

## **A Field Test of the Effect of Contextual Variety During Skill Acquisition**

**Craig A. Wrisberg**

The University of Tennessee at Knoxville

Laboratory research in motor behavior has consistently demonstrated higher transfer when practice occurs under conditions of high contextual interference/variety (e.g., Lee & Magill, 1983; Shea & Morgan, 1979). In the present study, an attempt was made to determine whether contextual variety could be easily incorporated into a physical education class setting and whether it produced a significant influence on final skills-test performance. Four practice schedules differing in the amount of contextual variety were administered during a regular college physical education class. Beginning badminton students were matched for skill level and practiced the long and short serves according to their respective conditions at the beginning of each of six class periods. Students monitored each other's practice sessions without significant alterations in normal class procedures. Conventional skills tests administered at the end of the semester revealed that the short-serve performance of the group receiving the highest level of contextual variety during practice was significantly superior to that of two of the other three conditions. The results are discussed in terms of possible theoretical significance for contextual-interference theory and practical relevance for physical education teachers.

Following a flurry of theory testing and highly controlled, process-oriented research in the 1970s and 1980s, scholars in the field of motor behavior are now being confronted with questions like, What good is it all? Will your results hold up in the gym? Can they be replicated in the real world? Increasingly, researchers are being challenged to establish the ecological validity of laboratory findings in more applied contexts. At a recent symposium held at Arizona State University on the topic of future directions in exercise/sport research, several speakers offered their wisdom as to how scientists might move beyond the study of phenomena emanating from artificially created laboratory situations and begin to assess the relevance of their research in applied settings (Christina, 1989; Schmidt, 1989; Stelmach, 1989).

In spite of such appeals, few studies have as yet been conducted to determine the generalizability of laboratory results to physical education classes. One

---

Craig A. Wrisberg is with the Department of Human Performance and Sport Studies, 344 HPER, The University of Tennessee, Knoxville, TN 37996-2700.

theoretical phenomenon that appears to have good potential for the practitioner is the contextual-interference effect, originally proposed by Battig (1966, 1979) for the verbal-learning domain. This effect has consistently been observed in studies in which the variety of practice experiences received by subjects during skill acquisition is systematically manipulated.

In the first motor-learning laboratory experiment conducted to investigate contextual interference, Shea and Morgan (1979) used a task in which subjects attempted to knock over a sequence of three small wooden barriers as rapidly as possible with a tennis ball held in the preferred hand. During acquisition trials, subjects were assigned to either a low or a high contextual-interference condition. In the former condition, 18 trials with each of three spatial configurations of barriers were performed in a blocked fashion (i.e., 18 trials in a row were practiced with one configuration before practice was begun with the next one). In the latter condition, subjects practiced an unsystematic sequence in which 6 trials with each of the three spatial configurations were performed within each block of 18 trials. All subjects were instructed to move as quickly as possible on each trial, and the primary dependent measure was movement time. Following a retention interval of either 10 min or 10 days, subjects performed 6 additional trials (3 in a blocked sequence and 3 in a random sequence) with each of the original barrier configurations. They were then given a set of 3 trials with each of two transfer tasks involving barrier configurations not experienced previously.

The results revealed that the movement times of subjects working with low contextual interference were significantly faster than those of subjects working with high contextual interference during acquisition trials but significantly slower during retention and transfer trials. Thus, it was concluded that contextual interference (or, in a more positive vein, contextual variety) during acquisition of a motor skill leads to better learning than does repetitious practice.

Although this conclusion has been supported in subsequent laboratory experiments (Del Rey, 1982; Del Rey, Whitehurst, Wughalter, & Barnwell, 1983; Del Rey, Wughalter, & Whitehurst, 1982; Lee & Magill, 1983; Shea & Kohl, 1991; Shea, Kohl, & Indermill, 1990; Whitehurst & Del Rey, 1983), only one investigation has been conducted to determine the efficacy of contextual variety in the learning of an applied sport skill. In that study, Goode and Magill (1986) used the badminton service as an experimental task and examined the effects of three levels of contextual variety on acquisition, retention, and transfer performance.

During acquisition (3 days a week for 3 weeks), subjects attempted (from the right court) three different serves (short, long, and drive) under one of three practice conditions. During each session, blocked-practice subjects performed 36 trials with only one of the serves; serial- and random-practice subjects performed an equal number of trials (i.e., 12) with each of the three serves. In the former condition, a different serve was performed on each trial in a predictable and repeating order; in the latter condition the three serves were performed in a random fashion with no version attempted more than twice in succession. Thus, during the course of acquisition, all subjects performed the same number of trials with each of the three serves but did so under different contextual conditions.

