. Looking at a gray page with a + sign in the middle of it to record the base condition.
2. Watching a video in which the executor throws a ball inside a ring (observation).
3. The child had to do the movements that he had saw in the video (execution).

Each video was 120-second long and all of them were soundless and were played in a black and white background on a computer monitor. Children were sitting in an approximately 48-cm distance from the monitor when they were watching the videos. To ensure that children were paying attention to the videos, they were asked about the number of times the videos were paused by the examiner. After the pretest, the experimental group participated in eight weeks of intervention (3 sessions per week). Each testee took part in 24 educational sessions in eight weeks and underwent the interventions (perceptual – motor exercises). Each session lasted for 40-45 minutes.

In the first 10 minutes, the testees did stretching exercises and warmed up. In the next 30 minutes, they did perceptual – motor activities (including balance, body awareness, visual and hearing cognition, movement, tactile and coordination cognition exercises) which were followed by 5 minutes of doing cool down exercises. It must be pointed out that one of the children in the control group did not take part in the posttest and therefore was eliminated from the research procedure.

Statistical analysis method

To analyze the data, descriptive and inferential statistical methods were used. To estimate the normality of distribution of the raw data, the Shapiro-Wilks Normality Test was used. Since distribution of the dependent variables was normal and variances were homogenous (tested by using the Levine Test), to analyze the data associated with mu frequency, 2 (group) *2 (condition) *2 (test) *3 (electrode) analysis of variance with the repetition of the last three factors and Bonferroni post hoc test were used. It is necessary to state that to measure mu Suppression in the control and the experimental group for each electrode, ratio of power at the time of observation and execution to power of base was calculated. This was done to control the changes in the absolute mu power resulted from individual differences such as skull thickness and resistance of electrode. Since the relativity data are not essentially normal, the data were converted to a logarithm (log) before the analysis. Logarithms lower than zero, equal to zero and higher than zero were indicative of mu Suppression, lack of mu Suppression and enhance of mu , respectively. Furthermore, the multivariate analysis of variance of difference scores was used to analyze the effectiveness of perceptual – motor activities on children’s behavioral disorders. Also, 2(group)*2(test) analysis of variance with the repetition of three factors was used for testing the social growth variable. All of the statistical analyses were done using SPSS ver.21 software and at the significance level of $p < 0.05$.

Results

Table 1 shows mean and standard deviation of the demographic features of the groups under study. The results of the independent t-test did

not show a significant difference between the age ($t_1=-0.43$ and $p=0.675$) and IQ ($t_2=-0.029$ and $p=0.778$) in the control and the experimental groups.

Table 1: mean and standard deviation of the demographic features of the groups under study

Variables	Experimental group		Control group	
	Mean	Standard deviation	Mean	Standard deviation
Age	8.83	1.47	9.2	1.3
IQ	23.33	3.78	24	3.81

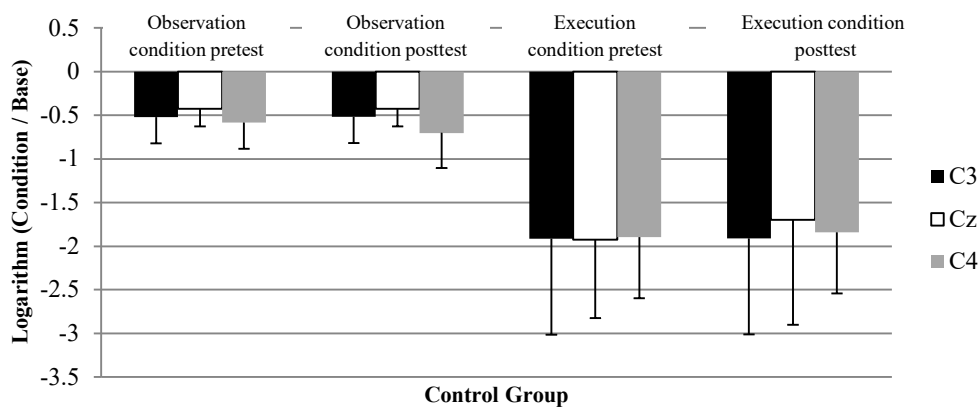


Fig. 1: mean and standard deviation of mu Suppression of the control group in various conditions and electrodes

