

Effects of Feedback With Different Frequency on Throwing Skill Learning in Children With Autism Spectrum Disorder Compared to Normal Children

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Background: Autism spectrum disorder (ASD) is a developmental and neurological disorder that impairs many processes as perceptual, motor and cognitive function. Feedback frequency and its influences on ASD aspects indicate conflict impairs.

Objectives: The aim of the current study was to investigate the frequency of feedback in children with autism and comparison with normal children during learning a new throwing task.

Patients and Methods: In this study, 21 children with autism and 21 normal children were selected and each group was randomly divided into three subgroups (receiving 0%, 50%, 100% feedback). Participant's task was throwing beanbags toward the goal. In the acquisition phase, each participant performed 60 throws. Experimentally, group (0%) did not receive any feedback, group (50%) received feedback in half efforts and group (100%) received feedback in all the efforts. The retention test was performed 24 hours after the acquisition phase. One-way analysis of variance and Tukey post hoc test were used to analyze data.

Results: Children with autism showed more learning by 100% feedback. Nonetheless, normal children learned more through reduced feedback (50%).

Conclusions: In learning a new task, children with autism bring more performance in high frequency of feedback, but normal children showed better performance using reduced feedback. This finding indicates that children with autism need to get feedback different from normal children in learning.

Keywords: Learning; Autism; Feedback; Children

1. Background

Motor processes play an important role in learning and development and provide a background for other areas of learning such as academic and social skills (1). After presence of motor pattern efficiency, perceptual system grows. Therefore, any disruption to motor process affects perceptual systems and learning and causes disorders and deficits in learning (2). Autism spectrum disorder (ASD) is a developmental and neurological disorder, which typically presents during the early life and persists throughout lifespan (3, 4). The main features due to autism include failure in interchange (5, 6), stereotyped behaviors (7, 8) and significant deficits in communicational skills (9). Studies have shown that about 75% of people with autism have mental retardation (10, 11). Latest statistics by the Centers for Disease Control (CDC) showed that patients with this disease are increasing. This statistic has increased from 1 in 150 people in 2007 to 1 in 88 people in 2012 (12). However, this is not the same in all countries and most of the Anglo-American countries reported the highest prevalence of autism. The studies also stated that ASD is almost 5 times more in boys than girls. In America, ASD

is diagnosed in one of every 54 boys. Autism disorder occurs in all races and communities. Economic status, education and parents' lifestyle do not affect the likelihood of their children having the disorder (3). Children with ASD are impaired in many processes as perceptual, motor and cognitive (2). Cognitive processes defect in these individuals negatively affect their activities (13, 14). There are several studies reporting limitations on cognitive performance of social deficit in patients with ASD in the capability to perform social stimuli, feedback and reward. For example, Dawson et al. (15) stated that weak function in children with ASD on a delayed non-matching to sample task is due to difficulty in making abstract stimulus-reward associations than dysfunction in visual object recognition. Ingersoll et al. (16) showed that deficits in fronto-striatal reward system may lead to dysfunctions in feedback and reward processing (17). Destruction in dopaminergic metabolism system including ACC, basal ganglia and prefrontal cortex could be associated with behavioral dysfunctions in ASD, through interfering with the ability to respond effectively to feedback and punishment (18). Therefore, according to

