Middle-East Journal of Scientific Research 8 (1): 222-227, 2011
ISSN 1990-9233

A Comparison of the Effects of Two Practice Session Distribution Types on Acquisition and Retention of Discrete and Continuous Skills

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Abstract: Distribution of the relationship between practice and rest is one of the most important issues in planning practices. The goal of doing this research is to determine the effect of long practice session distribution on acquisition and retention of discrete and continuous skills. 120 students of 2nd grade elementary schools in Tehran were chosen with the average and standard deviation of 13.7±0.6 of age, 40.8±2.3 kilograms of weight, 130±3.8 centimeters of height, having no record of emotional trauma or disorder, all having their right hand as the preferred hand and they were randomly divided into four experiment groups of 30 subjects. 40 practice attempts were distributed at the acquisition stage in four sessions, each having 10 attempts for the discrete task of creating force using ergometer, as well as the continuous task of mirror-tracing both massed (in a day) and distributed (4 days). The mean absolute error of subjects was calculated for acquisition attempts of each session and retention attempt that was performed 48 hours after acquisition attempts. We compared the performance of subjects of each skill in two groups of massed and distributed, using multivariate analysis of variance (2 groups × 4 sessions), as well as by continuously measuring factors of groups and sessions. Then using t-test for dependent groups, the retention of massed and distributed groups were compared ($P<0.05$). The results showed that in discrete skill, the performance of massed and distributed practice groups in four sessions of acquisition and retention stage has no significant difference, but retention of continuous skill has significant statistical difference in massed and distributed practices and this difference is in favor of the distributed group. Taking into account the findings of the present research which is, at some parts, consistent with the findings of previous researchers, it is recommended that in order to design practice for acquisition and retention of continuous skills, distributed practices be used, while for discrete skills, both massed and distributed practices can be used with regards to specific situations.

Key words: Motor learning · Practice session distribution · Massed practice · Distributed practice · Discrete skill · Continuous skill

INTRODUCTION

Practice and various experiences in specialized skills are vast concepts which cannot yet be precisely specified. Practice can be done in different times, different places and under different conditions. We can systematically change many properties of practices in order to make them more effective. Many of these conditions are under direct control of the trainers. The question is how we can modify practice conditions to make learning more effective.

Of the interesting discussions noted by many motor behavior specialists are the length, quality and the number of practices in each session. In other words, how much practice is helpful for learning? We can make various decisions; how much the overall period of practice should be (three months, three weeks, three days, etc.): how should practice sessions be planned during each week (everyday, once a week, twice a week, etc.); how long should each practice session take (half an hour, an hour, two hours, etc.); along these activities, which factors of fatigue and rest should be taken into account [1].

One of the most important issues that must be noted in practice session distribution is the balance between practice efficacy and practice efficiency. What is meant by practice efficacy is learning with less error, improving motion model, retention and better transfer to new motor skills which are assessed in retention and transfer tests;

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what is meant by practice efficiency is its being economical, less time consuming, involving less injury and other practice costs [2].

Although most researchers, trainers and teachers try to decrease educational costs and save time, in planning practice sessions we must pay attention to specific situations and conditions. It is possible that in the practice of elite individuals (for whom high level of performance is important) for trivial learning many costs are expended, while in some of the schools' physical education plans where there are so many students and few facilities, practice efficiency is not very much taken into consideration. It might be assumed that distributing practice sessions over several days decreases practice efficiency in comparison to a one day session, but the important question is whether or not decrease of efficiency can be made up for by effective learning [3].

The effect of practice session distribution on learning verbal communication skills has been previously researched upon [4]. During the 1980's there were researches in the area of motor skills too, but for a while these researches were suspended and it appears that they were suspended because according to scientific and economic viewpoint, it is more economical to plan practices in a single intensive session. Because, in this way, trainers and those who practice can easily plan and can transfer and settle more quickly. And also from a theoretical perspective, in cognitive psychology and motor learning, there has been no dominant theoretical structure that can sufficiently justify the distribution of practice in a single session or its distribution with longer intervals of, for example, several days. Recently, scientists have introduced "Memory Consolidation Hypothesis" and based on that, have designed new research models. Generally, memory consolidation hypothesis is an expression used to describe nervous alteration in which memory moves from a relatively unstable phase to a stable one. In this hypothesis it is believed that memory processes continue for a long time after practice repetitions and every attempt of a task incites chemical processes in memory which are stored in an anatomical part of the brain; thus, performing a new attempt before the previous attempt is consolidated which leads to disturbances in learning.

