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# VARIABILITY OF PRACTICE AND ENHANCEMENT OF ACQUISITION, RETENTION AND TRANSFER OF LEARNING USING AN OUTDOOR THROWING MOTOR SKILL BY CHILDREN WITH INTELLECTUAL DISABILITIES

**Key words:** intellectual disabilities, motor learning, variable practice.

ABSTRACT

The aim of this study was to examine the effectiveness of variability of practice in the acquisition, retention and transfer of learning of throwing motor tasks by individuals with mild intellectual disabilities. Twenty-two children at the age of 10 ± 2 years were randomly divided into two experimental groups (n = 8 each) and one control group (n = 6). The subjects in each experimental group were assigned either a constant or a variable practice schedule. The acquisition and retention test consisted of throwing a tennis ball at a fixed target from the distance of 5 m, whilst the transfer test consisted of throwing a basketball into the hoop. The experiment also included a pre-test and a post-test for the two experimental groups for the acquisition and retention tests. Three days later, all three groups undertook a transfer motor task. No statistically significant effects on the acquisition and retention tests related to the type of practice were noted, whereas the variability of practice was found to significantly enhance learning transfer between similar motor skills. Further research is necessary in order to clarify the degree of variability with the use of different sample groups.

## INTRODUCTION

Motor learning is an internal process described as changing one's ability to perform a motor task. This ability has to be characterized by a continuous evolution and progressively improved stability, which is a result of practice [19]. Thus, it is very common for coaches, therapists and physical educators to create learning environments where multiple skills are to be learned. The major goal for practitioners is to create a practice environment that will promote learning during practice which will ideally be transferred to enhance performance on a later retention or transfer test. Persons with intellectual disabilities (ID) as compared with normal individuals seem to be at a disadvantage in terms of acquisition, retention and transfer of motor skills. This could be related to difficulties in recognition of a specific motor problem, or inadequate presentation of a motor task and, consequently, inability to select and produce the appropriate motor program [1]. Despite the fact that individuals with ID experience difficulties in methodology and elaboration of a motor program, it is possible to increase their ability to learn and transfer a motor task through practice [6, 19].

Research on contextual interference (CI) in motor learning has revealed that a higher rather than lower amount of contextual interference in practice leads to enhanced learning when measured

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during a later retention or transfer test [11]. More specifically, several variables are referred to as contributing to the CI effect in review studies: learner's skill level [5, 13, 15], age [8], number of practice trials [25], characteristics of various tasks [14, 16], whether practiced tasks are controlled by the same or different generalized motor program [7, 13, 23], and whether practiced tasks are of laboratory or non-laboratory character [2].

On the part of subjects with ID, Edwards, Elliott and Lee [4] found a positive effect of high contextual interference on the transfer performance of an anticipation timing task in a Down syndrome group of adolescents and a mental age matched group of children, but their results were not statistically significant [19]. Also they were unable to obtain a statistically significant level of differences in the transfer and retention of a beanbag tossing task in mildly mentally handicapped children; however, subjects in random practice conditions tended to demonstrate a better performance. Del Rey and Stewart [3] did obtain significant contextual interference effects with mildly mentally handicapped children on the retention of an anticipation timing task, but their subjects failed to transfer their performance to a movement with a different speed. Weber and Thorpe [29] reported that variable practice, as compared with constant practice, interspersed with already known movements improved the gross movement skills in children with autism and severe ID. The same research team using the same methodology in subjects aged 10-13 years with severe ID reported similar results, emphasizing the effect of distributed practice on learning gross movement skills. Furthermore, Painter, Inmam and Vincent [17] suggest that performance of individuals with ID in learning, retention and transfer of throwing skills, is improved significantly when interference concerns the spatial dimension of motor skill.

