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A Comparison of Three Practice Schedules Along the Contextual Interference Continuum

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The organization of practice sessions is recognized as one of the most important functions teachers and coaches perform (Silverman, 1990; Vickers, 1990). However, as noted by Newell and McDonald (1992), despite considerable interest among researchers and practitioners, clear guidelines for organizing practice sessions have yet to be formulated. Magill (1992) has argued that the practice schedule research provides a knowledge base from which guidelines can be developed. This research, ongoing for over a decade, has compared the effects of practice schedules, which represent levels of contextual interference, on the performance and learning of motor skills. Predominately laboratory based, this research has produced an impressive set of findings (for a review, see Magill & Hall, 1990). However, replication of these findings in applied settings has been difficult, and questions regarding the applicability of contextual interference have been raised (Newell & McDonald, 1992).

The Contextual Interference Continuum

Contextual interference (CI) originated in verbal learning research and refers to the relative amount of interference created when practicing two or more tasks (Shea & Morgan, 1979). The amount of CI within a practice session is determined by how the tasks are integrated. In a low CI arrangement, skills are practiced individually, while a high CI schedule involves the simultaneous practice of multiple skills. For example, a volleyball unit is likely to include skills such as serving, passing, and setting. A low CI schedule would consist of practicing one skill at a time, while high CI practice would involve drills combining the three skills.

The motor learning literature is replete with studies comparing high CI and low CI practice schedules, and the results consistently show that skill acquisition is enhanced by high CI practice (Magill & Hall, 1990). Specifically, high CI schedules tend to depress performance during practice but then lead to greater learning, as indicated by retention or transfer tests. The reverse of this pattern is associated with low CI practice. As Magill (1993, p. 231) put it, low CI practice creates a "context dependency" that hampers performance on variations of the task or when the context of the performance is altered. Conversely, high CI allows the learner to adapt to these fluctuations.

While laboratory-based results have been, as Magill and Hall (1990, p. 249) pointed out, "remarkably consistent in demonstrating the CI effect," applied CI research has produced equivocal results. Some studies reported strong benefits (e.g., Hall, Domingues, & Cavasos, 1994), others have yielded mixed findings (Bortoli, Robazza, Durigon, Carra, 1992; Goode & Magill, 1986; Hebert, Landin, & Solmon, 1996; Wrisberg, 1991; Wrisberg & Liu, 1991), while others reported little or no benefits (French, Rink, & Werner, 1990).

One possible explanation for the equivocal findings is the Magill and Hall (1990) notion of a CI continuum based on the skill level of the learners. Magill and Hall argued that the difficulty of high CI practice overwhelms learners in the early stages of skill acquisition and that the learner needs some degree of proficiency before the benefits of high CI are realized. It is well accepted that the benefits of low CI practice stem from the learner's

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opportunity to test minor adjustments in technique from trial to trial, while the benefits of high CI can be attributed to the elaboration or reconstruction of a motor plan (Lee & Magill, 1985; Shea & Zimny, 1983). If the relative benefits of each practice schedule is mediated by skill (i.e., the advantages of blocked practice outweigh those of random practice for beginners while the opposite holds true for moderately skilled learners), then a proficiency-based continuum emerges. Supporting this notion are indications that low CI conditions enhance learning for children or low-skilled performers, while high CI becomes beneficial only after a certain skill has been attained (Del Rey, Whitehurst, & Wood, 1983; Pigott & Shapiro, 1984). Further support comes from laboratory-based research (Del Rey, 1989; Del Rey, Wughalter, & Whitehurst, 1982; Magill, 1992; Shea, Kohl, & Indermill, 1990; Shea & Zimny, 1983) and a recent applied study (Hebert et al., 1996).

Magill and Hall (1990) alluded to another factor which may contribute to the difficulty in replicating laboratory-based findings in applied settings and that is a reliance on the extremes of the continuum (i.e., random and blocked). Due to variations in learner characteristics, the complexity of most sport skills, and the managerial difficulty associated with implementing random schedules (French et al., 1991) it seems plausible that a level of CI which falls near the center of the continuum may be more suitable in applied settings.

Two reports in the literature have employed moderate CI levels during practice. Pigott and Shapiro (1984) and Proteau, Blandin, Alain, and Dorion (1994) had participants practice an underhand toss and a barrier knockdown task, respectively, on schedules that were blocked (low CI), random (high CI), or at a moderate level of interference (labeled random-blocked or blocked repeated). Although having drawn participants from vastly different populations—elementary school children in Pigott and Shapiro, whereas Proteau et al. used college students—both studies reported that the moderate CI condition was superior. Proteau et al. attributed this superiority to the notion that the moderate schedule combined the best of the high CI and low CI schedules. That is, it allowed repeated trials under one condition, which facilitated error correction but also provided the interference of changing tasks. The results of these two studies appear to have considerable implications for applied research. If moderate CI enhances the learning of relatively simple laboratory skills, it seems logical that it would also benefit the learning of sport skills.

