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The Effects of Variable Practice on the Performance of a Basketball Skill

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Since the proposal of the schema theory of motor learning (Schmidt, 1975, 1976), researchers have shown interest in its variability of practice (VP) hypothesis. According to this hypothesis, transfer of learning between variations of a skill, governed by the same motor program, will be enhanced with increased practice variability. That is, by practicing many variations of a skill, a learner will perform novel versions more effectively. For the practitioner, the VP hypothesis could be applied to skills in which novel variations are encountered during performance, such as field goal kicking in the game of football.

The paradigm most frequently used in testing the VP hypothesis has one group of subjects practice a single form of a task while another group practices several variations. Then all subjects are given a transfer test, a posttest on a novel variation of the task not previously practiced. The results generally, but not entirely, support the view that VP enhances transfer performance. Most VP studies (Carson & Wiegand, 1979; Catalano & Kleiner, 1984; Lee, Magill, & Weeks, 1985; Moxley, 1979; Newell & Shapiro, 1976; Wrisberg & Ragsdale, 1979) reported results that support the VP hypothesis; some, however (Johnson & McCabe, 1982; Zelaznik, 1977), found that VP did not enhance transfer. Furthermore, inconsistent findings have also been obtained within the same experiment. That is, VP enhanced performance on some transfer tests but not others (Lee et al., 1985; Newell & Shapiro, 1976).

A second posttest, used less frequently, is a retention test. This is a test of a practiced version of the skill. Although the effect of VP on retention performance was not included in original schema theory predictions, an early study (Carson & Wiegand, 1979) found that VP also facilitated retention of a practiced form of the skill. Again, however, the support is equivocal; Johnson and McCabe (1982) reported that criterion practice was superior to VP on their retention test, and Wrisberg (1992) reported that VP facilitated performance on one retention test but not on another.

Recently, Shea and Kohl (1990, 1991) have taken a somewhat different approach to the study of the VP. These authors contrasted the effects of VP and specific practice on retention. Specific practice is based on the "specificity of learning principle" (Adams, 1971; Henry, 1960), which holds that practice should be on skills identical to those anticipated in subsequent games or tests. Changing a skill, even slightly, results in a new motor skill.

In their first paper, Shea and Kohl (1990) conducted two experiments in which subjects practiced a force production task, under either specific or variable practice conditions. In these two experiments subjects in *specific* groups practiced exerting only one criterion force (175 N). Subjects in *specific + variable* groups also practiced exerting the criterion force; however, between these trials they practiced exerting forces greater and less than 175 N. One day after practice, subjects were given a retention test at 175 N. In both experiments, the *specific + variable* group performed better on the retention test, particularly on the initial trials. Thus, subjects who practiced under variable conditions, which included the criterion task, performed better on a retention test than subjects who practiced only the criterion task.

In a follow-up paper, Shea and Kohl (1991) again conducted two experiments, using a similar task, to explore the effects of various intervening activities on retention performance. Subjects again practiced under either specific or specific + variable conditions. In the first experiment, between criterion trials, one group received additional trials at 150 N, a second group practiced exerting variable forces, and a third group practiced an unrelated task. The retention test results showed

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that the group that practiced exerting variable forces between criterion trials performed best.

The second experiment focused on the effect of the number of variable tasks practiced between criterion trials. Between trials at 150 N, subjects had either zero, one, or three trials at variable forces. Results of the subsequent retention test showed that practicing either one or three variable forces between criterion trials was better than specific practice alone.

Taken together, the Shea and Kohl experiments suggest variable practice that includes the criterion skill leads to better performance on a retention test than specific practice. Although these results raise some intriguing questions regarding the practice regimens used in sports that have criterion skills (e.g., basketball foul shooting, tennis serving, extra-point kicking in football), the generalizability of this research is limited by the use of simple laboratory tasks. Shea and Kohl (1990) recommend contrasting variable and specific practice with actual sport skills as a logical extension of their work.

The purpose of our study was twofold: (a) to explore the generalizability of the Shea and Kohl practice paradigm with a real work skill and (b) to test the generalizability of the original VP hypothesis. We used a design similiar to that of Shea and Kohl (1990) to investigate the effects of specific and variable practice on the learning, and subsequent performance, of the basketball set shot. Based on the findings of Shea and Kohl (1990), it was predicted that variable practice, which included the criterion skill, would result in greater retention performance than specific practice alone. Transfer performance was also assessed following variable or blocked practice. The VP hypothesis predicts that transfer performance would be better following variable rather than blocked (i.e., specific) practice.

