Biology and Medicine

Hajihosseini, Biol Med (Aligarh) 2016, 8:7
DOI: 10.4172/0974-8369.1000339

Research Article | Open Access

The Effect of Moderate Contextual Interference on Motor-Skill Learning

Samaneh Hajihosseini*

Department of Physical Education & Sport Sciences, Gorgan University of Agricultural Sciences & Natural Resources, Gorgan, Golestan, Iran

***Corresponding author:** Hajihosseini S, Department of Physical Education & Sport Sciences, Gorgan University of Agricultural Sciences & Natural Resources, Gorgan, Golestan, Iran; E-mail: s.hajihosseini@gmail.com

Received: Jul 26, 2016; **Accepted:** Aug 24, 2016; **Published:** Sep 22, 2016

Abstract

The purpose of this study was to investigate whether the systematic increase of contextual interference (CI) levels during practice is more beneficial for retention and transfer than practice schedules involving only low levels of CI. Thirty healthy male (n = 15) and female (n = 15) shooters participated voluntarily in this study. All were in the associative stage of learning and right-hemisphere. For counterbalancing among groups, participants were randomly assigned to two acquisition conditions—Serial (n = 15) and Blocked (n = 15). Two-way ANOVA (Blocked and Serial groups × 9 blocks), with repeated measures on the second factor, was used to analyze the acquisition results. Independent two sample t-tests were conducted to determine the effect of practice condition on motor-skill learning. Interaction effect of CI and the session is significant ($p < 0.000$). There was a significant difference in the average scores of nine sessions ($p < 0.000$). Retention and transfer of Serial results were significantly better than that of Blocked results, ($p < 0.000$) and ($p < 0.015$), respectively. Results of this study suggested that participants who practiced with gradual increases in CI generally performed better on a retention and transfer test compared to participants who practiced with traditional Blocked scheduling. Serial practice, indeed, with several elements in a prescriptive order, may benefit from changing conditions from trial to trial. As a consequence, deeper elaboration and extra distinction between variations of the task can facilitate adaptation to transfer conditions.

Keywords: Motor learning; Contextual interference; Shooting skill; Serial practice

Introduction

Human beings have a remarkable learning capacity which allows them to acquire a wide range of skills, from motor actions to complex abstract reasoning [1]. Within the motor-learning literature, many factors have been identified as contributing to the learning of motor skills [2]. One of these factors, known as contextual interference (CI) has been defined as the interference in performance and learning that arises from practicing one task in the context of other tasks [3].

In the last decade, comprehensive researches have clearly shown the effects of practice schedule (high and low CI) on motor-skill performance and learning [4]. The empirical evidence largely based on laboratory studies indicated that CI is enhanced motor-skill acquisition and retention. Recently, more research has been implemented for testing the generalizability of CI effects in applied settings [4]. However, this kind of studies using nonlaboratory tasks did not consistently reveal the CI effect. This last finding is not consistent with the review of the CI effect by Magill and Hall and Brady [5,6].

The contextual interference effect refers to a random practice schedule—varying tasks or parameters of a given task so that the learner would not perform consecutive trials in the same condition—yielding better learning than a Blocked-practice schedule—performing all trials of a given task or parameters of that task, consecutively [7]. The assumed superiority of a random practice has been based on two main hypotheses: (a) elaboration and distinction and (b) action-plan reconstruction. The theoretical prediction for the acquisition phase was that a decrease during practice would occur in a high-interference practice condition [8]. Both viewpoints highlight an important role for top-down executive control processes, such as response selection, task comparison, and an effortful process of reconstructing an action plan [4].

Therefore, many questions have risen concerning the generalizability of the CI effect and its limiting factors. Barreiros and *et al*. analyzed 27 studies on applied practice research. In 60 percent of them, the positive effect of high CI conditions was not observed. Accordingly, there was strong evidence to state that either the experimental organization, in general, was not adequate to illustrate the expected effect, or it did not exist at all. Those results partially agree with Shewokis and Snow's [9].

When the CI effect was tested in more complex, "real-life" skills, the benefit of random practice has also been found in several skills, such as badminton serves [10-12], kayaking [13], rifle shooting [14], table tennis serves [15] volleyball skills [16], baseball batting [17], and bimanual limb movements [18]. Results of applied studies, however, have been equivocal. This was likely due to a number of factors involved in field-based research, such as lack of sensitivity of the scoring system, subjects' differing skills, various task characteristics, insufficient contextual interference created in practice, etc. [10,16,19,20]. Moreover, most related applied research used modified field tests, which may limit the applicability for the practitioners.