Figures 1 and 2 display mean and standard deviation of mu Suppression (logarithm of ratio of power at the time of observation and execution to the power in the base condition) in the two groups in the pretest and posttest. As it can be seen, mu

Suppression means at the time of execution were considerably higher than that at the time of observation.

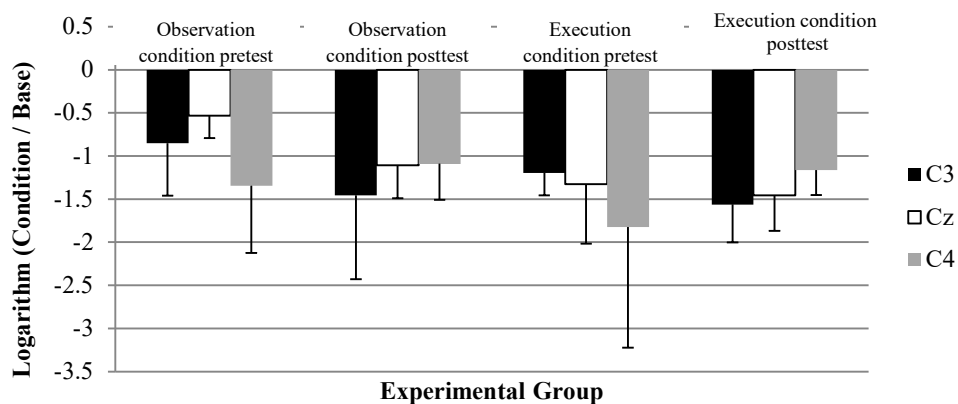


Fig. 2: mean and standard deviation of mu Suppression of the experimental group in various conditions and electrodes

Figure 3 shows the mean and standard deviation of behavioral disorders and social growth of the two groups in the pretest and posttest. As it can be seen, in the posttest, intrinsic and interstitial behavioral disorders of the experimental group

were exponentially reduced. Figure 4 also shows the improvement of social development factor after the interventions.

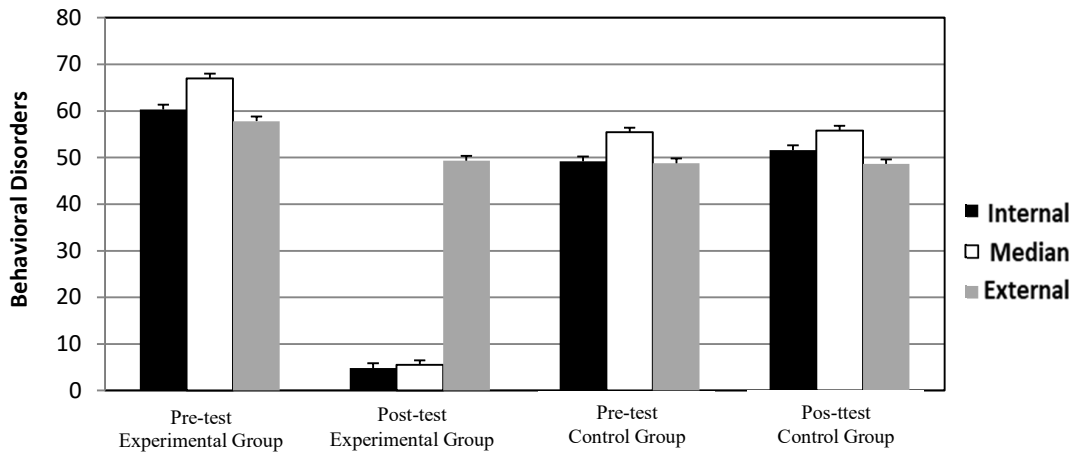


Fig. 3: mean and standard deviation of behavioral disorders in various groups and tests.