the characteristics of autism deficit in children as well as learning importance, in the present study, we intended to investigate the effects of one of the most important factors with a significant impact on motor learning. The variable considered in this study is feedback. Numerous studies conducted on various aspects of feedback supported its role as the most important variable for motor learning (19). The key aspect of feedback argued in the current study is relative frequency of feedback. Major studies were conducted in this field on normal participants with different and conflicting results. It is important to know that whether high or low frequency of feedback enhances learning. It is a challengeable question faced by researchers. It was claimed that feedback with more frequencies can cause destructive results (20). It was also shown that subjects who had received feedback after every trial showed weaker performance compared with those who had received less feedback frequencies (21). The effects of knowledge of result (KR) on motor learning are known as guidance hypothesis (22). Studies have shown that in spite of strong effect of KR, elevated feedback frequency has three negative effects including impairing in information processing, reduced movement stability and feedback dependency (22). Nevertheless, some results disagree with the guidance hypothesis and state that due to a high need for control, attention and memory processes, feedback with more repetition is required to learn complex skills (23). However, other studies reported that children who have received low-frequency than high frequency feedback had more benefited to learn. For example, Chiviacowsky et al. (24) showed that participants receiving 100% feedback showed better performance than the group receiving little feedback. Moreover, Sullivan et al. (25) showed that participants who received 100% feedback in the acquisition phase, showed more accurate and more stable performance compared to the group who received reduced frequency in the retention test. Sabzi et al. (26) showed that children who received 100% feedback in their trials had more accuracy during the retention test compared to other groups. For optimizing motor learning, children may require more practice trials with feedback to form a more accurate and stable internal representation of a motor skill. These results are in agreement with the challenge point framework. The challenge point framework further predicts that this optimal challenge point is different for learners with different information processing capabilities and skill levels such as children and adults (27). Therefore, consistent with this challenge point framework, children in their information processing limitations are compensated by a higher frequency of feedback. All of these studies were performed on normal children. No other researches are available on this aspect of frequency feedback in children with autism. Unfortunately, there are few studies on feedback of children with autism. For example, Groen et al. (28) showed that children with autism have a larger anticipation via getting positive feedback throughout the task. Ingersoll et al. (16)

found that, in comparison with the social feedback, sensory feedback leads to better imitation performance to evaluate using toys in ASD children.

2. Objectives

Based on the Challenge Point Framework in this study, it was hypothesized that children who had received feedback in 100% of their trials, show better performance than other groups. Our main purpose was to understand the effects of feedback frequencies on motor learning to provide accurate feedback levels for optimal performance during skill acquisition in children. Since studies on the effect of feedback frequencies on children with ASD are not available, the aim of this study was to describe more useful frequency of feedback in children with autism and its comparison with normal children.

3. Patients and Methods

3.1. Participants

Participants were 21 healthy normal children and 21 individuals with ASD diagnosed with high functioning ASD (IQ > 80). Each child with autism had to meet the criteria of ASD diagnosis on both DSM-IV (29) and the autism diagnostic inventory-revised (ADI-R) (30), examined by a child psychiatrist or psychologist. The age range of individuals was 6-8 years. All participants were selected from a group of individuals who were right-handed and had no disabilities in performing hand and no gross visual deficits and all were novices in the skill (throwing ball). All participants gave informed consent and their legal guardians gave informed consent. Patients with autism were included from autism specific schools in Ahvaz and the normal group was selected from elementary schools in Ahvaz. The protocol was approved by the Review Board of Shahid Chamran University prior to participant recruitment and all participants provided a written informed consent before participation in experimental procedures. The study was also approved by the Ethics committee of Shahid Chamran University of Ahvaz.

3.2. Apparatus and Task

The apparatus, task, and procedure were similar to those used in previous studies (24, 31, 32). The task required participants to toss beanbags to a target placed on the floor, using their non-dominant arm. The target was circular, had a radius of 10 cm, and was placed at a distance of 3 m from the participants. Concentric circles with radii of 20, 30, 40, 50, 60, 70, 80, 90, and 100 cm were drawn around the target. These served as zones to assess the accuracy of throws. If the beanbag landed on the target, 100 points were awarded. If it landed in one of the other zones or outside the circles, 90, 80, 70, 60, 50, 40, 30, 20, 10, or 0 points were recorded respectively. If the ball landed on a line separating two zones, the participant was awarded

the higher score. In addition, the target was divided into four quadrants for the provision of KR (Figure 1).