Magill and Hall suggested that additional types of practice schedules ought to be investigated to account for apparent discrepancies in the results of some CI experiments [21].

The benefits of adaptive training conditions can be interpreted in terms of optimal amount of information to be processed on a given trial to improve the control of action on the next trial [22]. Therefore, when designing a practice schedule for learning multiple variations of a skill, it is important to consider the level of CI the learner will encounter during practice [23].

That there may be optimal practice schedules other than Blocked and random is a possibility that has received little attention by researchers. Several reasons have been proposed to account for the conflicting results, which indirectly propose conditions associated with optimal practice schedules [21,24].

On the other hand, the effects of contextual interference on motor-skills learning would be dependent on factors such as the stage of learning or level of experience [25]. If introducing a beginner to high amounts of CI in the beginning of practice can be overwhelming, then one would predict that a schedule that offers a gradual increase in CI would not lead to the "learning problem" [21]. In short, researchers argued that higher levels of interference are not compatible with the initial learning phases. Some previous experience is necessary to promote maximum benefit [5]. Boyce and colleagues offered a similar suggestion in a review of sport-pedagogy literature by recommending that learners should encounter low CI early in practice while they are "getting the idea of the movement" (p. 334), and CI should not increase until a certain level of mastery is achieved [26]. Consistent with those recommendations, Jefferys proposed that early Blocked practice followed by later increases in CI might lead to improved agility performance [27].

Thus the purpose of this experiment was to investigate whether the systematic increasing of CI levels during practice is more beneficial for retention and transfer than practice schedules involving only low levels of CI. Furthermore, there has been no study which has examined this question for the shooting skill.

Methods

Participants were 30 in number—male ($n = 15$) and female ($n = 15$) right-hemisphere volunteer shooters (mean age = 35.95 years, SD = 8.25 years) who had no prior experience with the experimental task and were unaware of the specific purposes of the study. Upon arrival at the training schedule, each participant completed an informed-consent form and received written and verbal instructions regarding the goals of the study.

All are in the associative stage of Fitts and Posner's three-stage model of learning [3]. Some studies have considered the performer' ability levels. Their findings seem to indicate that acquisition in novice subjects tends to be higher in low interference conditions. On the other hand, highly skilled subjects show no detrimental effect of high-interference conditions during acquisition and can take advantage of high-interference conditions in retention and transfer [8,17,28]. Fifteen air-rifle shooters who have the average of 8 ± 1.2 scores of 10 shoots and 15 air-pistol shooters who have 7 ± 1.5 scores of so selected, according to the condition of this study, from their clubs consist of shooters from Seoul, Tarbiat Modares, and Gorgan. Before starting the experiment, according to that information, for counterbalancing among groups, participants were randomly assigned to tow acquisition conditions, Serial ($n = 15$) or Blocked ($n = 15$). All of them were in older shooting range. This study utilized a pretest and posttest applying quasi-experimental design. The experiment consisted of three phases named "Acquisition", "Retention," and "Transfer". In Acquisition Procedures, the shooting process was divided in to three parts: shooting position, aiming, pulling the trigger, and breathing. The effects of contextual interference manipulation were tested in a truly natural setting, including the tasks, equipment, and training environment, as well as an objective scoring system. All participants should be shut in 3 weeks/three sessions per week/20 bullets in each session. Blocked-practice participants should practice each part in 1 week, Serial-practice participants, consequently, practice the first part in the first week. They added the second one to the first part in the second week and the third part to the previous setting in the third week and kept it up to the end of ninth session. At the start to select the participants, we tested their ability of mental imagery, because all the elements of the shooting skill were done in each trial, but the focus of instruction was on one stage. For example, the Blocked-practice participants in the first session focus on positioning. The mental imagery assessed by employing a revised version of the MIQ questionnaire was designed by Hall and Martin [29]. Retention-transfer procedures: Participants were given no-instruction retention tests at least 48 h following the acquisition phase on the 40 bullets used during acquisition. A transfer test used ten bullets in final step and formal shooting competition will be added to the retention test.

This study has been confirmed by the research council's Department of Physical Education and Sport Sciences, Tarbiat Modares University, Tehran, IR Iran.

To assess normal distribution from the Kolmogorov-Smirnov test and Levene test, the heterogeneity of variance was used. With regard to the acquisition phase, the sum of shooting scores over 20 trials (180 trials totally—nine blocks of 20 trials) was the dependent measure of interest. The sum in the acquisition phase was submitted to two-way ANOVA (Blocked and Serial groups × 9 blocks), with repeated measures on the second factor for each retention interval separately. Two independent sample t-tests were conducted to determine the effect of the practice condition within the retention and transfer phases, separately. The departures from sphericity were verified through the Mauchley's test, and the Greenhouse-Geisser's method was used to correct the degrees of freedom when necessary. For all statistical tests, the significance level was set at $p < 0.05$. All analyses were carried out using SPSS 20.