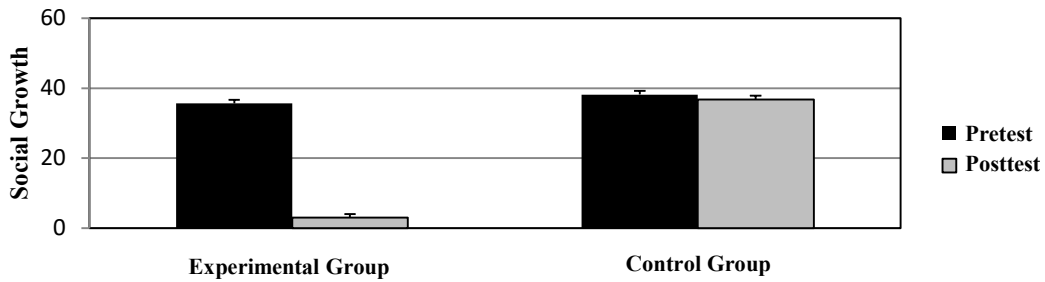


Fig. 4: mean and standard deviation of social growth in various groups and tests.

Results of 2 (group) *2 (condition) *2 (test) *3 (electrode) analysis of variance with the repetition of the last three factors for mu Suppression have been presented in table 2. As it can be seen in table 2, only the main effect of the condition and the mutual effects of the two factors group and condition and mutual effects of the three factors group, test and electrode were significant. According to the results, mu Suppression in the observation condition (-0.79) was significantly lower than the execution condition (-1.647).

Paired comparisons associated with the significant mutual effects of condition and group were done using independent and dependent t-test modified by Bonferroni ($P < 0.0125$). The obtained

results showed that mu Suppression of the observation condition (-1.064) in the experimental group was significantly higher than that in the control group (-0.53) ($t_3 = -4.238$, $p = 0.002$); however, there was no significant difference between the control group (-1.871) and experimental group (-1.422) in terms of mu Suppression in the execution condition ($t = 1.22$, $p = 0.254$). Additionally, there was no significant difference between mu Suppression of the experimental group in the observation and execution condition and mu Suppression of the control group in the observation and execution condition (respectively, $t_5 = 1.892$, $p = 0.117$; $t_4 = 3.638$, $p = 0.022$).

Table 2: results of four-factor analysis of variance for the mu Suppression variable

Source of variation	F	df Assumption	df Error	p	α
Group	0.047	1	9	0.833	0.005
Condition	1.6928	1	9	0.002	0.675
Test	0.439	1	9	0.524	0.047
Electrode	0.518	2	8	0.614	0.115
Group * Condition	6.264	1	9	0.034	0.41
Group * Test	0.871	1	9	0.375	0.088
Group * Electrode	0.063	2	8	0.939	0.016
Test * Condition	2.19	1	9	0.173	0.196
Electrode * Condition	0.172	2	8	0.845	0.041
Electrode * Test	4.387	2	8	0.052	0.523
Group * Test * Condition	0.556	1	9	0.475	0.058
Group * Electrode * Condition	0.177	2	8	0.841	0.042
Group * Electrode * Test	5.829	2	8	0.027	0.593
Electrode * Test * Condition	0.251	2	8	0.784	0.059
Group * Electrode * Test * Condition	0.013	2	8	0.987	0.003

Paired comparisons relative to the significant mutual effects of the variables condition, electrode and group were done using dependent t-test modified by Bonferroni ($P < 0.005$) and independent t-test modified by Bonferroni ($P < 0.008$) (table 4-5). The results have shown that there was no

significant difference between mu Suppression of each of the electrodes in each group and condition.

