

Effects of Frequency of Feedback on the Learning of Motor Skill in Preschool Children

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Background: Feedback is one of the most important variables which affect the motor acquisition and the performance of a skill which plays a significant role in motor control as well as the learning of a motor skill.

Objectives: The present study serves to assess the acquisition and retention of a new motor skill in pre-elementary school students, while presenting them with an additional feedback with different frequencies (0%, 50%, and 100%).

Patients and Methods: The methodology of the current study is Semi-experimental, with pretests and posttests conducted on children presented with three different frequencies of additional knowledge of results (KR) feedback (0%, 50%, and 100%). The statistical population consisted of all 6-8 year old pre-elementary school students of Ahvaz, of whom 45 were selected through multilevel cluster sampling, and were subsequently divided, in three different groups. The selected task for the subjects consisted of throwing a tennis ball from over the shoulder toward a target depicted on the ground. The subjects performed 60 try-outs within the acquisition phase, in which the 0% group was presented with no feedback at all, 50% group received feedback in 50% of the try-outs, and 100% group obtained feedback in all try-outs. Three days after the acquisition phase, retention tests with 10 throws were conducted. One Way Analysis of Variance (ANOVA), Tukey test, and repeated measures test were used on each block for data analysis.

Results: The results indicated significant differences between all three groups, both within the acquisition and retention tests ($P=0.001$). The findings were suggestive that the 100% group performance was significantly superior to the other two groups in the acquisition phase, while the 50% group was significantly superior within the retention phase.

Conclusions: In short, it can be concluded that children might benefit more from the reduced feedback for learning a skill.

Keywords: Learning; Children; Feedback

1. Background

The importance of feedback for the acquisition and retention of a task in individuals have been highlighted in different theories, such as the goal setting theory (1), the control theory (2), and the social cognitive theory (3). Feedback demonstrates how much effort is required to fulfill certain goals in different tasks. This helps individuals to identify efficient strategies to achieve the goal and the amount of effort required to perform efficiently as well as to modify the already applied strategies and the used amount of effort to increase the efficiency of their performance (2, 4). However, despite the numerous advantages theoretically attributed to feedback, empirical research has provided evidence that feedback can impact the acquisition and retention of motor skills both in positive and negative ways (5). The positive influence is related to the informative nature of additional feedback of KR which serves as a source for the athletes to correct errors and improve the future performances (6). On the other hand, negative impacts may be observed when over presentation of KR feedback result in the at individual's dependence on the information (7). These para-

doxical effects are often attributed to different aspects of feedback, of which succession or frequency is considered as the major variable of the current investigation. Most of the studies conducted on the feedback frequency take for granted that higher frequency in feedback presentation can improve the acquisition and retention of a motor task (8). The logical explanation justifying this hypothesis is that feedback provides the individual with information which can be exploited for more efficient acquisition of, and compatibility with the motor task strategies. Furthermore, previous field and laboratory studies provide remarkable evidence to support the aforementioned hypothesis. For instance, Bilodeau (9) and Cook (10) found that more frequent feedback allows individuals to exploit the acquired information to better learn the task's key strategies and to improve their performance. Similarly, Komaki et al. (11) reported that compared to the individuals provided with less frequent feedback, those receiving more frequent feedback were more efficiently capable of learning a motor skill. These studies were all supportive of the hypothesis expressed in 1931 which ar-

gued that high feedback frequency improves the acquisition (12). However, Winstein and Schmidt (13) proposed that augmented frequent feedback has leading properties and can thus result in the dependence of the individual, which in the absence of the feedback can impair the performance. Moreover, Salmoni et al. (8) reported that providing the individual with a more frequent feedback can lead to a better performance in acquisition and a weaker functioning in the retention phase. This is due to the fact that the availability of the additional feedback in each try can lead to the dependence of the individual on the provided feedback, in a way that when unavailable, the person cannot perform as efficiently as within the acquisition phase. One of the most straightforward methods for the reduction of the resulting dependence is to decrease the KR. It has been hypothesized that the reduction of KR frequency can help the individual to identify and correct his/her errors in unavailable feedback condition. Furthermore, when presented with lower frequency of KR within the acquisition phase, the possibility of feedback dependence decreases and thus a more stable response pattern can be observed within the without KR conditions (7). The results of previous research do not properly show the level of feedback frequency which can provide the best results for the acquisition and retention of motor skills. For example, Chiviacowsky et al. (14) reported that children presented with 100% feedback frequency exhibited a better performance compared to those receiving a lower frequency of feedback. Similarly, Sullivan et al. (15) who investigated the effect of feedback frequency in children and adults found that compared to children receiving reduced frequency of feedback, those presented with 100% feedback frequency in the acquisition phase performed significantly better within the retention tests. In addition, Mononen et al. (16) reported that though no significant difference was observed between the groups provided with 10% and 33% feedback frequency, those presented with 100% frequency had a significantly better performance compared to the 33% group within the retention tests. However, results of some other studies do not conform to the aforementioned reports. One example was an investigation conducted by Williston et al. (17) who studied the effect of the frequency of a KR feedback presentation (50% and 100%) in a group of 16 individuals with growth retardation found that the group provided with 50% KR feedback had a superior performance in the retention tests. Similar results were reported by Winstein and Schmidt (13), who also observed the superiority of the 50% KR feedback group in the retention tests. Interestingly, these researchers observed that the performance of the group provided with 100% KR feedback was similar to their performance in the first day of the acquisition phase.