On the day following the last acquisition session, all subjects performed 6 trials with each of the three serves in a random sequence. Immediately after this retention test, a transfer test was given involving another random sequence of

the three serves but from the opposite (i.e., left) service court. Each of the serves was evaluated using adaptations of standardized badminton tests (French & Statler, 1949; Scott & French, 1959). Unlike the majority of laboratory studies investigating the contextual-interference effect, no differences were found between groups for any of the serves during the acquisition phase. However, there was a significant group effect for the short serve during the retention and transfer phases. Although specific pairwise differences were not reported, the performance of the random condition was found to be more accurate than that of the blocked condition in both phases. Thus, it was concluded that random practice (i.e., high contextual interference/variety) offered better prospects for retention and transfer, at least for the badminton short serve.

Although the Goode and Magill (1986) study represents an important step in establishing the ecological validity of a particular phenomenon that has repeatedly been evidenced in laboratory experiments, additional research is needed to verify the contextual-interference effect within an actual class setting. Goode and Magill incorporated an applied sport skill in their study, but experimentation took place under controlled conditions typically not present in the normal physical education class. For example, they reported that "participants were not part of an organized badminton class and only received instruction for the serves that were taught. In order to control for prior experience in racket sports, the subjects were screened as to extended experience in badminton, raquet ball, or tennis. Any subject with such experience was eliminated from the experiment" (p. 310).

Practitioners will probably not incorporate laboratory-derived theoretical concepts in the structuring of their classes until they see the phenomenon experimentally demonstrated in a standard instructional setting. At the present time, implementation of the contextual variety notion does not appear to be taking place in most physical education classes. In fact, as Goode and Magill (1986) have observed, contemporary teacher instruction texts (e.g., Harrison, 1983; Rink, 1985) continue to emphasize motor skill practice sessions that are more blocked than varied in nature. Therefore, the purpose of the present study was to determine the effect of contextual variety on the learning of an applied sport skill (i.e., the badminton serve) during a normal college physical education class. At the request of the instructor, experimental procedures were designed to create the least disruptions in regular class activities. Thus, the functionality as well as the theoretical significance of contextual variety was assessed.

Discussions as to the basis of contextual-interference effects have typically centered on two propositions. J.B. Shea and colleagues (Shea & Morgan, 1979; Shea & Zimny, 1983) have suggested that the reason individuals benefit from a varied practice schedule is because they are required to engage a greater number of different strategies than persons who practice under blocked (i.e., the same movement being repeated for a number of trials) conditions. This "elaboration" view emphasizes the importance of *multiple comparisons* of strategies made by subjects practicing under conditions of contextual variety, which purportedly leads to a more distinct and flexible memory representation.

An alternative to this position has been offered by Lee and Magill (1985), who suggested that the primary benefit of contextual variety is the necessity for *action-plan reconstruction*. Because subjects are attempting to perform a different movement on every trial, they must alter the motor plan from trial to trial, which results in more active processing than that required of subjects performing

the same movement across trials. In an effort to determine the relative merits of these two views, subjects in the present study were assigned to groups that differed according to the number of response variations and/or the extent to which a movement was repeated on successive trials.

## Method

### *Subjects*

The subjects were 16 male and 16 female students from a beginning badminton class at the University of Tennessee at Knoxville. All subjects volunteered to take part in the experiment, and none received payment or class credit for their participation.

### *Tasks*

The badminton tasks in this study were the clear (or long) service and the short service. All serves were practiced and tested on a regulation court. Subjects used a regulation racket and plastic (Carlton blue stripe) shuttlecocks.

A modification of the French Short Serve Test (French & Statler, 1949) was used to assess short-serve performance on the final skills test. A rope was extended between two portable standards 50 cm above the height of the net. Four concentric scoring areas, each 20-cm wide, were drawn in the right service court beginning at a distance of 55 cm from the midpoint of the intersection of the center line and the short-service line. The 55-, 75-, 95-, and 115-cm distances corresponded to point values of 5, 4, 3, and 2 points, respectively. Serves landing outside the 115-cm arc but within the doubles service area received a score of 1; those landing outside the doubles service area received a score of 0. Any serve passing above the rope resulted in a 1-point deduction.