According to Porretta and O'Brien [18] the lack of significant effects on learning transfer in the previous studies may have been due to an insufficient number of practice trials used aimed at development of the cognitive processes needed to enhance retention and transfer. Moreover the subjects in these studies undertook from 45 to 64 trials over a single practice session. This amount of trials was approximately the same as in studies with subjects with no ID [18]. With these in mind physical educators must decide the best way to schedule practice trials of tasks to be learnt. By manipulating the order or scheduling of practice trials the practitioner will consequently alter the amount of contextual interference he or she encounters [12, 21]. If additional practice trials were administered, he could have been better able to develop the cognitive processes needed for enhancing transfer and retention [1]. However, adding trials to a single session may prove to be counterproductive to learning in mentally handicapped individuals, who exhibit short attention spans. The authors of this study, whole taking into consideration Magill's earlier research [10] suggesting that distributing practice trials over time by including more than one session facilitates both performance and learning, decided to allocate 120 trials over a 3-day period in order to better understand the effect of variability of practice on learning a motor skill. Specifically, the question to be answered is whether varied practice schedules are more effective than constant practice schedules in acquisition, retention and transfer of a gross motor trial by children with mild ID. The selected skill for the acquisition and retention test were an overhand tennis ball throw at a fixed target; whereas for the transfer tests an overhand basketball throw, from the same distance, into a hoop.

## METHODS

### *Subjects*

Twenty-two children with mild ID (10 boys and 12 girls) from special public school classes in Northern Greece took part in the study. Subjects' age ranged from 8 to 12 years (mean age = 10 ± 2 years). According to school data their mental ages were determined with the Weschler Intelligence scale [30, 31] and their Intelligence Quotients (IQs), ranged from 50 to 68 (mean = 59). All subjects were right handed and had no neurological, orthopedic, or sensory impairments. Informed consent was obtained for all participants. Subjects were randomly assigned to two experimental groups (n = 8 each), with different practice schedules (constant and variable) and one control group (n = 6) which did not receive any kind of practice during the study. The control group took part in the examination only during the transfer test.

The subjects did not have any organized experience of performing the selected tasks.

*Apparatus and tasks*

**Target.** A wooden square target 110 cm by 110 cm divided into five colored rectangles was used in the study. The rectangles were of different colors, 10 cm apart. The colors of the first, second, third, fourth and fifth rectangles were yellow, red, blue, black and white, respectively, from the center to the perimeter. Each rectangle covered a specific area in the wooden square, which represented a range of scoring points whenever the ball hit that area. In each trial a subject was rewarded with 55-50, 45-40, 35-30, 25-20 and 15-10 points whenever the ball hit the yellow, red, blue, black and white, respectively. In the event the ball hit the area outside the boundaries of each rectangle no points were awarded. The target was similar to the one suggested by Vodola [27] for subjects with ID who had undertaken a precision throwing task at a fixed target. Three shooting positions used during the training phase were marked onto the court: the criterion distance, 5 m from the front of the target, and two variable distances: 3 and 7 m.

**Hoop.** In order to assess motor skill transfer, a red iron basketball hoop 50 cm in diameter was constructed [24] and fixed on the target used in the training phase. The shooting position, marked onto the court, was 5 m from the front of the hoop. The goal of each attempt was to throw a basketball overhand through the hoop. Scores were kept following a system developed by Wallace and Hagler [28], 1 (the worst shot) to 5 (the best shot).

*Procedure*

The skill selected for the acquisition and retention tests was an overhand tennis ball throw from a distance of 5 m at a fixed target; the skill selected for the transfer tests was an overhand basketball throw, from the same distance into a hoop. During the training phase, the constant practice group (CG) practiced only from the criterion distance of 5 m against the fixed target whereas the variable practice group (VG) practiced from the criterion, 3 m and 5 m distances. Each subject was assigned 120 trials equally distributed (40 trials per each practice day) over three consecutive days (2$^{nd}$, 3$^{rd}$ and 4$^{th}$ day of the study). The constant practice group threw all 120 trials from the criterion distance, whereas the variable groups threw 40 trials from each distance in random order. At the start of each session the subjects watched a male performer who demonstrated the traditional method of throwing from the criterion distance. The demonstrations were accompanied by verbal instructions about the key elements of the movements. A verbal encouragement such as “good shot” and “nice job” was given after each practice. All subjects were given a brief rest after 20 trials.