Therefore, it is the purpose of this study to continue a line of research examining the generalizability of laboratory-based CI research to applied settings. Our hypothesis is that due to variations in learner characteristics and task difficulty, a moderate level of CI will prove to be most beneficial and produce the greatest amount of learning. Specifically, this experiment compares the traditional practice schedules (high CI and low CI), with one characterized by a moderate level of interference, on the acquisition and learning of a sport skill.

Method

Participants

Undergraduate college students (N= 30; 15 women and 15 men; Mage = 20.5 years, SD = 1.4) recruited from a university student population agreed to participate through informed consent. Inclusion criteria were 2 years of high school basketball experience and no intercollegiate competition. These criteria were used to control for skill level, which, as discussed earlier, is a factor influencing CI effects. Thus, these participants represented those typical to most instructional settings, falling somewhere between the extremes of beginner and advanced players.

Task

We selected the basketball set shot as the task. Six positions, varying in distance and angle to the basket, were numbered 1 through 6 and identified by nonskid rubber mats placed on the floor (see Figure 1).

Procedure

On Day 1, the participants were pretested under blocked conditions from Positions 2, 3, and 4. The pretest consisted of 15 trials, 5 from each position. Scores

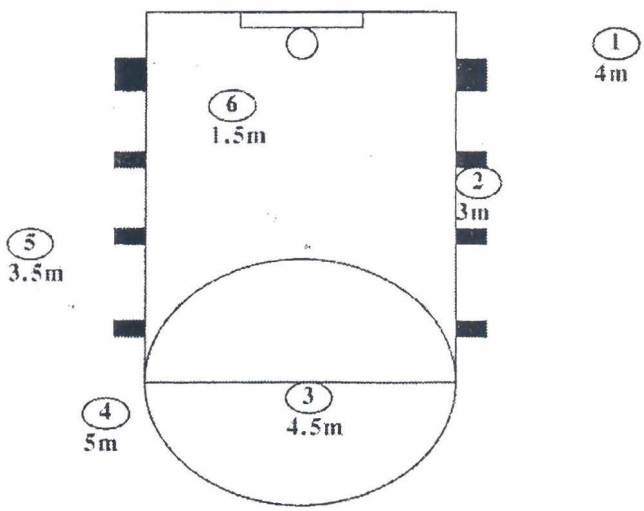

Figure 1. Diagram of shooting positions.

from the pretest (percent of successful trials) became the basis for assigning participants to one of three practice schedules: low, moderate, and high CI.

Days 2 through 4 comprised the practice phase during which each participant performed 30 trials per day, 5 from each position, in accordance with their practice schedule assignment. Participants assigned to the low CI condition performed six successive trials from each position. Those practicing under the moderate CI schedule performed three successive trials at each location and repeated the sequence twice. The third condition was high CI, which involved performing one trial per position in a serial arrangement and repeating the sequence six times.

On Day 5, learning was assessed through three counterbalanced retention tests: (1) a 12-trial blocked test from Positions 2, 3, and 4, (2) a 12-trial serial test from the same three positions, and (3) a 10-trial free-throw test performed in 2-trial sequences separated by brief intervals. The dependent measure for practice and posttest data was the percent of successful trials.

Results

Practice

Practice data were analyzed using a 3 x 3 (Practice Condition x Days) repeated measures analysis of variance (ANOVA). This analysis revealed only a significant effect for days, $F(2, 54) = 3.67$, $p < .05$, which signaled improvement over time. Neither the condition effect, $F(2,27) = 2.53$, $p < .10$, nor the Day x Condition interaction, $F(4,54) = 1.53$, $p = .21$, were significant. Practice data indicated, however, that the moderate CI group ($M = .52$, $SD = .14$) had the highest percentage of successful trials, followed by the low CI group ($M = .45$, $SD = .11$) and high CI group ($M = .40$, $SD = .16$).

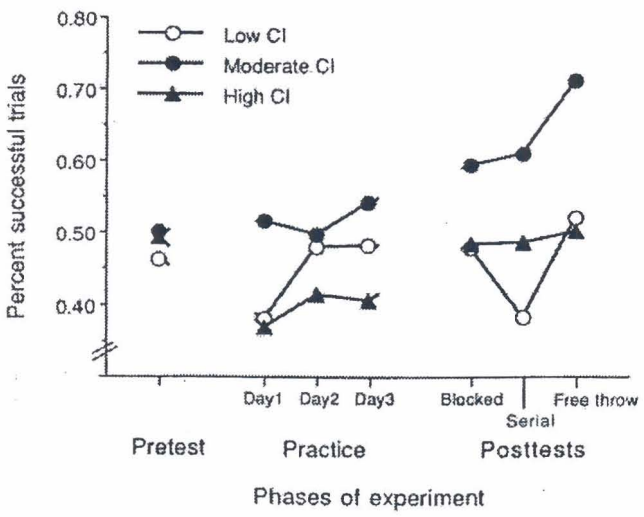

Figure 2. Test results.