2. Objectives

In short, given the utmost importance of feedback in

acquisition and retention of motor skills and the controversial results reported about the role of the frequency of KR feedback, the aims of the present research were to provide more information for the clarification of the in hand paradox. The results of this research can enable the physical education teachers and coaches to better plan their training sessions for the more efficient fulfillment of their training goals. Therefore, the prime objective of the current investigation was to find the type of feedback frequency (high or low), which can better serve the efficiency of mastering a motor skill.

3. Patients and Methods

3.1. Participants

The participants in this study were 45 healthy normal children aged from 6 to 8 years and selected according to randomized controlled sampling method. All participants were selected from a group of right-handed individuals in the elementary schools in Ahvaz who had no disabilities in hand performance with no gross visual deficits and were novices in the skill (throwing ball). Informed consent was obtained from the school, the parents/guardians, and participants provided their assent. The protocol was approved by the Review Board of Shahid Chamran University prior to participant recruitment. 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 (14, 18). 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 meter from the participant. 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 the 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, the respective scores were 90, 80, 70, 60, 50, 40, 30, 20, 10, or 0. If the ball landed on a line separating two zones, the participant was awarded the higher score. Also, the target was divided into four quadrants for the provision of KR (Figure 1).

3.3. Procedure

This study is a Semi-experimental research designed with pre-test, post-test and retention test with three groups including 0%, 50% and 100% feedbacks. The study population included 45 male children aged 6 to 8 years selected through multi-level cluster sampling, and then randomly divided into 3 groups of 0%, 50% and 100% feedbacks. It should be noted that their parents allowed school to perform any given training.

3.4. Methods of Research Implementation

participants performed the task with their non-dominant hand and rehearsed. One skill training session was dedicated to throw. In this session, participants learned how to perform the task. After that they performed 1 block consisting of 10 trials, which trials scores were recorded as the pre-test score. The participants were then randomly assigned to three groups of 0% group, 50% training conditions and 100%. Then three participants tried 60 throws (6 blocks of 10 trials) in the training phase. The participants of 50% group received the knowledge of the trials in half and participants of 100% group received the entire knowledge of the effort, whereas the participants of 0% group did not receive 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 the obtained 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 comprising 6 block × 3 groups with repeated measures on the blocks was used to analyze differences within groups and between groups in the acquisition phase. Tukey test also used to determine differences between and within groups. Also, analysis of variance test was used for group equalization at pre-test and also to analyze the results in the retention phase.

4. Results

Table 1 shows the descriptive characteristics of each group within the pretest, acquisition and retention tests. As clearly seen, the 100% group had a significantly better performance within the acquisition phase, while the performance of the 50% group was significantly superior to 0% and 100% groups within the retention tests. It should be noted that higher scores signifies better performance and accuracy of the subjects. Also,

to determine the normality of the data, the analysis by Leven test showed that all data were normalized (Table 1). Table 2 tabulates the results of the throws within the acquisition tests analyzed by the one-way ANOVA and repeated measures on the Blocks factor. As seen in Table 2, significant differences were observed amongst different blocks and different groups. To simplify the observation of their significant differences, the detailed information regarding the comparison of the blocks is shown in Table 3.

Tukey test was applied to determine the position of the intergroup differences. The results demonstrated significant differences between the 0% group and the 50% (P = 0.001) and 100% (P = 0.001) groups, as well as between the 50% and 100% groups (P = 0.001). Table 4 demonstrates the results of the throws in retention phase analyzed by one-way ANOVA. As clearly shown in Table 4, significant differences were observed amongst different groups within the retention phase (P = 0.001). Tukey test was applied to determine the location of these differences. The results indicated a significant differences between the 0%, 50% and 100% group (P = 0.001). Figure 2 demonstrates the results of the try-outs in the acquisition and retention phases.

