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Original research article

THE EFFECT OF BLOCKED, RANDOM AND SYSTEMATICALLY INCREASING PRACTICE SCHEDULES ON LEARNING DART-THROWING·

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Abstract. *The purpose of this study was to determine the effect of different Practice Schedules (Blocked, Random, and Systematically increasing) on the acquisition, retention and transfer on learning dart-throwing (300, 360 and 420 cm). Forty five healthy non-athlete male secondary school students (age 14.05± 0.75 years, height 156.6 ± 5.2 cm, weight 48.53 ± 2.4 kg; means ± S.D.) volunteered to participate in this study. The participants were divided into a Blocked group (n=15), Random group (n=15) and Systematically increasing (systematically increasing contextual interference in training duration) group (n=15), after performing the pre-test. The participants did not have any experience in dart-throwing. All of the groups performed the same learning program in 9 days, 9 sessions and each session consisted of 9 trials. The participants were tested for performance before and after the 9 days. Acquisition, retention, and transfer tests during 10 trials in each pass (distance: 250 and 420 cm) were conducted 24 hours after the training sessions. The results of the repeated measure and one way ANOVA ($p<0.05$) showed the effect of practice session was significant but no significant difference in acquisition between the groups was determined. In retention and transfer tests, there were significant differences between mean scores of the practice groups. However, the findings showed the systematically increasing group had slightly more improvements in dart-throwing when compared to other groups, which supported Magill and Hall theory (1990) and challenged the point idea of Guadagnoli and Lee (2004)..*

Key words: *contextual interference, challenge point, systematically increasing.*

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INTRODUCTION

The amount of CI in a practice setting can be varied by the scheduling of the order in which the skill variations will be practiced. A low amount occurs when each skill variation is practiced in its own set of trials, known as a blocked practice schedule. In contrast, a high amount occurs when each skill variation is practiced in random order, commonly referred to as a random practice schedule. Between these two extremes are a variety of practice schedules that represent different amounts of CI (Magill, 2007). The CI effect refers to the learning phenomenon where a learning benefit is derived from a practice schedule that invokes high rather than low contextual interference. The theoretical basis and demonstration of this learning phenomenon dates back to Battig (1966) in applications to verbal learning situations. Shea and Morgan (1979) provided initial evidence that this phenomenon also applies to the learning of motor skills. Since that time, numerous studies have demonstrated the effect for a variety of skills (Brady, 1998 & Magill & Hall, 1990). In light of this evidence it is interesting to note that the predominant experimental design of CI studies has involved the comparison of only high and low levels of contextual interference, i.e., random and blocked practice schedules. However, these comparisons have not always demonstrated the CI effect. Several reasons have been proposed to account for the conflicting results, which indirectly propose conditions associated with optimal practice schedules. For example, Magill and Hall (1990) hypothesized that a random practice schedule would not produce better learning than a blocked schedule when the skill variations to be learned were parameter modifications of the same generalized motor program. Brady (1998) concluded from his review that the failure to demonstrate the CI effect often occurred when applied rather than laboratory skills were learned. And, Landin and Hebert (1997) suggested that the conflicting findings were due in part to the skill level of the performer as they practiced with schedules involving fixed high and low levels of CI, with more experienced learners benefiting from random rather than blocked schedules and novices benefiting more from blocked schedules (Guadagnoli, Holcomb & Weber, 1999). That there may be optimal practice schedules other than blocked and random is a possibility that has received little attention by researchers. One way to explore this possibility is to consider and apply the perspectives of "desirable difficulties" (Bjork, 1994 & 1999) and the "challenge-point hypothesis" (Guadagnoli & Timothy, 2004) as important considerations for designing effective practice conditions. The concept of desirable difficulties refers to practice conditions that engage the learner in a difficult learning processes during practice that will enhance long-term retention and transfer. As Bjork (1994 & 1999) has already indicated, incorporating CI in practice schedules is one way to introduce a desirable difficulty into practice.