Multivariate analysis of variance was used to compare the groups in relation with behavioral disorders posttest. According to the results, the effect of group was significant ($\eta^2 = 0.095$, $F_{(3,7)} = 22.172$, $p = 0.001$, $\eta^2 = 0.905$) and an initial

significant difference was observed for two subscales: intrinsic and interstitial behavioral disorders. Firstly, to examine the possibility of doing multivariate analysis of covariance, the presumption of homogeneity of slopes was tested and given the significant mutual effects between the group factor and the covariable of the posttests ($p < 0.05$), difference scores of the pretest and posttest were calculated instead of multivariate analysis of covariance, multivariate analysis of variance was used. The results were indicative of the significant effect of the group factor ($\eta^2 = 0.003$, $F_{(3,7)} = 677.925$, $p < 0.001$, $\eta^2 = 0.997$). According to the results of the post hoc test of analysis of variance, the difference score of the intrinsic behavioral disorders of the experimental group (-55.5) (improvement of the disorder) was significantly higher than that of the control group (2.4) (increase of the severity of the disorder). In addition, the results of the post hoc test suggested that the difference score of interstitial behavioral disorders of the experimental group (-61.5) (improvement of the disorder) was significantly higher than that of the control group (0.4) (increase of the severity of the disorder). Also, the results of the post hoc test for the extrinsic behavioral disorders subscale suggested that there was no significant difference between the difference score of extrinsic behavioral disorders of the experimental group (-8.5) and the control group (-0.2) ($p = 0.024$).

The intergroup comparison between the posttests using independent t-test did not show an initial significant difference between social growth

of the two groups. Therefore, to analyze the data associated with social growth, $2(\text{group}) \times 2(\text{test})$ analysis of variance with the repetition of measurement of the test factor was used. According to the results, the main effect of the group factor ($F_{(1,9)} = 198.384$, $p < 0.001$, $\eta^2 = 0.957$), the main effect of the test factor ($F_{(1,9)} = 1264.168$, $p < 0.001$, $\eta^2 = 0.957$) and mutual effect of the group and the test factors ($F_{(1,9)} = 1064.9$, $p < 0.001$, $\eta^2 = 0.922$) was significant. The results of the intergroup and intragroup paired comparisons using independent and dependent t-test modified by Bonferroni ($p < 0.0125$) showed no significant difference between the social growth of the control group in the pretest (38.2) and posttest (36.8) ($t_4 = 1.51$, $p = 0.206$) and a significant difference between social growth of the experimental group in the pretest (35.67) and posttest (3) ($t_5 = 77.476$, $p = 0.001$) and a significant difference between the social growth of the experimental group and the control group ($t_9 = 23.405$, $p = 0.001$).

Discussion

The findings of this research have shown that the perceptual-motor activities intervention improved the mirror neuron activities in the observation and execution condition (through a stronger Suppression of mu rhythm in the brain). Some studies have announced that mirror neurons might be developed and evolved as the child grows and become more experienced by being in the environment (Westermam, 2002); because their mirror neurons would be more adapted to perceiving their actions through adaption of the

sensory and motor information {Gales et al. (1996), Haus et al. (2007)}. According to the Associate Sequence Learning (ASL) Theory, in the beginning, mirror neurons have initial motor features, but they do not have a special sensory feature. In fact, they might respond to a wide spectrum of sensory stimuli, but they do not respond to a similar action that has been codified from a motor aspect. The ASL theory explains that sensory-motor experiences reinforce the relationship between sensory-motor representations of an action and lead to the production of motor neurons that respond to sensory stimuli (mirror neurons) [Perkins et al. (2010) and Meltzoff et al. (2003)]. In fact, the findings of the present study mean that the property of mirror neurons are neither completely intrinsic nor completely constant in a time interval and instead, they are developed through sensory – motor learning. This finding is in compliance with the findings of Meltzoff et al. (2003), Heyes (2001) and Keyser et al. (2004).