Method

Subjects and Setting

Female university students ($N = 28$, $M = 20.57 \pm 2.01$ years) registered in physical education activity classes volunteered for the study and received course credit for their participation. All subjects were right-handed and had no prior basketball experience. Informed consent was obtained from the subjects before the start of the study. The practice phase and the retention and transfer tests were conducted in a university gymnasium.

Apparatus and Task

The skill selected for the study was the basketball set shot, which, during practice, was performed from a position perpendicular to the backboard. The three shooting positions used in practice were marked onto the court (see Figure 1): the criterion distance, 12 ft (3.6 m) from the front of the rim, and two variable distances, 8 and 15 ft (2.4 and 4.5 m). All subjects used an official NCAA women's basketball. The goal of each attempt was to "swish" the ball through the rim. Scores were kept according to a system developed by Wallace and Hagler (1979), shown in Table 1.

Procedure

Subjects were divided into two groups differentiated by practice schedule. The *specific* group (SP) practiced from only the criterion distance, 12 ft (3.6 m), whereas the *specific + variable* group (SP + VR) practiced from the criterion distance, as well as the two variable distances, 8 and 15 ft (2.4 and 4.5 m).

Each subject received 120 practice trials spread equally over three days (Monday, Wednesday, and Friday) and was given two posttests on the following Monday. At the start of each session, subjects read a written description of the procedures and scoring system. Subjects then watched a videotape containing verbal instructions and five demonstrations of the skill by an expert performer. The model was a male expert performer who shot from the criterion distance and provided an example of the traditional method of foul shooting. The videotape contained both anterior and right lateral views of the model. The demonstrations were accompanied by a voice-over highlighting the key elements of the movement. Subjects were able to see only the shooting motion, not the outcome of the shot, and were encouraged to mimic the model's movement pattern.

Following these preliminary instructions, subjects were given warm-up attempts to minimize the *warm-up decrement.* Warm-up decrement, a phenomenon characteristic of nearly all motor tasks (for a review, see Adams, 1961), is described as a drop in performance following long rest periods. Research indicates that this warm-up decrement can be reduced by a few practice trials (Schmidt, 1988). Therefore, to reduce the warm-up decrement induced by the interim periods, the subjects were given five warm-up attempts each day, which

Table 1. Scoring system

Score	Description
1	Ball misses rim completely or hits backboard first.
2	Ball hits the outside of the rim and bounces away from the basket.
3	Ball hits on the top of the rim; would fall in or out of the basket.
4	Ball hits on the inside of the rim and would most often fall through the basket.
5	Ball passes cleanly through the basket without touching the rim.

consisted of shooting the ball against a wall from a distance of 1.5 m.

Following the warm-up activity, the subjects then performed 40 trials on each practice day. The SP group shot all 120 practice trials from the criterion distance, whereas the SP + VR group's 120 trials consisted of 40 trials from each distance, in random order. The score for each trial was announced and recorded by an assistant. For the SP + VR subjects, the outcome score was followed by directions regarding the position of the next trial. All subjects were given a brief rest period after 20 trials.

Seventy-two hours after the third practice session the subjects were administered two posttests, retention and transfer, with the order of testing counterbalanced. The retention test consisted of 10 trials from the criterion distance, whereas the transfer test consisted of 10 trials from a different distance and location relative to the backboard (see Figure 1).

The selection of this transfer test was guided by the conclusion of Wrisberg, Winter, and Kuhlman (1987) that the more similar practice conditions are to transfer conditions, the lower the probability is of finding superior performance following variable practice. Previous research has generally found that transfer to dissimilar versions of a task is enhanced by VP (Carson & Wiegand, 1979; Catalano & Kleiner, 1984; Johnson & McCabe, 1982; Lee et al., 1985; Moxley, 1979; Wrisberg & Ragsdale, 1979), whereas transfer to tasks that are similar to practiced versions revealed no difference between groups (Catalano & Kleiner, 1984; Husak & Reeve, 1979; Lee et al., 1985). Therefore, to test the transfer ability of the groups in the present experiment, a transfer test was selected that required adjustments for both distance and visual display.

Results and Discussion

Practice

Only those practice trials performed from the criterion distance were analyzed (Note 1). These trials were grouped into blocks of five, resulting in eight practice blocks, for which means were calculated. Practice blocks were analyzed with a 2 x 8 (Group x Trial Block) ANOVA with repeated measures on the last factor. The effect for trial block, $F(7, 182) = 3.21$, $p < .01$, was significant, indicating improvement over practice (see Figure 2). The Geisser–Greenhouse ($\varepsilon = .83$) adjustment did not alter this significant trial block effect ($p < .01$). However, neither the group effect, $F(1, 26) = .08$, $p > .05$, nor the Group x Trial Block interaction, $F(7, 182) = .49$, $p > .05$, were significant.