The challenge-point hypothesis expands on this perspective by proposing that difficulty in practice conditions are a function of the relationship between the nominal task difficulty (i.e, the constant amount of task difficulty regardless of who is performing the task or the performance situation) and functional task difficulty (i.e., how challenging the task is related to the performer's skill level and the performance situation). As a learner becomes more skilled during practice the functional difficulty of the practiced task is reduced. This implies that in order to appropriately challenge the learner at a "desirable" level of functional task difficulty the practice environment should change as the learner's skill level changes. One way to accomplish this type of change is to vary the amount of CI in the practice schedule. An important question remains concerning the introduction of

the appropriate amount of CI in the practice schedule to optimize learning. According to the challenge-point hypothesis, changing levels of CI during practice would provide a way to match functional levels of task difficulty with the learner's stage of learning. That is, novices should benefit more from low levels of CI, whereas those with higher skill levels should benefit more from higher levels of CI. In light of these expectations, it would seem reasonable to predict that for novices learning dart-throwing from various distances, which is a task Guadagnoli and Lee (2004) considered to be "relatively complex in nominal [task] difficulty" (p. 219), neither a blocked nor random only schedule would be optimal. Rather, an alternative schedule of CI should lead to the best learning process, especially one that would engage learners in increasing amounts of CI as the number of practice trials increases. It is worth noting that the benefit of an "increasing CI" type of schedule was suggested by Magill and Hall (1990) on the basis of research evidence that showed learning benefits for novices when blocked practice was followed by later random trials (Goode & Wei, 1988 & Shea, & Zimny, 1983). Further support was later provided by Hebert et al., (1996). The initial practice trials would present the task variations in a blocked schedule. The rationale for the benefit of these early repeated experiences was that these repetitions would provide early opportunities for important error correction and movement pattern exploration, which would allow the learner to get a general idea of what is needed to be done to reach the action goal. This rationale is consistent with Gentile's (1972) learning stages model in which she argued that learners need repeated trials early in practice to facilitate their getting "an idea of the movement" (p. 3), i.e., a movement pattern that allows some success in achieving the task goal. The need to introduce higher levels of CI as practice progresses is consistent with the long-term benefits of introducing more "desirable difficulty" into the practice session. It is also proposed that a serial practice schedule would serve as an intermediate step between initial blocked practice and the more difficult random practice schedule. Thus the purpose of this experiment was to investigate whether the systematic increase of CI levels during practice is more beneficial for retention and transfer than practice schedules involving only low or high levels of CI. More specifically, the hypothesis was that a practice schedule that presents novices with three increasing amounts of CI when learning multiple variations of a sport skill that is relatively complex in nominal task difficulty and in which the variations require coordination parameter changes, will perform better on retention and transfer tests when compared to participants who practice the same tasks with traditional blocked or random practice schedules.

MATERIALS AND METHODS

The participants

Forty-five healthy non-athlete male secondary school students of Marivan City (age 14.05± 0.75 years, height 160.6 ± 5.2 cm, weight 51.53 ± 1.4 kg; means ± S.D.) volunteered to participate in this study. The participants were randomly assigned to either a Blocked group (n=15), Random group (n=15) and Systematically increasing (systematically increasing contextual interference in training duration) group (n=15) after performing the pre-test. Before undergoing the tests, the participants were given explanations about the assessment procedures, and study objectives. Before the study, the

participants were informed about the type and number of days in the week and the time of activities.

Experimental design

The dart-throwing skills test was used for data collection. Scoring was based on the measured absolute error (the absolute difference between the actual performance in each trial and the target).

In this experiment, the darts are thrown at 10 concentric circles, where scoring went from outside to inside, and outside the circle. The final score was 1 and then scoring grades ranged from 2 to 10. Each of these circles was to be hit by darts, according to the circle score shot points were given to every throw. The darts used in this study were metal darts approved by the International Dart Federation (WDF).

Procedure

Before any intervention, an introductory session was held where a skilled coach explained the correct type of dart-throwing to the participants (300 cm, 360 cm and 420 cm). The scoring procedure was also elaborated by one of the researchers. Given that this skill (darts) were performed at three different distances, the parameter was different, the number of trials and distance from targets was equal for all the throws. The participants were required to stand in line, with the purpose of hitting darts at the zero point. The pre-test was conducted at the end of the introductory session and the participants were randomly assigned to blocked, random, and increasing practice groups (n1= n2= n3=15). Each participant performed 27 trials for each throw with a total number of 81 trials during 9 sessions of practice (9 trials per session). The blocked practice group performed 27 trials of one throw, 27 trials of the second throw, and 27 trials of the third throw. The increasing practice group performed trails 1-27 in a blocked schedule (9 trials per distance), trials 28-54 in a serial schedule, and trials 55- 81 in a random schedule with an equal number of trials for each throw. The random practice group performed trials (in three distances) randomly. 24 hours after the practice period, the retention test (distance: 300 and 420 cm) and the transfer test (distance: 250 and 450 cm) were performed during 10 trials.