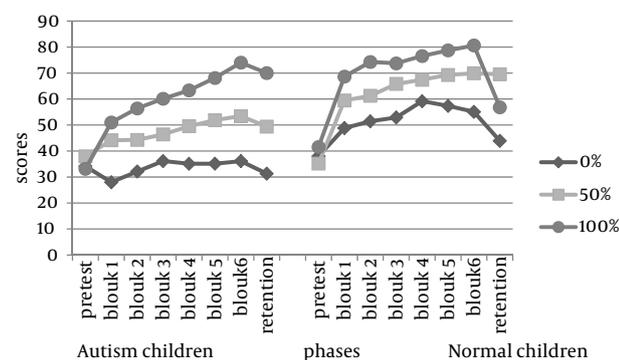


Figure 1. Participants Performances Graphs According to Frequency of Feedback

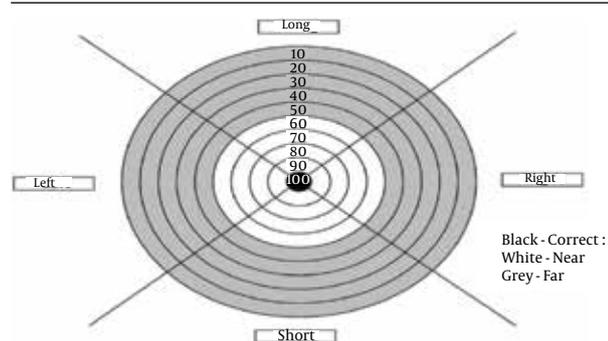


Figure 2. Schematic of the Target and Zone Areas Used for Providing Feedback

3.3. Procedure

This study was a quasi-experimental research designed with pre-test, post-test and retention test of the two experimental groups (normal group, $n = 21$ and autism group, $n = 21$). Each group was assigned into three subgroups (0% feedback, 50% feedback and 100% feedback). The study population included male children aged 6 to 8 years with and without autism disorder in Ahvaz in 2013 that 21 participants were selected with available methods for each groups and then randomly divided into three equal subgroups of 0% feedback, 50% feedback and 100% feedback. The whole process of research and selection took place under supervision of clinical psychologist and mental retardation children coach. Their parents allowed school to perform any given training. Professional therapists declared that these tests are beneficial to them. Therefore, we did not need to get the consent of their parents separately (Figure 2).

3.4. Methods of Research Implementation

Participants performed the task with their non-dom-

inant hand and rehearsed. Participants distance to the center of the circle was 3 meters. One skill training session was dedicated to throw. In this session, participants learned how to perform the task. After that participants performed 1 block consisting of 10 efforts, pre-test score was recorded. After the pre-test, participants were randomly assigned to three groups: 0% group, 50% training conditions and 100%. Then three participants practiced 60 throws (6 blocks of 10 attempts) in the training phase. The participants of 50% group received the knowledge of the effort in half and participants of 100% group received the entire knowledge of the effort and participant of 0% group did not received any feedback. The retention test was performed 24 hours after the acquisition phase.

3.5. Statistical Analysis

Descriptive and inferential statistics were used to analyze data. In the descriptive statistics, mean and standard deviation of the groups in the pre-test, acquisition and retention test were calculated. The Kolmogorov-Smirnov and Leven test were used for secure normal distribution and equality of variance assumptions, respectively. The analysis of variance (6 blocks \times 3 groups) with repeated measures on the blocks was used to analyze differences within the groups and between the groups in the acquisition phase. Tukey test was used to determine differences between and within the groups. Moreover, analysis of variance test was used for group equalization at pre-test and to analyze the results in the retention phase.