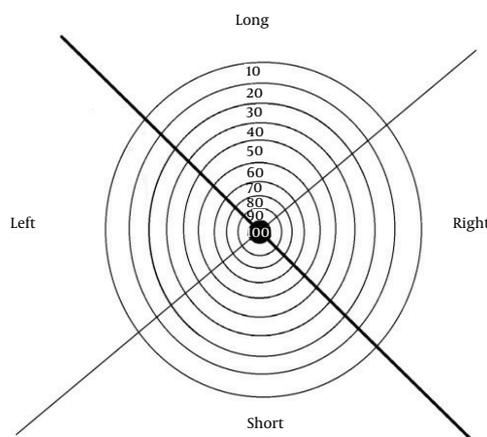


Figure 1. Task of Study

Table 1. Mean and SD Throw Accuracy in Pre-Test, Acquisition and Retention Phases ^a

Groups	Stages							
	Pre-Test	Acquisition						Retention
		Blocks 1	Blocks 2	Blocks 3	Blocks 4	Blocks 5	Blocks 6	
0%	38.00 ± 10.80	48.82 ± 12.68	51.45 ± 11.59	52.91 ± 7.16	59.18 ± 5.75	57.36 ± 6.37	55.09 ± 7.76	43.91 ± 3.41
50%	35.18 ± 13.28	59.45 ± 13.37	61.27 ± 11.33	65.82 ± 10.84	67.45 ± 10.53	69.27 ± 10.16	69.91 ± 10.26	69.55 ± 7.60
100%	41.55 ± 7.92	68.64 ± 9.93	74.27 ± 6.63	73.73 ± 6.19	76.55 ± 5.73	78.73 ± 4.77	80.64 ± 5.25	56.82 ± 4.35
Total	38.24 ± 10.87	58.97 ± 14.30	62.33 ± 13.63	64.15 ± 11.86	67.73 ± 10.35	68.45 ± 11.44	68.55 ± 13.17	56.76 ± 11.85

^a Data are presented as Mean ± SD.

Table 2. One Way Analysis of Variance Results With Repeated Measures in Acquisition Stage

Variable	Sum of Squares	Degrees of Freedom	Average of Squares	F Value	Significance
Blocks	51.7603	5	1520.70	12.74	0.001 ^a
Blocks group^a	692/022	10	69/202	0/56	0/83
Group	9393.80	2	4696.90	9.13	0.001 ^a
Error (blocks)	25608.13	210	121.94		
Error(group)	21590.40	42	514.05		

^a Significance level (P < 0.05).

Table 3. The Results of Blocks Comparison

Blocks	Mean Difference	Significance
Blocks 1		
Blocks 2	1.25	1.00
Blocks 3	2.40	0.051
Blocks 4	2.69	0.01 ^a
Blocks 5	3.80	0.001 ^a
Blocks 6	3.40	0.001 ^a
Blocks 2		
Blocks 3	1.28	1.00
Blocks 4	1.45	0.2
Blocks 5	2.63	0.01 ^a
Blocks 6	2.30	0.03 ^a
Blocks 3		
Blocks 4	0.28	1.00
Blocks 5	1.42	0.17
Blocks 6	0.94	1.00
Blocks 4		
Blocks 5	1.19	1.00
Blocks 6	0.68	1.00
Blocks 5		
Blocks 6	-0.48	1.00

^a Significance level (P < 0.05).

Table 4. The Results of One Way Analysis of Variance Test in Retention Phase

Variables	Sum of Squares	Degrees of Freedom	Average of Squares	F Value	Significance
Between group	1288.93	2	644.46	5.85	0.001 ^a
Within group	4621.86	42	110.04		
Total	5910.80	44			

^a Significance level (P < 0.05).