Statistical analyses

All of the statistical analyses were performed using SPSS software (version 18.0; SPSS Inc.). A repeated measures analysis of variance was used to examine the effect of practice sessions in the acquisition stage on the performance of the participants. A one-way analysis of variance (ANOVA) was applied to compare the performance of the participants in retention and transfer tests. A criterion α level of $P \leq 0.05$ was used to determine statistical significance.

RESULTS

The mean performance of the participants in the blocked, random, and increasing groups in the dart-throwing task is presented in Figure 1.

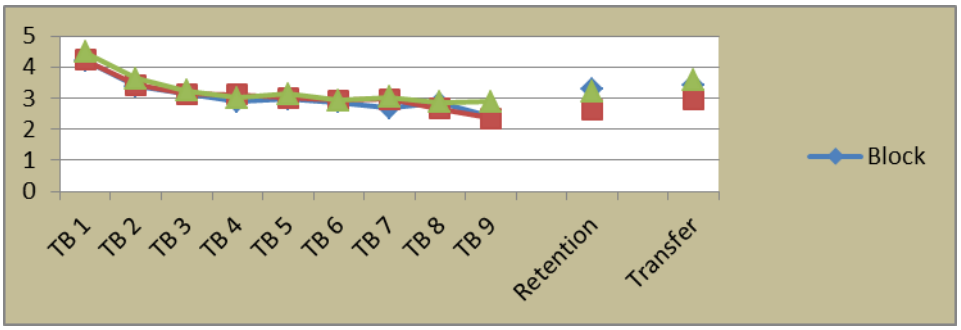

Fig. 1 Scores for the three practice schedule groups during the practice trials. The scores are the mean of scores for each trial block. Each trial block consists of 9 trials (3 for each distance).

Acquisition

Table 1 presents the results of the repeated measures ANOVA for the effect of practice group (blocked, random, and increasing practice) per trial block (9 trials per session).

Table 1 The results of the repeated measures ANOVA for comparing the performance of groups in the acquisition stage

Source of Variance	Measures	SS	Df	MS	F	P
Within-Subject	Practice	94.801	8	11.85	31.914	0.001*
	Grope× test	2.982	16	0.186	0.502	0.946
	Error	124.761	336	0.371		
Between-Subject	Grope	0.335	2	0.167	0.895	0.416
	Error	7.853	42	0.187		

* Significant at $p<0.05$

As can be seen from Table 1, the analysis shows that the effect of the group and the interaction of group and trial block are not statistically significant ($F<1$). Therefore, there is no significant difference between the practice groups in the acquisition of the skills.

A retention test analysis further revealed a significant main effect for the Practice Schedule with a value of $F(2, 57) = 5.80$, at the $p<0.05$ level.

Table 2 The retention test analysis

Tests	Source of Variance	SS	Df	MS	F	P
Retention	Between-Group	5.203	2	3.102	3.734	0.032*
	Within-Group	24.636	42	0.526		
	Total	29.839	44			
Transfer	Between-Group	5.687	2	2.343	3.646	0.035
	Within-Group	27.997	42	0.643		
	Total	33.684	44			

A Turkey-Kramer post hoc analysis of the Practice Schedules main effect indicated that the Blocked and Increasing schedule resulted in significantly better performance than the Random practice schedule.

Table 3 The results of LSD test for comparing the performance of the groups on the retention and transfer tests

	Gropes	Blocked	Increasing group	Random
Retention	Blocked	.....	.....	.....
	Increasing group	0.015*	.....	.....
	Random	0.688	0.038*	.....
Transfer	Blocked	.....	.....	.....
	Increasing group	0.016*	.....	.....
	Random	0.707	0.015*	.....

* Significant at $p<0.05$

DISCUSSION

In the current study, the effectiveness of a new form of the CI practice schedule was studied. In this "increasing CI" practice schedule, the learner progressed along the CI continuum by experiencing low CI early during the practice and systematically changing to two higher levels of CI later in practice. For the first third of the practice session, the participants who experienced the increasing CI schedule practiced dart-throwing from three different locations in blocked order. The middle portion of the practice schedule had learners practicing the same tasks in a serial pattern. The practice concluded with the participants practicing the same three skills in a random order. This new strategy of incorporating CI into practice was compared to the more commonly used blocked (low CI) and random (high CI) scheduling.