Researchers classify motor skills based on the way motions are discerned during skill performance. If a skill that requires a discernible motion can be identified with a beginning and an end, it is classified as a discrete skill; skills such as turning on the light, which takes a little time and has a specific beginning and a specific end [5]. Continuous motor skills include motions that are always repeated and the behavior of the factor takes a relatively long time and has no specific beginning and and no specific end. Generally, discrete and continuous skills can be totally different and can imply different processes, therefore for a trainer, how these skills are learned and performed, differ [6].

It appears that by distributing practice rehearsals we can attain a more effective practice distribution in comparison to practice in a single day, but such a strong variable has not yet been seriously noted in planning practice sessions [7]. Some researches show that practice session distribution is effective in acquisition and learning of motion skills [8]. Of course, most of these researches have been done with short intervals and continuous skills and the effect of long intervals and discrete skills has not been studied. Moreover, a review of the literature of researches in the area of distribution shows that the effects of distribution on learning continuous skills have not been completely and seriously confirmed [9].

A comparison between the distribution of massed practice attempts and distributed practice attempts in discrete and continuous skills shows that distributing practice attempts affects the learning of continuous tasks, but does not much affect learning discrete tasks [10]. Of course in most of the researches attempts at distribution have been used and practice session distribution has been less surveyed.

Also, if scientists in the area of motor learning want to relate the rules they have discovered in laboratories to the real world where tasks are learned within a few days then practice session distribution gains importance.

Since there has been no research on the effect of practice session distribution on learning discrete motor skills and in order to more generalize the results gained in continuous skills, the research is done on both a discrete skill and a continuous skill. In this research, the researcher tries to determine the effect of long a distribution of practice sessions on acquisition and retention of discrete and continuous skills and then compares them. The important question is whether or not the number and length of rest periods influence learning practiced skills, or in other words, what is the best way of distributing practice sessions in discrete and continuous skills [11].

The effects of practice session distribution in the cognitive-motor area has been more examined in continuous skills rather than discrete skills and most of the distribution effects referred to generally include distribution of practice in relatively short intervals

between attempts in one session and distribution of practice sessions in several days has been less studied; moreover, distribution of practice sessions for learning discrete motor skills and with long distribution has not been studied [12]. Therefore, in order to determine the effects of two types of distribution, long and short, on acquisition and retention of discrete and continuous skills and to determine the extent of such effects, the present research aims at comparing the effect of the two types of practice session distribution on acquisition and retention of discrete and continuous skills.

MATERIALS AND METHODS

All schools in Tehran form the population of this research, among which 12 schools have been randomly chosen without regard to any specific region; then, from all 2nd grade elementary students of each school and from those whose preferred hand was the right hand, 10 were randomly chosen from each school (120 in total) and were included in the research. The subjects of the research had no record of any emotional trauma or disorder and after being chosen and were randomly divided into 4 groups of 30 subjects.

Subject's Individual Specifications Were as Follows: average and standard deviation of 13.7±0.6 of age, 40.8±2.3 kilograms of weight and 130±3.8 centimeters of height. 40 practice attempts were distributed at the acquisition stage in four sessions, each having 10 attempts for the discrete task of creating force using ergo meter, as well as the continuous task of mirror-tracing both massed (in a day) and distributed (4 days). The mean absolute error of subjects was calculated for acquisition attempts of each session and retention attempt was done 48 hours after acquisition attempts. Descriptive and deductive statistics were uses in order to analyze the data. In deductive statistics, multivariate analysis of variance (2 groups×4 sessions) and dependent t-test with significance level of $P>0.05$ were applied in SPSS 16 software.

Stages of Tests Were as Follows

Ergometer: In this research we used a hand ergometer model JAGAMI (DM-100S), which has a graded screen and can display the generated force up to 100 kilograms. Taking into consideration previous researches, this device has enough credit and durability.

Mirror Tracer Machine: We used a mirror tracer machine in this research. The task of tracing an image in the mirror includes tracing a six-point star pattern with an electrode. The goal is to quickly finish tracing the star with the fewest errors possible. We can count the number of errors when the electrode touches the metal plate and the error is automatically recorded by the machine. Taking into consideration previous researches, this machine has enough credit and durability.

Discrete Task (Ergometer Machine): First, in order to familiarize the subjects with the machine, the researcher explained how ergometer worked and then three persons who were not of the subjects experimented with the device for the subjects to learn. The stages of the test were as follows: to perform each attempt of this task, the subject sat on a chair across from the examiner, held the handle of the ergometer in their right hand in a way that their hand would stay perpendicular and totally stretched-out; then with the order of the examiner, they pulled the handle to create force equal to 8 kilograms. Deviation of the subject from the set 8 kilograms force showed the absolute error of the examiner. Subjects were placed in a way that they could not see the generated force displayed on the machine's screen. After being certain of the force created and having recorded the deviation from 8 kilograms as the examiner's absolute error, the subjects let go of the handle and restored it to its initial position. After performing each attempt, the subjects were made aware of the number of their absolute errors and then they performed another attempt to finish 10 practice attempts designed for the day.