The transfer pretest and posttest were carried out on the 1$^{st}$ and the 9$^{th}$ day of the study for all groups (two experimental groups and one control group). The acquisition pretest and posttest were conducted on the 1$^{st}$ and the 5$^{th}$ day of the study for the two experimental groups. Two days after the acquisition posttest (8$^{th}$ day of the study), the subjects from both experimental groups took the retention test. Each of the acquisition, retention and transfer pretests and posttests consisted of 10 trials testing a required skill. The mean score across ten trials was recorded as the best value. The training phase and all tests were carried out on a school yard.

## RESULTS

A series of preliminary analyses were conducted to determine whether significant differences existed between the experimental and control groups. The normality of distribution and equality of variance for all variables were checked with the Kolmogorov-Smirnov test for each group. The results revealed a normal distribution and equality of variances in two groups, with values in some cases approaching 1. The Bartlett-Box and Cochran’s C tests employed to check the differences among groups in the selected variables in the pre-test revealed there was no difference beyond the 0.05 level of significance.

In order to examine the effects of the two different exercise conditions (constant practice – variable practice) on the acquisition and retention tests a repeated-measures univariate analysis of variance was conducted. Two (Groups) by three (Measurements) ANOVAs were initially used to examine the pre and post differences as well as the differences between the two groups in acquisition and retention of an overhand tennis ball throw at a fixed target. The analysis revealed a main effect for the factor measurement (significant differences

between pre- and post-test; $F_{1,14} = 22.5$, $p < 0.05$), but there was no correlation between the method of practice and measurement ($F_{1,14} = 0.78$, $p > 0.05$). The results indicate that although during the three measurements none of the two methods of practice (variable or constant) affected the outcome regarding acquisition and retention, a significant difference was found across measurements related to the volume of practice but not to the different methods of practice. Post-hoc comparisons with the use of the Scheffe test revealed significant differences between the 1st (pre) and 2nd (post) measurements for both the constant and the variable methods of practice ($F_{1,14} = 28.75$, $p < 0.05$ and $F_{1,14} = 13.07$, $p < 0.05$, respectively). Furthermore, significant differences were also found between the 1st (pretest) and 3rd (retention test) measurements for the variable group ($F_{1,14} = 17.07$, $p < 0.05$), whilst no such difference was found for the respective values for constant practice ($F_{1,14} = 9.1$, $p > 0.05$).

Despite the absence of a statistically significant difference between the two methods of practice in the acquisition of the mentioned motor skill, there is a better performance tendency with the use of constant learning in the acquisition test. But, this was not the case in the retention test where the subjects who practiced in variable conditions appear to be privileged. As can be seen, there are improvements for both groups, either in constant or variable practice, from the 1st to the 2nd measurement. Regarding the performance during the 3rd measurement (retention test) stabilization for the variable practice group was observed, whereas the performance of the constant practice group decreased rapidly, reaching the initial measurement.

**Table 1.** Means and standard deviations on acquisition, retention and transfer of learning among children with intellectuals disabilities

| | Acquisition test | | | | Retention test | | Transfer test | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pretest | | Posttest | | | | Pretest | | Posttest | |
| Groups | M | SD | M | SD | M | SD | M | SD | M | SD |
| Constant group | 29.12 | 4.16 | 40.17 | 4.47 | 32.56 | 5.08 | 1.37 | 0.51 | 2.42 | 0.64 |
| Variable Group | 28.37 | 4.98 | 37.12 | 5.21 | 37.98 | 4.29 | 1.32 | 0.53 | 3.12 | 0.45 |
| Control Group | | | | | | | 1.33 | 0.51 | 1.5 | 0.54 |