4. Results

As shown in Table 1, to test for groups (i.e. 0% feedback, 50% feedback and 100% feedback) difference on dependent variable in the pre-test phase, one-way analysis of variance (ANOVA) was used. Results indicated that groups were similar at the pre-test phase $F(2, 18) = 1.68$, $P = 0.21$ (autism children), $F(2, 18) = 0.90$, $P = 0.42$ (normal children). As shown in Table 2, the throwing scores in acquisition phase were analyzed using a 3×6 (group \times block) ANOVA with repeated measures on the second factor. This analysis indicated a significant main effect for groups, $F(2, 18) = 136.73$, $P = 0.001$, $\eta^2 = 0.947$ (autism children), $F(2, 18) = 39.99$, $P = 0.001$, $\eta^2 = 0.818$ (normal children). A Tukey-Kramer post hoc analysis indicated that there was a significant difference between 100% feedback and 50% feedback ($P = 0.001$) and 0% feedback ($P = 0.001$). The post-hoc analysis indicated that 50% feedback was significantly different from 0% feedback ($P = 0.001$) were (autism and normal children). The blocks main effect was significant, $F(5, 90) = 107.33$, $P = 0.001$, $\eta^2 = 0.900$ (autism children), $F(5, 90) = 48.04$, $P = 0.001$, $\eta^2 = 0.727$ (normal children). Participants significantly improved from block 1 to block 6. The groups \times Blocks interaction was also significant, $F(10, 90) = 11.07$, $P = 0.001$, $\eta^2 = 0.405$ (autism children), $F(10, 90) = 10.54$, $P = 0.001$, $\eta^2 = 0.604$ (normal children) (Table 2).

Table 1. Results of pre-Test Analysis of Variance ^{a, b}

Variables	SS	df	SM	F	P Value
Autism subjects					
Between groups	467.42	2	233.71	1.68	0.21
Within groups	2495.71	18	138.65	-	-
Total	2963.14	20	-	-	-
Normal subjects					
Between groups	178.28	2	89.14	0.90	0.42
Within groups	1765.71	18	98.09	-	-
Total	1944.00	20	-	-	-

^a Abbreviations: SS, sum of squares; df, degree of freedom; SM, sum of means.

^b Significant differences (P < 0.05).

Table 2. Analysis of Variance Results With Repeated Measures in Acquisition Phase

Variables	SS	df	SM	F	P Value ^a
Autism subjects					
Blocks	2084.25	5	416.85	107.33	0.001
Blocks group	430.22	10	43.02	11.07	0.001
Group	54697.96	2	27348.98	136.73	0.001
Blocks error	349.52	90	3.88	-	-
Group error	3600.19	18	200.01	-	-
Normal subjects					
Blocks	1973.39	5	394.67	48.04	0.001
Blocks group	396.87	10	39.68	10.54	0.001
Group	14807.34	2	7403.67	39.99	0.001
Blocks error	739.28	90	8.21	-	-
Group error	3331.85	18	185.10	-	-

^a Significant differences (P < 0.05).

Table 3. Results of One-Way Analysis of Variance

Variables	SS	df	SM	F	P Value ^a
Autism subjects					
Between groups	6201.81	2	3100.90	17.48	0.000
Within groups	3193.14	18	177.39		
Total	9394.95	20			
Normal subjects					
Between groups	1658.00	2	829.01	29.34	0.000
Within groups	508.57	18	28.25		
Total	2166.57	20			

^a Significant differences (P < 0.05).