As shown in the research, maximum of 30 to 40 percent of resistance does not create much physical fatigue; thus, in order to determine 8 kilograms, first, we measured the maximum force created by all the subjects, then the average was calculated and 35% of the average of the maximum force created by subjects was calculated which, equalled 8 kilograms.

Continuous Task (Mirror Tracer Machine): First the researcher explained about the device for the subjects to familiarize them with it and then 3 persons, who were not amongst the subjects, experimented with the device four times to teach the subjects how to use it. The stages were as follows: to perform each attempt of this task, the subject sat on a chair and behind the table on which the device was placed in a way to be able to see the image of the star in the mirror of the device; then they held the

electrode in their right hand and from the beginning point on the top of the star, traced the star image clockwise until they returned to the beginning point. Each attempt included a complete tracing of the star image in the mirror. The number of times subjects failed to trace the star's path were displayed as absolute error on the device. During the task, the subject sat on the chair in a way that they would not be able to see the number of errors recorded by the device and after each attempt was finished, the examiner made a note of the recorded error and reset the device. Having performed each attempt, the subjects were notified of the number of their absolute errors. Each practice session included 10 mirror tracing attempts. The image of the mirror tracer device is included in annex 5.

Experiment No.1 (Discrete Skill Acquisition Stage): In the stage of discrete skill acquisition two groups of the samples performed the discrete task of creating force with ergometer.

- Group no.1 (massed group) performed four practice sessions in one day with two practice sessions in the morning and two in the afternoon. There was a 30-minute interval between the two practice sessions in the morning. Four hours later, two practice sessions were held in the afternoon and there was also a 30-minute interval between the two practice sessions. In each practice session, the subjects performed 10 practice attempts, with the overall number of 40 attempts at the end of 4 practice sessions and the absolute error of 10 attempts in each session was calculated as the acquisition grade of that session.

The practice plan for the massed group that performed four practice sessions in a day: first session; 30 minutes later, second session; 4 hours later, third session; 30 minutes later, fourth session.

- In the discrete task of group no. 2 (distributed group), subjects performed their four practice sessions in four consecutive days and at a certain hour. In this group, the interval between two practice sessions was 24 hours.

The practice plan for the group that performed four practice sessions in four consecutive days: first session; 24 hours later, second session; 24 hours later, third session; 24 hours later, fourth session.

Experiment No. 2 (Continuous Skill Acquisition Stage): In the stage of continuous skill acquisition, practice sessions were held exactly like in the discrete task practice for group no.1 (practice sessions in one day) and group no.2 (practice sessions in four days). It must be noted that the number of attempts of each of the massed (1) or distributed (2) groups are equal, but the overall time of practice differs.

Retention Stage: In all the four experiment groups, retention test was given 48 hours after acquisition attempts were done. In the retention stage, subjects performed an attempt at the specified task and their absolute error was taken as their retention grade.

Therefore, in four acquisition sessions, subjects perform 40 attempts and the mean absolute error of 10 performed attempts is calculated as their acquisition grade. Retention grade is their absolute error in a single attempt in the retention stage.

RESULTS AND DISCUSSION

Among two groups of discrete skill and two groups of continuous skill, "Levine's Test" was done to homogenize the variances for the mean absolute error of each sample's attempts and the homogeneity of variances in two groups of discrete skill and two groups of continuous skill was specified. The specific results of the Levine's test for two groups of discrete skill and two groups of continuous skill are presented in Tables 1 and 2.

With regards to the results obtained from multivariate analysis of variance test (2 groups × 4 sessions) which is presented in Table 3 and the continuous measurement between the factors of sessions and groups, although there is a significant difference between sessions of each group, there is no significant difference between the sessions of massed group and the sessions of distributed group. Therefore, there is no significant difference between the effect of distribution of practice sessions in one day and their distribution in four days on acquisition of discrete skills ($F=0.355$ and $P<0.05$).

With regards to the results obtained from multivariate analysis of variance test (2 groups × 4 sessions) which is presented in Table 4 and the continuous measurement between the factors of sessions and groups, although there is a significant difference between sessions of each group, there is no significant difference between the sessions of massed group and the sessions of distributed group.