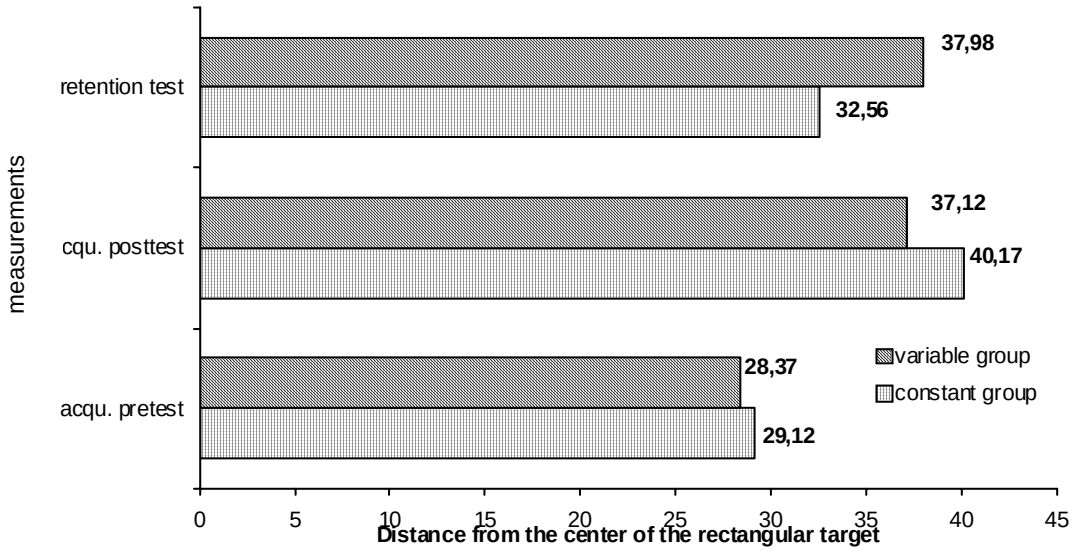


**Figure 1.** Improvements across trials of subjects in constant or varied practice conditions for acquisition and retention tests

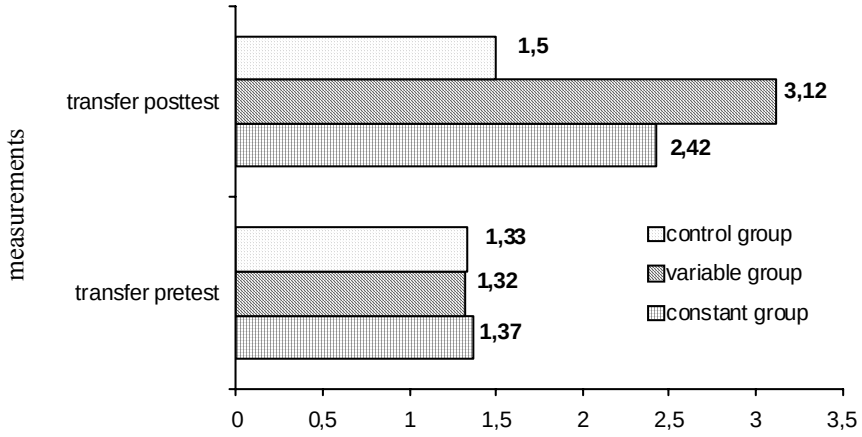


**Figure 2.** Improvements across trials of subjects in constant, varied or no practice conditions for transfer test

In order to examine the effects of the three different exercise conditions (constant practice – variable practice – no practice) on learning transfer using a new throwing motor skill, a repeated-measures univariate analysis of variance was conducted: three (Groups) by two (Measurements) ANOVAs were initially employed to examine the pre and post differences as well as the differences among the three groups in learning transfer of an overhand basket ball throw into a hoop. The analysis revealed that there was a significant effect for the factor measurement ($F_{1,19} = 56.74$, $p < 0.05$) as well as a correlation between method of practice and measurement results ($F_{2,19} = 9.34$, $p > 0.05$). The post hoc analysis was employed to examine the differences among the three groups with the use of Scheffe's test. As can be seen, significant differences were found between pre and post measures for the variable practice group ($F_{1,19} = 45.64$, $p < 0.05$), while there were no statistically significant differences between pre and post measures for the constant practice group ($F_{1,19} = 5.34$, $p > 0.05$). Finally, no significant differences were found for the respective values for the control group ($F_{1,19} = 0.37$, $p > 0.05$). Regarding the findings of the study, even if there is an increasing course from the 1st to the 2nd measurements in constant practice, the magnitude of this increase is much lower and statistically non-significant than that of the variable practice method. Finally, the control group, as expected, did not show any increase in performance between the two measurements.