Posttests

Test scores were analyzed using a 3 x 3 (Practice Condition x Test) ANOVA which revealed significant main effects for both practice condition, $F(2, 27) = 4.16$, $p < .05$, and test, $F(2,54) = 3.46$, $p < .05$. Follow-up analysis of the practice condition effect was performed using the Student-Newman-Keuls procedure ($p < .05$). This post hoc analysis revealed that the moderate CI group ($M = .64$, $SD = .16$) had significantly higher scores than the other two groups which did not differ (high CI group: $M = .49$, $SD = .20$; low CI group: $M = .46$, $SD = .18$) (see Figure 2).

Discussion

Attempts to replicate the results of laboratory-based CI research in applied settings have produced somewhat inconsistent findings and contribute to concerns regarding the generalizability issue addressed by Magill and Hall (1990). We suggested that one factor limiting the applicability of laboratory-based CI research is the exclusive focus on the extremes of the CI continuum. This view is supported by two laboratory-based experiments, which reported findings suggesting that a moderate level of CI may offer advantages equal to and possibly greater than those associated with the random and serial schedules typically used to operationalize high CI (Pigott & Shapiro, 1984; Proteau et al., 1994).

In the present study, we examined the effects of three schedules, along the CI continuum, on the acquisition and learning of a basketball shooting task. Participants practiced the basketball set shot for 3 days under low, moderate, or high CI. Performances for all three groups improved during the acquisition phase of the study, with the moderate CI group showing the most improvement. However, we found no significant differences attributable to practice condition. This result is contrary to laboratory research (which most often reports an advantage of low CI practice during acquisition) but parallels the results of most applied CI research (e.g., Bortoli et al., 1991; Goode & Magill, 1986; French et al., 1990; Hebert et al., 1996; Wrisberg, 1991).

More important, however, are the results of the posttests, which revealed a significant advantage for moderate CI over the other two conditions. This finding adds to the evidence that moderate levels of CI may be superior to the extreme ends of the interference

continuum (Pigott & Shapiro, 1984; Proteau et al., 1994). Although research involving moderate CI is scarce, the results are consistent. Proteau et al. suggested that moderate CI may be superior, because it combines the best features of high and low levels of interference. The moderate schedule, with its repeated trials per position, afforded participants the opportunity to make adjustments on each task, yet still offered the learning advantages associated with higher levels of interference by requiring them to perform several tasks during each practice session.

These results, in combination with those of Pigott and Shapiro (1984) and Proteau et al. (1994), suggest a reconsideration of the conclusion that practice schedules representing high CI are best. Further, it is possible that by focusing exclusively on the extremes of the CI continuum, researchers have ignored schedules which may be more advantageous. Pigott and Shapiro (1984) touched on this notion in their discussion when they suggested that there appeared to be an optimal way to structure practice, which included "...selecting an appropriate number of repetitions before random changes..." (p. 44). These results suggest that the optimal schedule along the CI continuum may be determined by the learner's level of proficiency.

As mentioned in the introduction, several characteristics of applied settings favor a moderate level of CI. Most obvious are the differences in the task environment and the range in skill levels. Laboratories are strictly controlled environments, wherein nearly all possible confounding variables are repressed. This is not true in applied settings, where a myriad of factors influencing performers occur freely and interact differentially from one task to another. If task complexity can magnify the difficulty of a high CI condition, it seems reasonable to suspect that the complexity of the practice environment can also. Therefore, the moderate schedule may be best, because it provides learners with the opportunity to adjust to environmental as well as task variables.

A second feature typical of applied settings is that a wide range of ability levels are likely to be present. Most practitioners work with learners who do not possess skill levels that would be considered elite. Our results suggest that teachers and coaches working with nonelite performers could, by incorporating a moderate level of CI into the drills, create a practice environment beneficial to a wide range of skill levels.

In summary, our results offer evidence for the value of moderate levels of CI for learning sport skills, corroborate findings from most previous applied research, and reveal potential avenues for further study. Most evident is the need to explore schedules along, rather than at the extremes of, the CI continuum and to attempt to determine the mechanisms underlying the advantages of different practice conditions. Second, more research is needed which examines how basic research conclusions may be operationalized and implemented for training complex movement tasks. Finally, concerns over factors which influence practice schedule effects, such as the between- versus within-movement class debate, children versus adult subjects, and a focus on the middle stages of learning, have been expressed (Newell & McDonald, 1992). These questions have yet to be adequately addressed, because little practice schedule research has involved children or examined the impact of task similarity and stage of learning.

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