Table 1: Pretest of Groups in Discrete Skill

				F: Levine's Test for Homogeneity of Variances	
Discrete Groups	Mean Absolute Error	Standard Deviation	Variance	F Value	Significance
One Day Group	1.666	0.569	0.324	0.006	0.938
Four Days Group	1.664	0.569	0.324		

Table 2: Pretest of Groups in Continuous Skill

				F: Levene's Test for Homogeneity of Variances	
Continuous Groups	Mean Absolute Error	Standard Deviation	Variance	F Value	Significance
One Day Group	11.239	11.157	124.479	0.035	0.854
Four Days Group	12.840	11.165	124.658		

Table 3: Comparison of 4 Acquisition Sessions in Two Discrete Skill Groups

Discrete Skill	Degree of Freedom	Average	F Value	Significance
Between the Session of Each Group	3	1.765	7.950	0.000
Between the Session of the Two Groups	3	0.113	0.507	0.678
Between Two Groups	1	0.539	0.885	0.355

Table 4: Comparison of 4 Acquisition Sessions in Two Continuous Skill Groups

Cnotinuous Skill	Degree of Freedom	Average	F Value	Significance
Between the Session of Each Group	3	277.217	18.115	0.000
Between the Session of the Two Groups	3	16.839	1.100	0.354
Between Two Groups	1	90.637	3.940	0.057

Table 5: Comparison of Retention in Two Discrete Skill Groups

Group	Mean Absolute Error	Standard Deviation	Degree of Freedom	Calculated t	Significance
One Day Discrete	1.766	1.099	28.00	0.462	0.648
Four Days Discrete	1.533	1.619	24.64		

Table 6: Comparison of Retention in Two Continuous Skill Groups

Group	Mean Absolute Error	Standard Deviation	Degree of Freedom	Calculated t	Significance
One Day Continuous	0.400	0.507	28.00	2.269	0.034
Four Days Continuous	0.066	0.258	20.80		

Therefore, there is no significant statistical difference between the effect of distribution of practice sessions in one day and their distribution in four days on acquisition of continuous skills ($F=0.057$ and $P<0.05$).

Also, according to the results of dependent t-test presented in Table 5, it was proven that there is no significant difference between the effect of practice session distribution in one day and distribution in four days on retention of discrete skills ($t=0.648$ and $P<0.05$).

Finally, according to the results of dependent t-test presented in Table 6, it was proven that there is a significant difference between the effect of practice session distribution in one day and distribution in four days on retention of continuous skills ($t=0.034$ and $P<0.05$).

DISCUSSION

The goal of the present research is to survey the effect of two types of practice session distribution on acquisition and retention of discrete and continuous skills.

The results show that for discrete skills, performance of massed and distributed practice groups in four sessions of acquisition and the retention stage has no significant difference, but retention of continuous skills in massed and distributed practice has significant statistical difference and this difference is in favor of the distributed group. The findings of the present research are at parts in accord with the findings of previous researches but at some parts they are not consistent with the previous findings. What follows are the possible reasons of having such results:

In a general discussion about the effect of practice session distribution on acquisition and retention of discrete and continuous skills, it must be noted that the effect is different in discrete skills from the effect in continuous skills. Mednick [7] reviewed previous researches and concluded that distribution of practice sessions has no effect on the acquisition and learning of discrete skills. In research of Stickgold *et al.* [9] too, the results of the aforementioned research were verified, that is, there is no difference between massed practice and distributed practice. One of the goals of the present research was to examine the effects of practice session distribution on discrete skills. The results of our research showed that practice session distribution, like practice attempt distribution, has no significant effect on the acquisition and retention of discrete skills. Also according to Mednick's review [7] and the results of Stickgold *et al.* [9], practice session distribution have a significant effect on the acquisition and retention of continuous skills. In this research, the researcher tried to examine the effects of practice session distribution on the acquisition and retention of continuous skills. The results of our research showed that practice session distribution has little effect on the acquisition of continuous skills, but this effect is not significant. As for retention, the results of our research showed that practice session distribution in continuous skills improved performance at retention test which was given 48 hours later and these effects are significant. And as for the variables of skill types (discrete or continuous) and practice group types (massed or distributed), in discrete skills, acquisition and retention in massed group shows no significant statistical difference from distributed group, but in continuous skills retention of the distributed group is better that massed group.

To sum up, in comparing the effects of massed practice and distributed practice on the acquisition and learning discrete and continuous skills, the results of this research confirms the results of previous researches on the effect of distribution between practice attempt.

Generally, the results of our research are as follows:

- Distribution of practice sessions has little effect on the acquisition and retention of discrete skills.
- Distribution of practice sessions has a relatively persistent effect on the retention of continuous skills.
- There is a significant difference between the variables of skill types (discrete or continuous) and practice group types (massed or distributed) in retention.

Finally, the results of this research show that practice session distribution has significant effects on the retention of continuous skills, but there has been no sign of its effect on the acquisition and retention of discrete skills. Thus, the type of task is important in the effects of massed and distributed practice. In an overall summary it can be noted that the nature of the task to be practiced, time frequency between practice attempts and practice sessions, as well as interaction between these variables significantly affect the relationship between practice conditions and subjects' performance and the effects of practice distribution serves as a performance of a specific task.

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