## DISCUSSION

The results of the present study show that there were not any statistically significant differences among the subjects who practiced in constant or variable conditions, in acquisition and retention tests. These findings are in accordance with previous studies of children with mild ID which did not find a varied (random) practice better than constant practice in the performance of motor skills. Del Rey and Stewart as well as Porreta and O'Brien [3, 18] suggested that the lack of performance differences between subjects with mild ID during acquisition may be due to similarities in how random and constant learning groups construct action plans. Because of their mental deficit, all subjects with ID are involved in constant mental processing during acquisition of a motor skill and may need to engage in active processing when learning motor tasks, regardless of the practice condition, presenting similar action plans. On the contrary, subjects without ID, are involved in constant mental processing only when practicing in variable conditions. It is possible then that some cognitive maturity for persons with ID is necessary to reveal differences among different practice groups. Despite the fact that in the present study none of the experimental groups showed more efficiency in acquisition, an increase in performance of subjects who practiced in constant conditions was noted. These observations are partly in agreement with those of Stadulis & Eidson [26] which suggest that for motor skills characterized by

some degree of complexity in organization, the constant method of practice is more effective in acquisition of learning motor skills in individuals with ID.

Consistent with studies that have compared the variability of practice with motor performance of individuals with ID [4, 17, 20], this study showed that the variable practice group during retention, even if statistically non-significant, performs better than the constant practice group. Constant practice of a throwing skill does not appear to be conducive to good retention test results in subjects with ID. These results could be reflect the probable differences between the processing activities experienced by the two groups in practice conditions and the processing activities required during the retention test. Subjects from the constant practice group did not change the condition of throwing tennis balls between acquisition and retention; while subjects in the variable practice group were performing randomly (different throw distances). According to Action Plan Reconstruction Theory [9], it is the accessibility of variable strategies (or action plans), not the multiple processing of them, which causes active reconstructions or memory representations. If we supposed with caution in our study that the degree of requirements of action plan reconstruction trial was lower for the subjects who practiced in constant conditions, acquisition performance would be better for them if exposed to constant schedules than for subjects exposed to variable practice conditions.

In contrast, subjects practicing in variable conditions exhibited a significantly greater transfer performance than subjects in constant practice conditions. While the previous studies elicited marginal support for variability of practice, this study provides greater support in favour of variable effects on children with intellectual disabilities.

Elaboration theory [22] has been offered as explanation for our results. It suggests that processing of multiple strategies in a varied context during practice results in the elaboration of memory representations, which leads to enhanced retention and transfer. The more extensive multiple and varied processing demanded in variable practice conditions results in poor performance during acquisition but enhances retention and transfer, which is in accordance with our findings confirming the basic hypothesis of this study.

In conclusion, despite the fact that the differences between the two methods of practice did not reach the level of statistical significance in the acquisition test, the achieved results suggest with caution that the constant model of practice favors the acquisition of a simple throwing skill in individuals with ID. Additionally, the variability in practice might facilitate the retention and transfer of similar motor skills contributing to better performance of students with mild ID and especially in open game situations where demands for random responses are increased.

Variable (random) practice was chosen for this study because most game situations in physical education classes call for random responses. The lesson plan format for many physical education classes often entails a practice session followed by some type of lead-up or actual game play. In open game situations continual repetition of the same motor skills is not conductive to effective performance. Not only are random responses essential to game play, but novel responses also enhance performance when unexpected situations arise.

Regarding the applications of the present study in physical education, the teacher should carefully select the most efficient method of practice in relation to the type of motor skill and to the participants' mental level. This procedure could greatly reduce the influence of the "negative expectation" factor, thus increasing the self-confidence and self-respect of individuals with ID. A proper organization of the class would constitute an important factor of motivation for the acquisition of a new motor skill. Constant external feedback throughout practice contributes to the discovery of solutions and to an increase in the levels of mental processing and methodical planning of motor information. The chosen methods of practice should take into account the specific demands of individuals, and they should be characterized by flexibility and applicability not only for research but also for educational purposes in schools thus, contributing to the progressive increase of pupils' performance. Finally, future studies should be conducted in different geographical locations on other special population groups and, if possible, include large sample sizes.

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