Most VP studies report that subjects who practiced only one version of the task perform better in acquisition than those who performed many versions (Lee et al., 1985; Pigott & Shapiro, 1984; Shea & Kohl, 1990 [Experiment 2], 1991; Wrisberg et al., 1987). However, this is not always the case; other studies have found that the acquisition performance of variable and criterion groups is similar (Christina & Merriman, 1977; Moxley, 1979; Shea & Kohl, 1990, Experiment 1). Results from the practice data of our study showed that the groups performed similarly.

Retention Test

Retention data were grouped into two blocks of five trials, and means were calculated. Overall retention performance was analyzed with a 2 x 2 (Group x Trial Block)

Figure 1. Location of trials for practice, retention, and transfer.

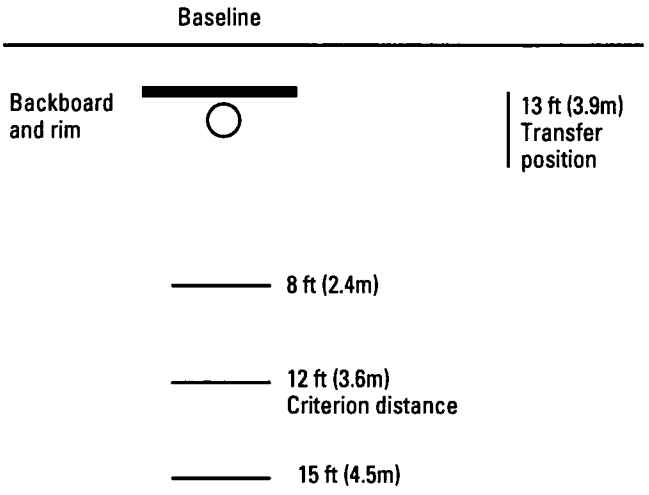
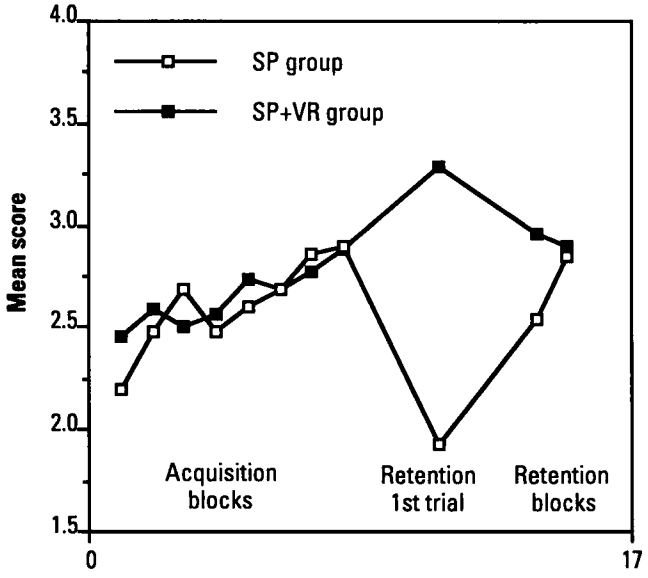


Figure 2. Acquisition and retention performance for *specific* (SP) and *specific + variable* (SP + VR) groups.



Note. Maximum possible score = 5.

ANOVA with repeated measures on trial block. In addition, because basketball players typically have only one attempt at a shot at any given moment, the first trial was analyzed using an independent *t*-test (Note 2).

The *t*-test performed on the first trial, $t(26) = 3.61$, $p < .01$, indicated that the SP + VR group scored higher than the SP group (see Table 2). The magnitude of this difference, determined by effect size, was large (ES = 1.0) and indicated that the SP + VR group scored, on average, one standard deviation above the SP group.

The ANOVA revealed no significant effects for trial block, $F(1, 26) = .81$, $p > .05$, or Group x Trial Block interaction, $F(1, 26) = 1.76$, $p > .05$. The main effect for group, $F(1, 26) = 2.24$, $p > .05$, also failed to reach significance; however, group differences were in the predicted direction (see Figure 2).

The results of the analysis of the first trial support the findings of Shea and Kohl (1990) and demonstrate the generalizability of their practice paradigm to settings beyond the laboratory. This initial advantage of the SP + VP group on retention performance takes on added importance because of the nature of game situations in sports. Free throw shooting in basketball involves one or two attempts at any given moment. Practice of such criterion skills (e.g., basketball free throw shooting, tennis serving, etc.) is traditionally blocked; however, the results of this study and those of Shea and Kohl (1990) suggest that blocked practice may not be the best choice.