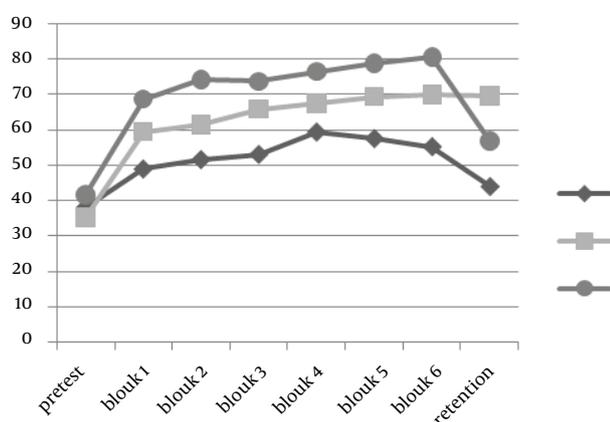


Figure 2. The Results of Pre-Test, Acquisition and Retention in Different Groups

5. Discussion

The prime objective of the current study was to investigate the effect of KR feedback presentation with different frequencies upon the acquisition and retention of a throwing task in pre-elementary school children. Significant differences were observed amongst all three groups both within the acquisition and retention phases, with the 100% group performing significantly superior within the acquisition tests, and the 50% group performing significantly better within the retention tests. In all, the results were suggestive that for the children of this age, practicing while receiving reduced frequency feedback is more effective. These findings confirm the results of several other studies. For instance, Ishikura (19) revealed that the group presented with higher feedback frequency performed better within the acquisition phase. Similarly, Sullivan et al. (15) reported that subjects receiving 100% feedback frequency performed significantly better than those presented with reduced frequency feedback within the acquisition tests. In an investigation on subjects with growth retardation, Williston et al. (17) observed that for the acquisition of a skill, the 100% frequency feedback was more advantageous than the reduced frequency version. In addition, Butki and Hoffman (20) reported that continuous feedback led to a better performance within the acquisition phase compared to the non-continuous form. Furthermore, Winstein and Schmidt (13) made a similar observation about better acquisition in subjects receiving KR feedback in 100% of the cases compared to those getting feedback in 50% of the cases. The results of our research within the acquisition phase are in line with Adams learning theory (21). Based on this theory, the presented KR after each try-out leads the individual toward the correct move. Then, when close to this correct move, an individual has a deep feeling about it, which forms an internal reflection about the goal or the target so called a correction reference. The closer the person gets to the

target move, the stronger this reflection grows, and thus the more it helps the person to recognize and correct his/her errors. Therefore, based on Adams theory, KR has a leading role toward the goal, till this internal correction reference is formed. Similarly, Schmidt's leading theory also states that KR can lead the person toward the correct performance, and can thus positively affect it. However, when presented more frequently, it can decrease the learning efficiency regarding retention phase (8). Consequently, most of the research dedicated to this field is suggestive that high feedback frequency leads to a better performance, while reduced feedback frequency improves retention. The relative and absolute frequency of KR can thus exert two different impacts on performance and retention. When KR is presented more frequently, it will reduce the error recognition and correction processes, which leads to a less efficient performance in KR under unavailable situations (22-24). One of the possibilities to decrease the formation of dependence characteristics of KR feedback presentation is to reduce the KR frequency, which refers to decreasing the number of try-outs for which the individual is presented with a feedback. This idea is consistent with the findings of our study within the retention phase, where the 50% group exhibited a superior performance compared to the 0% and 100% groups. In this context, several other studies also confirm our finding. For example, in an investigation made by Hemayattalab and Rostami (25) on the mentally paralyzed children, the 50% feedback frequency resulted in a better retention than the 100% one. The study conducted by Chiviawosky et al. (26) also demonstrated that presentation with reduced feedback frequency could lead to a better performance under conditions where feedback is unavailable. Similar results were reported by Winstein and Schmidt (13); Rice and Hernandez (27); Butki and Hoffman (20) who found that reduced KR frequency could lead to the improvement of retention. However, our results do not conform to the findings of Sullivan et al. (15) and Chiviawosky et al. (14), who observed an improved retention following the presentation of augmented KR feedback. The contrast between our findings and those of Sullivan et al. (15) can be due to the difference in the designated task, degree of dependence on the presented feedback for each specific task, task protocol, and individual differences between the statistical samples. The observed contrast between the current study and that of Chiviawosky et al. can be attributed to the difference in the appointed task as well as the skill level of the subjects.

Although completely unexpected, feedback can sometimes reduce the rate of the learning process. In certain cases additional feedback can really deteriorate the retention of a skill. This is especially seen when a beginner becomes too dependent on the presented feedback. Proteau et al. (28) presented an interesting hypothesis about how this dependence is formed. They hypothesized that the KR feedback will form a part of the person's memory reflection which is created while practicing, and will thus

form a part of what the person has learned. As a consequence, when obliged to perform the task without this additional external feedback, the internal feedback will not be strong enough to guide the individual toward a successful performance (28). The results of the current study are suggestive that, as a whole, when learning a new motor skill, the children benefit more from the reduced frequency feedback. Therefore, considering that feedback provides the individual with much information, the children have a limited capacity for information processing. Thus it is recommended that while designing their training plans, the physical education teachers and coaches take this aspect of feedback into consideration, to ensure the improvement of the performances and the optimisation of the training sessions.

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Authors' Contributions

Study concept and design: Mohamad Hossein Zamani. Mehdi Zarghami Acquisition of data: Mohamad Hossein Zamani Analysis and interpretation of data: Mohamad Hossein Zamani Drafting of the manuscript: mohamad hossein zamani Critical revision of the manuscript for important intellectual content: mohamad hossein zamani Statistical analysis: Mohamad Hossein Zamani Administrative, technical, and material support: mehdi zarghami Study supervision: mehdi zarghami

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