Final skill-test performance for the long serve was evaluated using the Poole Long Serve Test (cited in Johnson & Nelson, 1974). Four 5-cm wide lines were drawn in the right service area to form the scoring zones. The first line was placed 5 cm behind and parallel to the back boundary line, and the second line was placed 40 cm inside of the first line. The remaining two lines were located parallel to 40 and 80 cm, respectively, inside the back doubles service boundary. Point values corresponding to the resulting four 40-cm wide zones were 5, 4, 3, and 2, respectively, beginning with the deepest zone. Serves landing on a line between two zones received the higher point value, those landing outside the zones but within the singles service area received a score of 1, and those landing outside the singles service area received a score of 0. Any serve passing lower than the judged height of an opponent with racket extended standing near the front of the service area resulted in a 1-point deduction.

### *Procedures*

Classes were held on a Monday, Wednesday, Friday schedule and lasted 50 min each. Experimental conditions were introduced midway through a 7-week unit. This decision was based on the results of previous research that has suggested that contextual-variety effects are more likely when subjects have already achieved some degree of performance skill (Del Rey et al., 1982; Goode, 1986). At the time practice manipulations were introduced in the present study,

all of the fundamental shots of badminton, including the short and long serve, as well as the rules of singles and doubles play had been covered, and students had had opportunity to practice the various shots and to participate in both types of games.

Following a presentation by the principal investigator as to the requirements of the study, interested volunteers signed consent forms. The instructor of the class was then asked to rate students on overall badminton skill. The Likert-type rating was based on a subjective evaluation of the performance of each subject during class drills and in game situations. An equal number of males and females were then assigned to each of four experimental conditions with the restriction that the mean skill ratings of the groups be similar.

The experiment consisted of two phases, a practice phase and a test phase. The practice phase covered six class periods, during each of which subjects performed 18 short serves and 18 long serves. Practice always occurred at the beginning of class and was followed by participation in singles or doubles tournament play. Subjects worked in pairs with one person calling out the type of serve the other was to hit on each trial and then checking off the serve after it was performed. Servers received visual feedback by observing the location of shuttle landing but, similar to most drill-type situations, were given no verbal feedback regarding performance accuracy. During the test phase, subjects performed 12 short serves and 12 long serves in a blocked fashion with order counterbalanced within each group. The principal investigator and course instructor recorded all test results. Testing was conducted in a conventional fashion with all students either involved in taking the test, warming up to take the test, or watching/waiting.

In summary then, all subjects performed a total of 108 trials with each serve during the practice phase and 12 trials with each serve during the test phase. The only knowledge of results available to subjects in either phase was their vision of the location of the shuttle's landing point.

*Practice Phase.* Subjects were assigned to one of four practice conditions that varied according to the number of different long and short serves required (one or three) and whether trials of the same movement were repeated or nonrepeated. All subjects were reminded to try to keep the short serves low and close to the front service boundary and to hit the long serves high and deep. Individuals practicing a single version of the serve were simply told to "hit a short [or a long] service." Subjects practicing three variations were instructed to hit each serve toward a designated area of the long or short service court. Although no target zones were marked on the court, subjects attempted to direct serves toward either the front left, front center, front right, back left, back center, or back right areas of the service court.

Depending on the nature of instructions regarding the number of variations of each serve to be attempted, subjects performed different numbers of repeated trials with a given movement. Groups instructed to simply hit long (L) and short (S) serves practiced either 9 consecutive short serves and 9 consecutive long serves on each day (i.e., repeated) or an alternating (i.e., nonrepeated) pattern of short and long serves (i.e., S,L,S,L, etc.) with the order counterbalanced across days within subjects. Groups attempting to hit serves to target zones either hit 3 consecutive serves to each of the six zones (i.e., repeated) or performed an equal number of long and short serves to each of the zones in a random sequence

with the restriction that no more than 2 serves of the same type (long or short) be attempted in succession. The order of presentation of tasks and target zones was counterbalanced within subjects across days. A different randomized sequence was generated for these two groups on each of the 6 practice days.

*Test Phase.* Performance of both the short and long service was tested on the final day of class (which was the class period immediately following the end of the practice phase) with all subjects required to perform 12 trials of each serve in a blocked fashion. The order of the blocks was counterbalanced within groups, with half of the males and females in each condition performing short serves followed by long serves and the other half performing blocks in the opposite order.