The most appropriate evaluation of a practice schedule is its effects on subsequent test/game performance, a position taken by several motor learning theorists (Bransford, Franks, Morris, & Stein, 1979; Lee, 1988; Magill, 1992; Morris, Bransford, & Franks, 1977). For game situations, the preferred practice schedule would be that which facilitates performance on the initial trial(s) of the test. Although several researchers (Carson & Wiegand, 1979; Husak & Reeve, 1979; Moxley, 1979) have recommended a variable schedule for practicing sport skills, until recently the empirical evidence has not supported this position. However, Shea and Kohl (1990, 1991) and the findings of our study offer evidence that suggests that VP, which includes the criterion skill, promotes initial retention performance. As such, the results of our study indicate that some practice schedule conclusions from laboratory research have generalizability to sport settings.

Transfer Test

Transfer data were analyzed in a manner similar to that of retention. Neither the *t*-test performed on the first trial of transfer, $t(26) = 1.07$, $p > .05$, nor the 2 x 2 (Group x Trial Block) ANOVA revealed any significant differences between groups, $F(1, 26) = .20$, $p > .05$ (see Table 2). However, the effect for trial blocks, $F(1, 26) = 11.18$, $p < .01$, indicated that performance improved over trial blocks. The Groups x Trial Blocks interaction was not significant, $F(1, 26) = 1.70$, $p > .05$.

Schmidt's (1975) schema theory predicts that greater variability in practice should lead to better transfer test performance. Although several studies have reported that VP did enhance transfer performance, other studies have provided evidence to the contrary. The results of the present experiment indicate that, for this basketball skill, variable practice was not better than practicing only one version in promoting performance on this particular transfer test.

The transfer test employed in this study was a baseline set shot, which represented a change in both distance and visual display. The latter change apparently had a negative effect on the performance of both groups: both groups' transfer performance was markedly worse than in practice. Wrisberg et al. (1987) concluded from laboratory research that VP facilitates transfer performance when practice and transfer tasks are dissimilar. However, little research has examined transfer effects in sport environments. The two practice schedule studies that used sport skills and found positive transfer effects involved transfer tasks that were similar to those in practice (Goode & Magill, 1986; Wrisberg & Liu, 1991). The results of the present experiment suggest that when the transfer conditions are different from practice conditions, neither practice schedule is superior, nor effective, in enhancing transfer performance. This may indicate that, for gross motor skills found in sports, similarity between practice and transfer tasks is necessary.

Table 2. Retention and transfer means and standard deviations (in parentheses)

	Retention			Transfer		
Group	1st Trial	Block 1	Block 2	1st Trial	Block 1	Block 2
SP + VR	*3.29 (1.00)	2.93 (.51)	2.90 (.47)	1.93 (0.65)	2.06 (.52)	2.26 (.62)
SP	*1.93 (0.99)	2.69 (.59)	2.84 (.59)	1.57 (1.07)	2.01 (.61)	2.49 (.63)

Note. Maximum possible score = 5.
*$p < .01$.

Conclusion

This investigation sought to evaluate the generalizability of a variable practice paradigm (Shea & Kohl, 1990), designed for laboratory research, to a sport skill. The results indicate that performance on initial trials of a retention test was better following variable rather than specific practice. This suggests that a variable practice schedule, which includes a criterion skill, may be better than blocked practice. Further research in this area could replicate the Shea and Kohl design with other sports that involve criterion skills (e.g., badminton and tennis serving, extra-point kicking in football, archery).

Regarding the transfer test results, the findings suggest that neither practice schedule was superior. However, changes in the visual display for the transfer test appeared to have a detrimental effect on the performance of both groups, an influence that was unexpected. The visual displays surrounding sport skills change considerably as the performer's position relative to the court, or goal, changes. Our findings suggest that practice schedules may need to involve variations in the visual display as well as variations in the distance from which skills are practiced. Future research into practice schedule effects should include a variety of transfer tests to develop a better understanding of transfer of learning (Note 3).

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Notes

1. Following the procedures used by Shea and Kohl (1990, 1991), only those practice trials performed from the criterion distance were analyzed. From the first two practice sessions, criterion trials were numbers 2, 3, 5, 7, 15, 19, 20, 21, 23, 26, 27, 28, 30, and 37. In the third practice session, criterion trials were numbers 2, 3, 5, 7, 15, 19, 20, 21, 23, 26, 27, and 28.
2. Analysis of both the first trial, and trial blocks, of retention and transfer was included. This analysis is similar to that of Shea and Kohl (1990).
3. It should be noted that the transfer distance was similar to the criterion distance. The CR group received 120 acquisition trials at this similar criterion distance, whereas the VR group received only 40 trials. This difference in the number of similar acquisition trials may have been a factor affecting transfer performance.

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