At least two of the valid behaviors done by the mirror neuron system are: 1) imitation and 2) perceiving the activities of others. These neurons have a wonderful power when it comes to involuntary imitation of the observed actions. Pinda et al. (2008), by conditioning mu rhythm through neurofeedback training, concluded that autistic children's ability to express imitated behaviors has significantly improved due to the conditioning. Thus, it can be inferred that if the ability to imitate was dependent on how the mirror neuron system functions, in cases of improvement

of the mirror neuron activity, autistic children's ability to imitate and to pay attention would also be improved {Pinda et al. (2008), Shantaradha Krishna et al. (2010)}.

There are other behaviors resulted from the function of the mirror neurons, namely empathy, sharing emotions and therefore social interactions with other people. This is regarded as the mind theory. The mind theory lets people assign thoughts, desires and intentions with others, explain or predict their actions and now the intention behind particular actions they take (Primake et al. 1978). What is meant by this is that the mirror neuron system plays a key role in people's ability to perceive others' motions and actions and this is an essential ability for social interactions, particularly for autistic people who do not have a proper social interaction with their surrounding environment since they cannot reflect on the perception and expression of emotions and to properly respond to the emotional and social behaviors. Hence, given the obtained results which are indicative of the positive effect of perceptual – motor activities on the mirror neuron activity, it can be inferred that in the respect of stronger mu Suppression in autistic children, these activities improve their social interactions with their surrounding environment and enhance their ability to share their emotions (McDonald, 2011; Chin Yu Pan et al., 2010; Hua Chia et al., 2012). In the respect of this assumption that it is highly likely that the mirror neuron system and the behavioral system interact with one another, it can be assumed that some of other autism disorders, including

cliché movements, lack of eye contact, withdrawal, etc. have a bilateral relation with the mirror neuron system; meaning that focusing on improving the aforementioned behaviors might lead to the improvement of the mirror neuron activities as well and vice versa.

It is necessary to point out that since the positive effects of doing various physical activities, including walking, swimming, yoga, physical fitness, etc. on autistic behaviors have been shown in many studies, such as Afshari (2012), Movahedi et al. (2012), Lahmi (2011), Salehi (2011), Hua Chi et al. (2012) and Ulrich (2000), it can be inferred that physical activities, especially perceptual – motor activities, can be regarded as an intervention for improving the activities of the mirror neuron system, particularly in autistic children. The reasons behind such an inference is that these activities have similar features as mirror neurons (such as perceiving and planning for responding to an action). Ultimately, and given the findings of this study and some of the previous ones, it can be concluded that doing regular and purposeful motor activities can be a factor that not only affects motor aspects but also behavioral aspects and subsequently nervous activities. Considering the above-mentioned points, it can be concluded that observation is not just transient action, but it is tangibly an involuntary practical reflection. Therefore, observing action can lead to development of skills in the observer that similar to what the actor intended.

Other findings of this research have suggested that the disorders associated with intrinsic and

interstitial behavioral syndromes have been reduced after the perceptual – motor interventions {Pinda et al. (2008), Rebecca Ulrich (2000), McDonald (2011), Salehi (2011), Lahmi (2011) and Dehghan (2010)}. However, in relation with extrinsic syndromes, the interventions have been ineffective. Lack of significant effect of these interventions might be because of the fact that the statistical sample of this research consisted of participants with special conditions and it is practically impossible to control each and every condition in large samples and this can affect the final results. In fact, exercises improve motor skills of children and provide them with different opportunities that make them feel competent and sufficient in different situations such as their daily activities, playing with others and at school. Having more achievements, less failures and therefore having more positive evaluations reduce children's anxiety. Enhancement of motor skills make these children more capable to take part in activities such as playing with their peers and showing up to social situations and makes their behaviors towards adults and their peers more bearable and desirable which will ultimately lead to a higher level of social acceptance. As a result, these children will feel more competent and qualified in establishing social relationships, as an interstitial behavioral factor.