It was predicted that this progressive form of practice schedule (i.e. increasing CI schedule) would lead to superior learning when compared to schedules with a fixed, single level of CI. The results partially supported this prediction. During the retention test, the Increasing group performed significantly better than both the Random and Blocked groups. On the transfer test, the Increasing group performed significantly better than the Random group. These findings provide evidence that practicing along the CI continuum can be beneficial for a novice learning to dart-throwing at different distances. The results of this study are consistent with the predictions suggested by the challenge-point hypothesis (Guadagnoli & Timothy, 2004) for a task with nominal difficulty, such as a dart-

throwing task. In addition, the results provide a basis for how to effectively incorporate CI as a "desirable difficulty" (Bjork, 1994 & 1999) during practice for novices learning this task.

It is worth noting that there were no significant differences between the blocked and random practice conditions on the retention and transfer tests. Rather than considering this result as an indication of the lack of a CI effect in this experiment, it is suggested that this finding is consistent with other similar research in which no differences were found for learning skill variations that involved speed or distance parameter modifications (Brady, 1997 & Guadagnoli, Holcomb & Weber, 1999). In fact, it was this lack of a CI effect for these types of multiple task learning situations that led Magill & Hall (1990) to propose in their literature review the hypothesis that exclusively blocked or random practice schedules would not produce a CI effect and that some type of mixed level of CI during practice would be needed to produce the effect. The present experiment found that the increasing CI schedule supported that prediction.

Before presenting reasons as to why an increasing CI schedule is beneficial for learning, it was important to determine whether the effects observed here can be generalized and applied to tasks controlled by different generalized motor programs (Schmidt, 1975). Generalized motor program (GMP) learning has been shown to be a limiting factor in the CI effect (Magill & Hall, 1990); because of this it was important to test the expansion of the current findings when the practiced tasks were controlled by different GMPs. Testing this limitation allowed for a more generalized interpretation of the current data.

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UTICAJ BLOKIRANJA, NAIZMENIČNOG RADA I SISTEMATSKOG POVEĆANJA UČESTALOSTI U RASPOREDU TRENINGA NA VEŠTINU BACANJA U PIKADU

Cilj ovog istraživanja bio je da se utvrdi efekat različistih rasporeda treninga (blokiranja, naizmeničnog rada i sistematskog povećanja) na usavršavanje tehnike bcanja u pikadu (300, 360 i 420 cm). Ukupno je 45 mladih srednjoškolaca, koji se nisu aktivno takmičili (godište 14,05± 0,75 godinda, visina 156,6 ± 5,2 cm, težina 48,53 ± 2,4 kg; means ± S.D.), dobrovoljno učestvovalo u ovom istraživanju. Učesnici su podeljeni na: grupu koja je trenirala koristeći blokiranje (n=15), grupu koja je trenirala koristeći naizmenični rad (n=15) i grupu koja je trenirala koristeći sistematsko povećanje (sistematsko povećanje uticaja konteksta na trajanje samog treninga, n=15), nakon inicijalnog pre-testa. Učesnici nisu imali prethodno iskustvo u bacanju pikada. Pripadnici svih grupa su učestvovali u istom programu u trajanju od 9 dana, u sklopu od 9 sesija od kojih se svaka sastojala od 9 pokušaja. Sposobnosti ispitanika testirane su pre i nakon perioda od 9 dana. Testovi koji su se ticali usvajanja, pamćenja i transfera tokom 10 pokušaja (pri razdaljini od: 250 i 420 cm) vršeni su 24 sata nakon treninga. Rezultati ANOVA testova ($p<0.05$) prikazali su da je efekat učinka treninga bio značajan, ali da nije bilo značajnih razlika u pogledu usvajanja između grupa. Kod testova pamćenja i transfera, nisu uočene značajne razlike između srednjih vrednosti grupa. Ipak, rezultati pokazuju da je grupa koja je trenirala po metodi sistemsatskog povećanja pokazala veći napredak u poređenju sa ostalim grupama,, što je u skladu sa teorijom koju su razvili Magill & Hall theory (1990) ali koja nije potvrdila teoriju koju su razvili Guadagnoli & Lee (2004).

Ključne reči: *uticaj konteksta, bodovi, sistematsko povećanje.*