Results

Participants were randomly divided in tow groups (Serial: MIQ = 5.66 ± 0.65/preshooting test = 8.71 ± 0.37; Blocked: MIQ = 5.63 ± 1.53/preshooting test = 8.72 ± 0.71). Descriptive analysis of data showed that the mean (SD) age of the Serial group was 37.20 (±9.4) years, and the mean age of the Blocked group was 34.1 (±7.1) years.

There were no significant differences between groups for the pretest scores in the MIQ, and the shooting scores tests and homogeneous groups were assumed prior to the intervention.

Acquisition phase

Serial and Blocked data in nine sessions of the acquisition phase are normal ($p > 0.05$). The sphericity assumption is not valid ($p = 0.001$); thus Greenhouse-Geisser estimates of sphericity were used. Table 1 demonestrates the results of MANOVA analyses according to the modified Greenhouse-Geisser method. The interaction effect of CI and the session is significant ($p < 0.000$). There is a significant difference in the average scores of nine sessions ($p < 0.000$).

A lysergic acid diethylamide (LSD) post hoc analysis of the practice schedules' main effect indicated that the Blocked practice resulted in significantly better performance than the Serial practice schedule.

In order to compare the results further, the post hoc test was applied. The LSD test indicated that, although both groups showed significant improvement of performance over the acquisition phase,

Sorce	Sum of mean square type 2	df	Mean square	*F*	Sig.
Session	32,657.070	6.400	5,102.768	51.699	0.000
Session* CI	3,114.433	6.400	486.640	4.930	0.000

Table 1: Results of LSD test and interaction effects

Blocked groups showed a significantly higher sum in sessions two, three, five, six, seven, eight, and nine compared to the Serial one ($p < 0.05$). Figure 1 illustrates the results LSD testing has on the effect of Serial and Blocked practices on shooting performance.

Retention and transfer test

There were significant differences in the retention and transfer test between groups, thus ensuring that Serial setting is a good way to enhance the shooting skill (Table 2).

Discussion

Nearly 30 years ago, Shea and Morgan first reported that high rather than low amounts of CI benefits skill learning [23]. Many researchers followed this line of investigation by designing experiments to better understand this learning phenomenon [20]. But an important question remains concerning the introduction of the appropriate amount of CI in the practice schedule to optimize learning.

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 levels of CI.

The results of this study showed that the Blocked training was more effective in improving performance of the shooting skill during the acquisition phase. But in the retention test, the Serial group had greater scores than the Blocked one. In the transfer condition, although the result of the Serial practice was significantly better, because of the novel setting, the difference in scores was less. An increased contextual interference in practice appeared to allow participants to maintain a better performance in retention than in the low-contextual-interference condition wherein they practiced a more complex skill. These findings were similar to the results of the study by Bortoli *et al.* showing that a superior retention performance was found for the random and Serial practices compared with Blocked practice, in volleyball serves [16]. Keller *et al.* Results that the most complex skill among the three stages of air-pistol shooting, showed practicing in the Serial schedule depressed performance during initial training but maintained the performance better at retention, relative to the Blocked practice [4].

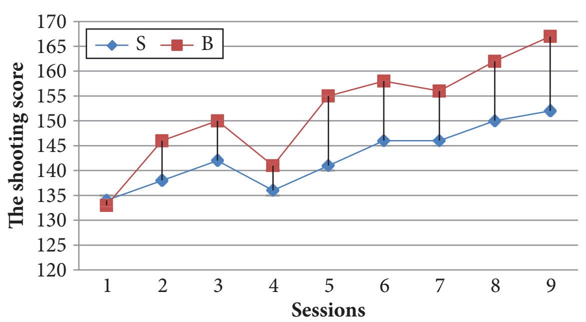

Figure 1: Comparison of Blocked (b) and Serial practice (s) in each session

	Retention test		Transfer test	
	Mean (SD)	Sig.	Mean (SD)	Sig.
Blocked	309.76 ± 24.27	0.000	82.93 ± 7.74	0.015
Serial	328.6 ± 13.46		88.06 ± 8.1	

Table 2: Results of the retention and transfer tests

Our findings showed a compatible tendency that practicing a closed skill in a natural setting could be enhanced by moderate contextual-interference practice schedules. According to the performer, Serial practice would lead the learner to compare task variations, increasing the similarities and differences between them in memory. This process would occur during the interval between trials and would allow the learner to formulate a more precise representation of the motor skill. In turn, the action-plan reconstruction hypothesis states that Serial practice would increase the cognitive effort, since the information about a particular task would be forgotten completely or partially—because of contextual interference—leading to the necessity of reconstructing action plans in subsequent trials instead of repeating a preexisting one [7].