## Results

No data were collected during the practice phase due to a request by the instructor that experimental procedures not alter standard class time allotments. However, as mentioned previously, it is probably true that in most physical education classes practice sessions do not include the kind of augmented knowledge of results that would have been given if target zones had been mapped out and practice data recorded. In addition, it should be pointed out that in the Goode and Magill (1986) study neither a main effect of groups nor a Groups  $\times$  Blocks interaction was obtained during the acquisition phase. The absence of between-group acquisition effects has also been noted in more recent testing (Wrisberg & Liu, 1991).

The principal dependent measure on the skills test was the total points obtained by subjects on the best 10 of 12 serves (with a maximum score of 50 possible) on each test. This scoring method was the one recommended for the Poole Long Serve Test and, for uniformity, was also employed for the French Short Serve Test. Group means were calculated and separate one-way ANOVAs were performed on the results of the short serve (Figure 1) and the long serve (Figure 2) tests.

The findings indicated that the accuracy of the two conditions that required subjects to alter their motor plan from trial to trial (i.e., nonrepeated) was higher than that of the conditions in which repeated trials of each serve were performed. The results of the ANOVAs revealed no effect for the long serve,  $F(3,28) = .80$ ,  $p > .05$ , but a significant effect for the short serve,  $F(3,28) = 7.53$ ,  $p < .01$ . Post hoc analysis using the Newman-Keuls procedure indicated that the short-serve performance of the group practicing three versions of each serve in a completely nonrepeating fashion was significantly ( $p < .05$ ) higher than that of both repeating serve conditions. In addition, the mean score of the group practicing single versions of the long and short serves in a nonrepeating manner was significantly higher than that of the group performing three versions of each serve in a repeating manner. No other significant pairwise differences were obtained.

## Discussion

Although the contextual-interference effect has been consistently observed in laboratory situations and/or with artificial tasks (Del Rey, 1982; Del Rey, Whitehurst, Wughalter, & Barnwell, 1983; Del Rey, Wughalter, & Whitehurst,

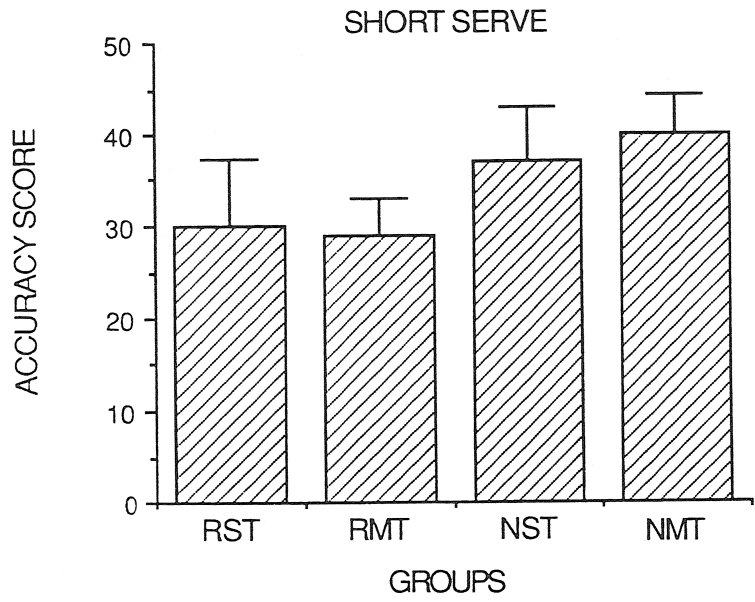


**Figure 1—Accuracy scores of the repeated-single target (RST), repeated-multiple targets (RMT), nonrepeated-single target (NST), and nonrepeated-multiple targets (NMT) groups on the short-serve test.**