Since the mirror neuron system has been introduced as an infrastructural system in disorders such as disorders associated with mapping one's and others' actions, social communications, speech defect, lack of sympathetic reactions in social

interactions, it can be inferred that this system and its function plays a crucial role in the presence of absence of some behavioral disorders. Although it is quite unlikely for deficient function of the mirror neuron system to be responsible for all of the symptoms of this disorder (such as routine and cliché behaviors, etc.). Nonetheless, activity of these neurons (in relation to other sensory and motor systems) seems to be necessary for special abilities such as imitation and because of them, behavioral disorders and their causes can be properly and accurately detected (Heyes, 2001). Moreover, while treating the behavioral disorders of these children, the key role of parents must not be ignored. Kazdin and Gouchman (1990, quoted by Haghshenas, 1999) believe that creating a balance between the attention parents pay to their child's adaptive behaviors and his/her problematic behaviors will reduce his/her behavioral problems. Various studies (Bagraley and Landert, 2001; Smith and Landert, 2003-2004; Halloway and Suzuki, 2005) have examined the effectiveness of treatments oriented on the parent-child relationship and these results obtained from them have shown a significant reduction in many of the behavioral problems of children. By taking into account the findings of the previous studies, resolution of the problems of children by a person who is in the concern circle (parents) can fluctuate or damage the deficient behavior cycle (Taklavi, 2011). In addition, Aberman (2008) reviewed the activities of mirror neurons in autistic children and concluded that these neurons have a better activity and a stronger mu Suppression in response to

familiar stimuli (family, and/or siblings). Therefore, it can be assumed that if parents continued the intervention programs presented in this research, in the form of physical activities and perceptual – motor exercises, at home, better results would be obtained.

Another finding of this study was that perceptual – motor exercises improve the social growth scores of children diagnosed with high functioning autism {Poorshakoori Sharemi et al. (2011); Donald (2011), Chin Yu Pan (2010), Hua Chia (2012)}. It might be surprising that although the interventions presented in this study have been carried out individually, social growth of children has been improved. Unfortunately, there is no study focused on autism that would systematically compare the effects of physical activities with two different approaches: individual interventions and group interventions. One of the advantages of using individual treatments for people with ASD is that in this way, it would be possible to design the treatments based on special and individual needs. In addition, individual intervention might prevent the child from feeling misunderstood by other group members; because having problems in establishing nonverbal connections lead to communicative problems with peers. Moreover, unpredictable incidents in the current of group physical activities considerably increase the stress level. Although the individual intervention approach prevents these negative side effects, group intervention might also have some advantages as far as autistic spectrum disorders are concerned. When team members support one

another, social behavior activities and communicative skills will be facilitated and improved (Michael Su O Milnburg, 2012).

Conclusion

Given the theories proposed by growth and evolution specialists and the findings of the studies which have focused on the role of physical activity and movement in the integrated growth of human beings, proper application of motor activities and physical exercises that are in proportion with the structural and psychological characteristics of humans, especially in childhood and teenage years, validate the physical and mental health of human beings and prepares them for living in a social environment (Poorshakoori, 2011). There are some reasons behind the relation between two growth areas (motor and social) which have been presented in this research and similar studies, one of the main reasons is the structure and function of the nervous system (McDonald, 2011).

It seems that perceptual – motor exercises and training used in the present study provided the children in the experimental group with a pattern of proper methods for encountering various social situation. This pattern is based on a behavior analysis approach (Spiger and Gormont, quoted by Hefner, 2003) and by using it new behaviors can be taught to children and target behaviors that they already know how to express can be improved and organized. Also, when a child successfully carries out a skill, his/her anxiety would be reduced and his/her positive behaviors would be indirectly encouraged. Therefore, such interventions can be

used as an effective tool for changing and directing the behaviors of autistic children and to improve social skills of children diagnosed with high functioning autism.

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