Barreiros *et al.* had analyzed 27 studies on applied-practice research in the CI field. They found that either the experimental organization, in general, was not adequate to illustrate the expected effect, or it did not exist at all. But in the case of Serial practice, a possible reason is that Serial tasks, with several elements in a prescriptive order, may benefit from changing conditions from trial to trial. As a consequence, deeper elaboration and extra distinction between variations of the task can facilitate adaptation to transfer conditions [8].

There is one point that should be noted: the learner's ability or inability to process information efficiently. Aloupis and colleagues proposed a theory based on the chunking models of Newell and Rosenbloom (1981) [30]. These models suggest that one's information-processing ability is limited, and the amount of information that one is able to process at any given time cannot be increased, but the efficiency of processing information can be improved [31]. Therefore in this study, we call all the shooters to the second stage of learning. In that phase, performers tried to correct their mistake instead of building a new version of their skill. Guadagnoli *et al.* and Hebert *et al.* provided evidence that presenting high levels of CI to a novice can be overwhelming and lead to degraded performance on retention and transfer tests. Their results suggest that when a learner is presented with a challenging task, the inefficiency of the information-processing system may not interpret needed information [25,32]. This inefficiency may be compounded when the tasks are practiced in a high-CI schedule [33].

Another benefit of increasing the amount of CI during practice is that the learning experiences during acquisition would not allow a "context dependency" to develop, which is one of the drawbacks of practicing with lower levels of CI. This type of practice schedule would also give the performer the needed experience that is needed, so the benefits of higher levels of CI can be noticed later in practice [8].

On the other hand, Guadagnoli and Lee provide a plausible explanation for why gradual increases in CI during practice promote a more effective learning environment than fixed amounts of CI [25]. "Challenge Point Hypothesis" suggests that consistently challenging learners at the appropriate level during practice creates an optimal learning environment. To consistently challenge learners at the desirable level during practice, the practice environment should become progressively more difficult as the learner becomes more skilled. Offering gradual increases in CI is one way to progressively increase the difficulty of the practice environment, which is needed to appropriately challenge learners as their skill is developed [21].

However, a precaution has to be stated because limitations of the current study were noticeable, such as the smallness of the sample tested. Undoubtedly, further investigations are required before a strong conclusion could be made.

Conclusion

In naturalistic settings, a tremendous diversity of variables combine in unpredictable ways, generating peculiar effects. The constraints of naturalistic sets make it very difficult to create the optimal conditions needed to generate and assess learning effects, such as the contextual-interference effect [8]. Results of the present investigation have significant implications for the importance placed on Serial practice as a good method to create enough contextual interference to enhance learning. Indeed, in nonlaboratory setting, because of the variability of the environment, a high level of CI usually doesn't work well, but it seems that increasing the CI systemically worked.

High amounts of CI can overwhelm a learner, creating a poor learning environment; it has also been suggested that low amounts of CI can create an equally poor learning situation. If the learner experiences minimal variability during practice, he or she has limited opportunity to adjust to novel experiences which may occur on future attempts. Therefore, according to the finding, we suggest the Serial practice as an effective method to create an appropriate CI in a realistic setting.

Acknowledgment

I gratefully acknowledge the support for this work received from the Department of Physical Education and Sport Sciences of Tarbiat Modares. Also, I wish to thank the shooters who helped us in this project.