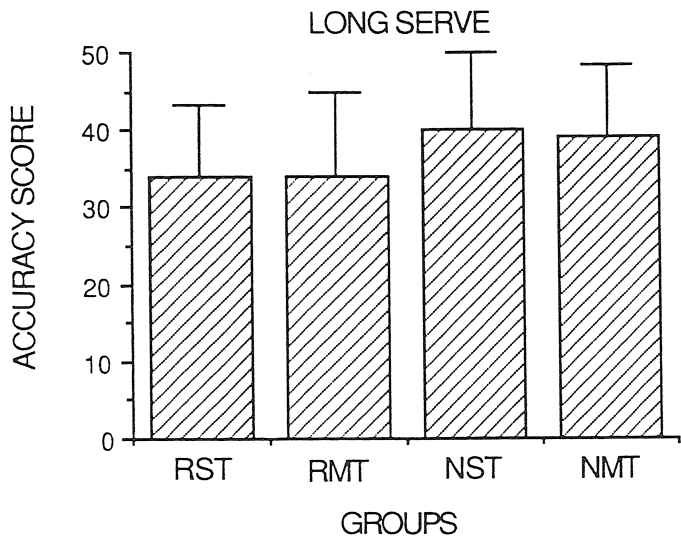


**Figure 2—Accuracy scores of the repeated-single target (RST), repeated-multiple targets (RMT), nonrepeated-single target (NST), and nonrepeated-multiple targets (NMT) groups on the long-serve test.**

1982; Lee & Magill, 1983; Shea & Kohl, 1991; Shea, Kohl, & Indermill, 1990; Shea & Morgan, 1979; Whitehurst & Del Rey, 1983), only Goode and Magill (1986) have attempted to determine whether such an effect "works" in the learning of an applied sport skill (i.e., the badminton service). In their study, some support was found for the use of contextual variety during skill acquisition. However, the conditions under which subjects received practice more closely resembled those of a controlled laboratory experiment than of the typical physical education class. Therefore, the present study was conducted within the context of an intact instructional setting to determine whether the structure of practice sessions influenced the test performance of students in a fashion consistent with the predictions of contextual-interference theory (Battig, 1966, 1979; Shea & Morgan, 1979).

Although some caution must be exercised due to the fact that acquisition performance was not analyzed, the results of this study indicate that retention of the badminton short serve is facilitated for subjects who have received previous practice with a greater variety of movements in a nonrepeating fashion. Of additional significance is the finding of higher retention for the group that practiced single versions of the long and short serves in a nonrepeating manner than for the group that practiced three versions of each serve in a repeating manner. That higher retention of the short serve was found for the two groups that had practiced a different movement from trial to trial during the acquisition phase (i.e., nonrepeated-single target and nonrepeated-multiple targets) suggests support for the notion that the benefits of contextual interference are linked to the need for action-plan reconstruction (Lee & Magill, 1985) during training. In other words, it appears that the number of serve variations attempted during practice may not have been as crucial to the development of the short serve as was the requirement to do something different on successive trials.

The present findings are consistent with the research of Goode and Magill (1986) in which significant group differences were obtained on a retention test for the short serve but not for the long serve. The reasons for this rather robust trend remain unclear at this time. In addition to the differential influence of varied practice on the long and short badminton serve, research on the effects of contextual variety on skill acquisition in other sport settings is needed. Moreover, the possibility that females may respond differently to practice manipulations than do males (e.g., Wrisberg & Ragsdale, 1979) is also in need of verification in standard teaching/learning environments using sample sizes larger than that employed in the present study.

On a more practical level, the present findings suggest that the concept of contextual variety is deserving of more serious consideration by today's physical education teacher. For one thing, this phenomenon lends itself to incorporation in the normal instructional setting. Students working in pairs can easily monitor each other's practice schedules. In this regard, several subjects in the present study commented that they enjoyed serving practice more during the experimental phase of the class when the purpose of practice was more clearly defined. Several others expressed the opinion that active observation/involvement in supervising another classmate's practice performance was beneficial.

Based on the enthusiastic cooperation of subjects in the present study, it would appear that the activity class setting offers better potential for applied research than is often assumed. Granted, there exist more potential confounds in

field studies (e.g., the fact that subjects in the present investigation performed additional repetitions of the two serves during tournament play). However, although appropriate cautions should be exercised as much as possible (see French, Rink, & Werner, 1990, for further discussion), the physical education teacher should be encouraged to attempt informal experimentation within the standard class setting in order to determine which variations of practice schedules are of the greatest benefit for different types of tasks and students.

In conclusion, the results of the present study suggest that the contextual-interference effect, which has been produced with novel tasks in the laboratory (e.g., Lee & Magill, 1983; Shea & Morgan, 1979) and with an applied sport skill under highly controlled conditions (Goode & Magill, 1986), is also generalizable to skill learning within the context of a normal physical education class. Although corroboration of these findings in other settings is certainly needed, they would appear to offer exciting instructional possibilities for the teacher/practitioner.