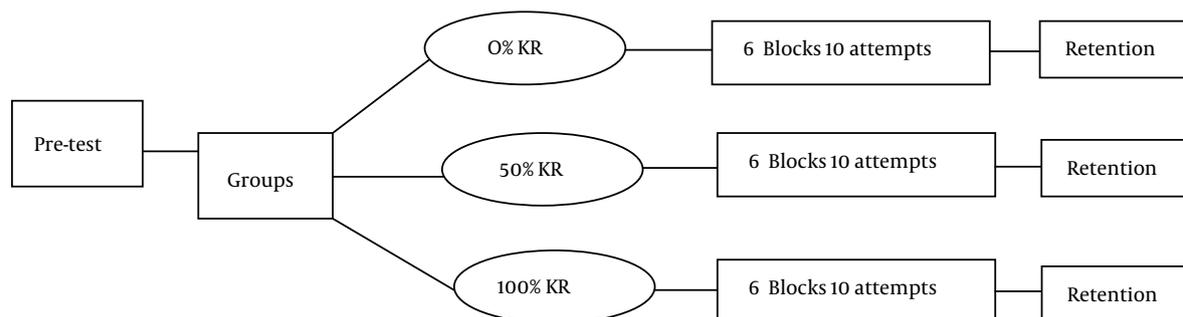


Figure 3. Research Design

As shown in Table 3, the throwing scores in retention phase were analyzed using one-way ANOVA. This analysis indicated a group main effect, $F(2, 18) = 17.48$, $P = 0.001$, $\eta^2 = 0.98$ (autism children), $F(2, 18) = 29.34$, $P = 0.001$, $\eta^2 = 0.105$ (normal children). A Tukey-Kramer post hoc analysis indicated that 100% group ($M = 86.71$, $SD = 4.42$) was significantly better than the 50% ($M = 70.29$, $SD = 4.53$) and 0% feedback groups ($M = 48.71$, $SD = 3.85$). The post-hoc analysis indicated that 50% feedback group was significantly different from 0% feedback group ($P = 0.001$) (autism children). However, in the normal children, Tukey-Kramer post hoc analysis indicated that 50% group ($M = 66.57$, $SD = 6.55$) was significantly better than the 100% ($M = 57.00$, $SD = 5.35$) and 0% feedback groups ($M = 44.86$, $SD = 3.62$). The post-hoc analysis indicated that 100% feedback group was significantly different from 0% feedback group ($P = 0.001$) (Table 3). To better illustrate the groups at pre-test, weeks of training, acquisition and retention, diagram is presented below (Figure 3).

5. Discussion

This study investigated learning of a motor skill in autistic and normal children through high frequency of KR feedback. There were significant differences in the acquisition and retention phases of all three groups. Based on Tukey results, a significant difference was observed between the three groups (0%, 50% and 100% feedback), but in spite of higher means, there was no significant difference between the results of groups 50% and 100%. These results indicated that for children with autism, reduced feedback is less effective in practice. In healthy normal children, in both acquisition and retention phases, there were significant differences between the three groups.

Besides, reduced feedback is more effective for normal children. In addition, descriptive data showed that the mean scores of normal children in three conditions (0%, 50% and 100% feedback) and the both phases (acquisition and retention) were higher than patients with autism in the same group. Consequently, based on the results of the Tukey test, significant differences were observed between the three groups (0%, 50% and 100% feedback). Thus, compared to normal participants, children with autism need more feedback frequencies to motor learning. This finding can be consistent with Adams learning theory (1971) and predictions of the challenge point framework (27). According to this theory, feedback provided after each attempt to guide person toward the right movement (as in the present study feedback had more effectiveness after each attempt). Then when the person is near to the goal of Motion, has received proprioception related to correct position and this feedback is from an internal representation related to goal (A corrected reference). Whatever motion person is near to goal, this representation becomes stronger and helps person more to identify the error. Thus, according to Adams, the feedback has a guidance role to more guide individuals toward the goal Until get corrected reference. Therefore, according to this theory

(as predicted by Adams [1971]), It is always useful effect of augmented feedback on learning (33).

However, normal children showed more learning by receiving reduced feedback. This is consistent with the Guidance hypothesis of Schmidt (1989) who stated that feedback has dependence and conductivity effects. According to the guidance theory, KR conducts people to proper functioning and thereby improves performance when it is offered, whereas the repeated presentation weakens the learning (22). Based on this approach, experimental studies showed that groups received more KR during training, would show better performance, but the experimental group that received fewer KR had a better learning. Researchers stated that reducing the frequency of feedback provided an opportunity for participants to enhance the capability of detecting and correcting errors in efforts without feedback and decreasing frequency during acquisition phase reduce dependence on feedback and ultimately increase the stability of response in efforts without feedback (34). For example, Bruechert et al. (34) showed that in a retention test, the group received reduced feedback (50%) in the acquisition phase had a better performance compared to the group receiving high frequency feedback (100%). As well, Naghdi and Zamani (35) showed that the 100% group performed significantly superior to other two groups in the acquisition phase, while the 50% group was significantly superior within the retention phase. In short, it can be concluded that children might benefit more from reduced feedback for learning a skill.