References

1. Luft CDB (2014) Learning from feedback: the neural mechanisms of feedback processing facilitating better performance. Behav Brain Res 261: 356-368.
2. Newell KM, McDonald PV (1991) Practice: a search for task solutions. In: Christina R, Eckert H, eds. Enhancing Human Performance in Sport: New Concepts and Developments. Champaign, IL:Human Kinetics, pp. 51-60.
3. Schmidt RA, Lee T (2005) Motor Control and Learning: A Behavioral Emphasis (4th edn.). Champaign, IL: Human kinetics.
4. Keller GJ, Li Y, Weiss LW, Relyea GE (2006) Contextual interference effect on acquisition and retention of pistol-shooting skills. Percept Mot Skills 103(1): 241-252.
5. Magill RA, Hall KG (1990) A review of the contextual interference effect in motor skill acquisition. Hum Mov Sci 9(3): 241-289.
6. Brady F (1998) A theoretical and empirical review of the contextual interference effect and the learning of motor skills. Quest 50(3): 266-293.
7. dos Santos JJ, Bastos FH, de Oliveira Souza T, Corrêa UC (2014) Contextual interference effect depends on the amount of time separating acquisition and testing. Adv Phys Educ 4: 102-109.
8. Barreiros J, Figueiredo T, Godinho M (2007) The contextual interference effect in applied settings. Eur Phys Educ Rev 13(2): 195-208.
9. Shewokis P, Snow J (1997) Is the contextual interference effect generalizable to non-laboratory tasks. Res Q Exerc Sport (Abstracts of completed research) A-64: 68.
10. Goode S, Magill RA (1986) Contextual interference effects in learning three badminton serves. Res Q Exerc Sport 57(4): 308-314.
11. Wrisberg CA, Liu Z (1991) The effect of contextual variety on the practice, retention, and transfer of an applied motor skill. Res Q Exerc Sport 62(4): 406-412.
12. Gholhaki MR, Beni MA, Fahimi M, Sadegheyan H, Alimardani A (2012) Effect of contextual interference on anxiety and achievement motivation in acquisition and retention of selected badminton skills. J Am Sci 12: 8.
13. Smith PJ, Davies M (1995) Applying contextual interference to the Pawlata roll. J Sports Sci 13(6): 455-462.
14. Boyce B, Rey P (1990) Designing applied-research in a naturalistic setting using a contextual interference paradigm. J Hum Mov Stud 18(4): 189-200.
15. Feghhi I, Valizadeh R, Rahimpour M, Tehrani MA, Karampour S (2015) Contextual interference in learning three table tennis services. Proc Social Behav Sci 191: 546-549.
16. Bortoli L, Robazza C, Durigon V, Carra C (1992) Effects of contextual interference on learning technical sports skills. Percept Mot Skills 75(2): 555-562.
17. Hall KG, Domingues DA, Cavazos R (1994) Contextual interference effects with skilled baseball players. Percept Mot Skills 78(3): 835-841.
18. Tsutsui S, Lee TD, Hodges NJ (1998) Contextual interference in learning new patterns of bimanual coordination. J Motor Behav 30(2): 151-157.
19. French KE, Rink JE, Werner PH (1990) Effects of contextual interference on retention of three volleyball skills. Percept Motor Skills 71(1): 179-186.
20. Brady F (2004) Contextual interference: a meta-analytic study 1. Percept Motor Skills 99(1): 116-126.
21. Porter JM, Magill RA (2010) Systematically increasing contextual interference is beneficial for learning sport skills. J Sports Sci 28(12): 1277-1285.
22. Andrieux M, Boutin A, Thon B (2015) Self-Control of task difficulty during early practice promotes motor skill learning. J Mot Behav 2016;48(1):57-65.
23. Magill RA (2007) Motor Learning and Control: Concepts and Applications (8th edn.). New York: McGraw Hill.
24. Yanci J, Reina R, Los Arcos A, Cámara J (2013) Effects of different contextual interference training programs on straight sprinting and agility performance of primary school students. J Sports Sci Med 12(3): 601.
25. Guadagnoli MA, Lee TD (2004) Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. J Mot Behav 36(2): 212-224.
26. Boyce BA, Coker CA, Bunker LK (2006) Implications for variability of practice from pedagogy and motor learning perspectives: finding a common ground. Quest 58(3): 330-343.
27. Jeffreys I (2006) Motor learning—applications for agility, part 1. Strength Cond J 28(5): 72-76.
28. Farrow DT (1995) Effects of Contextual Interference on Children Learning Forehand Tennis Groundstrokes. Deakin University.
29. Hall CR, Martin KA (1997) Measuring movement imagery abilities: a revision of the Movement Imagery Questionnaire. J Ment image 21: 143-154.
30. Newell A, Rosenbloom PS (1981) Mechanisms of skill acquisition and the law of practice. In: Anderson JR, ed. Cognitive skills and their acquisition. Hillsdale, NJ: Erlbaum, pp. 1-55. ISBN 0-89859-093-0.
31. Aloupis CH (1995) Manipulations of Task Switches During Acquisition: A Test of the Elaboration Hypothesis of Contextual Interference. Las Vegas: University of Nevada.
32. Hebert EP, Landin D, Solmon MA (1996) Practice schedule effects on the performance and learning of low-and high-skilled students: an applied study. Res Q Exerc Sport 67(1): 52-58.
33. Shea CH, Kohl R, Indermill C (1990) Contextual interference: contributions of practice. Acta Psychol 73(2): 145-157.