## References

- Battig, W.F. (1966). Facilitation and interference. In E.A. Bilodeau (Ed.), *Acquisition of skill* (pp. 215-244). New York: Academic Press.
- Battig, W.F. (1979). The flexibility of human memory. In L.S. Cermak & F.I.M. Craik (Eds.), *Levels of processing in human memory* (pp. 23-44). Hillsdale, NJ: Erlbaum.
- Christina, R.W. (1989). Whatever happened to applied research in motor learning? In J. Skinner, C. Corbin, D. Landers, P. Martin, & C. Wells (Eds.), *Future directions in exercise and sport science research* (pp. 411-422). Champaign, IL: Human Kinetics.
- Del Rey, P. (1982). Effects of contextual interference on the memory of older females differing in levels of physical activity. *Perceptual and Motor Skills*, **55**, 171-180.
- Del Rey, P., Whitehurst, M., Wughalter, E., & Barnwell, J. (1983). Contextual interference and experience in acquisition and transfer. *Perceptual and Motor Skills*, **57**, 241-242.
- Del Rey, P., Wughalter, E.H., & Whitehurst, M. (1982). The effects of contextual interference on females with varied experience in open sport skills. *Research Quarterly for Exercise and Sport*, **53**, 108-115.
- French, E., & Statler, E. (1949). Study of skill tests in badminton for college women. *Research Quarterly*, **17**, 257-272.
- French, K.E., Rink, J.E., & Werner, P.H. (1990). Effects of contextual interference on retention of three volleyball skills. *Perceptual and Motor Skills*, **71**, 179-186.
- Goode, S. (1986). *The contextual interference effect in learning an open motor skill*. Unpublished doctoral dissertation, Louisiana State University, Baton Rouge.
- Goode, S., & Magill, R.A. (1986). Contextual interference effects in learning three badminton serves. *Research Quarterly for Exercise and Sport*, **57**, 308-314.
- Harrison, J.M. (1983). *Instructional strategies for physical education*. Dubuque, IA: W.C. Brown.
- Johnson, B.L., & Nelson, J.K. (1974). *Practical measurements for evaluation in physical education*. Minneapolis, MN: Burgess.
- Lee, T.D., & Magill, R.A. (1983). A locus of contextual interference in motor skill acquisition. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **9**, 730-746.

- Lee, T.D., & Magill, R.A. (1985). Can forgetting facilitate skill acquisition? In D. Goodman, R.B. Wilberg, & I.M. Franks (Eds.), *Differing perspectives in motor learning, memory, and control* (pp. 3-22). Amsterdam: North-Holland.
- Rink, J.E. (1985). *Teaching physical education for learning*. St. Louis: Times/Mirror Mosby.
- Schmidt, R.A. (1989). Toward a better understanding of the acquisition of skill: Theoretical and practical contributions of the task approach. In J.S. Skinner (Ed.), *Future directions in exercise and sport science research* (pp. 395-410). Champaign, IL: Human Kinetics.
- Scott, M.G., & French, E. (1959). *Measurement and evaluation in physical education*. Dubuque, IA: W.C. Brown.
- Shea, C.H., & Kohl, R.M. (1991). Composition of practice: Influence on the retention of motor skills. *Research Quarterly for Exercise and Sport*.
- Shea, C.H., Kohl, R.M., & Indermill, C. (1990). Contextual interference: Contributions of practice. *Acta Psychologica*, *73*, 145-157.
- Shea, J.B., & Morgan, R.L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory*, *5*, 179-187.
- Shea, J.B., & Zimny, S.T. (1983). Context effects in memory and learning movement information. In R.A. Magill (Ed.), *Memory and control of action* (pp. 345-366). Amsterdam: North-Holland.
- Stelmach, G.E. (1989). The implications of process-oriented research: A commentary. In J.S. Skinner (Ed.), *Future directions in exercise and sport science research* (pp. 423-432). Champaign, IL: Human Kinetics.
- Whitehurst, M., & Del Rey, P. (1983). Effects of contextual interference, task difficulty, and levels of processing on pursuit tracking. *Perceptual and Motor Skills*, *57*, 619-628.
- Wrisberg, C.A., & Liu, Z. (1991). *The effect of action plan reconstruction on the acquisition, retention, and transfer of an applied motor skill*. Manuscript submitted for publication.
- Wrisberg, C.A., & Ragsdale, M.R. (1979). Further tests of Schmidt's schema theory: Development of a schema rule for a coincident timing task. *Journal of Motor Behavior*, *11*, 159-166.

---

### Acknowledgment

Appreciation is extended to Beth Foreman for assistance with data collection and to Ed Howley and Tinah Utsman for technical support.