Therefore, the relative and absolute frequency of KR can bring both different functional and learning effects and provide more KR causing dependence of trainer to more information to perform task. This process is hampered by lack of processing for error detection and in case of not being proposed, its performance compromises individuals (36-38). Therefore, among methods to reduce dependence effects of feedback to facilitate retention performance is to reduce the feedback frequency in the way that the number of trials receiving feedback is decreased. Now, the essential question is the difference between autism and normal children in receiving feedback for learning a task. We investigated this important question, because many children with autism receive regular feedback on how to learn a skill. Perhaps, attention is a reason for the differences between children with autism and healthy children in receiving more frequent feedback. Patients with autism have some problems with changing attention from one stimulus to another. Children with autism are considered so difficult to control excitation aspects of attention. These patients show impaired attention and easily change the focus of attention to irrelevant stimuli (39). Children with autism have defects in the shift of attention from one stimulus to other stimuli apart from paying too much attention to some stimuli (40). Comparison between the results of autistic children with normal children in neuropsychological

components (attention and inhibition control) showed that the components of autistic children were significantly weaker than normal children (41, 42).

There are several theories about the decline in cognitive functions of children with ASD. One of these theories is the central integration theory (43). This theory explains data processing procedure, especially tending to process information from the environment. This theory suggests that individuals with autism tend to have minimal processing in extensive environments (43, 44). Thus, different processing of sensory information can also be another cause of differences, which has been demonstrated by numerous scholars such as Shaywitz et al. (45), Wolf et al. (46), Bosse et al. (47), De Luca et al. (48), Romani et al. (49), Conlon et al. (50), Geary (51) and Stenneken et al. (52). These investigations showed that sensory processing in children with learning disabilities is lower than normal participants. All these researchers revealed the failure of some of different types of sensory information processing in children with learning disabilities. Thus, children with learning disabilities are low sensitive to different types of sensory information, particularly visual and auditory information.

This leads to inappropriate receiving data and storage in memory for later use. In addition, because of lack of appropriate current and not receiving clues for retrieval call, it is difficult to recall the memory. Perhaps, deficits in working memory of children with autism are attributed to this difference. This is proved by numerous studies that children with autism have poor working memory compared with hyperactive people (53-55). Working memory is responsible for temporary storage and manipulation of information is responsible for a wide range of complex cognitive activities (56). Therefore, because of weak working memory in this group and since working memory is essential and necessary for cognitive activities, children with autism need to high feedback levels to activate their memory and bring better performance. In the current study, children with autism showed a high frequency of feedback to do good performance.

5.1. Limitations and Future Directions

Regarding the limited population of children with autism, completely randomized selection was not possible. In addition, very few researches have been performed on learning in this population. It is suggested to assess different aspects of learning of this group. It is recommended to study different feedback patterns (FA, range, sum and average) on autistic and normal children. Furthermore, it is recommended to perform similar researches on girls with autism compared to the current findings.

5.2. Implications

This study provided a concept for clinicians and trainers to focus on feedback levels with different frequencies in motor skill learning to improve performance of children

with ASD. Besides, the results can be used by educators to better plan training sessions and exercises to improve normal children learning.

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Authors' Contributions

Study concept and design: Mohamad Hossein Zamani and Rouholah Fatemi. Acquisition of data: Mohamad Hossein Zamani and Sara Karimi. Analysis and interpretation of data: Mohamad Hossein Zamani and Rouholah Fatemi. Drafting of the manuscript: Rouholah Fatemi. Critical revision of the manuscript for important intellectual content: Rouholah Fatemi. Statistical analysis: Rouholah Fatemi and Mohamad Hossein Zamani. Administrative, technical and material support: Sara Karimi. Study supervision: Rouholah Fatemi.

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