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Effects of Bandwidth Feedback and Questioning on the Performance of Competitive Swimmers

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The effects of a coaching intervention involving Bandwidth Feedback and Questioning (BF-Q) on competitive swim times (cTIME), practice swim times (pTIME), and technique (TECH) were determined for competitive youth swimmers. The pre-post-transfer design spanned one short-course (25m) swim season. It was concluded that coaching in which feedback was delayed and replaced with questions directed to the athletes contributed to improved technique and subsequent faster race times. Compared to the Control group, the BF-Q group displayed greater gains in TECH during the intervention period and greater improvement in cTIME during the transfer period. Results are presented in a context of cognitive psychology, motor learning, and questioning. Applications to coaching practice and coach training are also discussed.

Over the last decade, a growing number of studies in motor learning and applied coaching research have supported delaying and reducing feedback in order to affect long term changes in performance (Goodwin & Meeuwsen, 1995; Lavery, 1962; Lee, White, & Carnahan, 1990; Sherwood, 1988; Weeks & Kordus, 1998). However, questioning was not recognized as a parallel tool in coaching, despite representing a fundamental instructional tool in education, counseling, psychology, outdoor leadership, and medicine (Bereiter & Scardamalia, 1985; Hammerman, Hammerman, & Hammerman, 1994; Knight, Guenzel. & Feil, 1997; Metzler, 2000; Otero & Graesser, 2001; Sachdeva, 1996). Although studies (e.g., Claxton, 1988) suggested inquiry was implicit in coaching methodology, it was not empirically verified.

Until recently, motor learning was viewed as a process of sensory feedback and motor control, exclusive of cognitive skills and decision making (e.g., Adams, 1971). Grounded in these theories were instructional methods that lead to athlete-coach dependency, high coach control, and low levels of athlete cognitive effort (for reviews see Christina & Bjork, 1991; Farr, 1987; Lee, Swinnen & Serrien, 1994; Schmidt, 1991; Vickers, 1994). Delivering high quantities of frequent, augmented feedback was one method used to reduce errors and increase the efficiency of

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athletes' performance during skill acquisition. Researchers recommended providing feedback "as soon after performance as possible, as often as possible, and in such a way as to reduce performance errors as efficiently as possible" (Lee et al., 1994, p. 332). These feedback schedules procured immediate and impressive improvements in performance (e.g., Thorndike, 1932). The research appeared conclusive; immediate gains and significant improvements were observed in people who received constant feedback. Providing abundant feedback was also a method advocated in sport psychology due, in part, to studies showing that athletes' perceptions of their abilities and that of their coaches were enhanced when this occurs (Allen & Howe, 1998; Amorose & Weiss, 1998).

However, these studies failed to test a critical characteristic of learning, namely the relatively permanent change in athlete performance over time. These studies did not assess the effects of abundant feedback on athlete performance in the longer term. As research designs shifted to include retention and transfer tests, a startling reversal was observed (Shea & Morgan, 1979; Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991; Schmidt & Lee, 2005; Vickers, Livingston, Umeris-Bohnert, & Holden, 1999). Methods of feedback that reduced, delayed, and summarized the information proved more effective for long term learning (Goodwin & Meeuwsen, 1995; Lavery, 1962; Lee et al., 1990; Sherwood, 1988; Weeks & Kordus, 1998; Winstein & Schmidt, 1990). Plausible reasons for this reversal were explained by "cognitive effort" (Lee et al., 1994). Athletes who received constant, external input regarding their performance grew to rely solely on that information. However, those who received less extrinsic feedback were required to mobilize cognitive processes for detecting sources of performance information.

Contemporary views embrace the opinion that "skill is highly cognitive" (cited in Lee et al., 1994). Expertise literature supports this claim, recognizing that significant expert/novice differences lie in the superior control experts have over the "integrated and coordinated actions of their bodies" (Ericsson, p. 60, 2003). Perceptual and cognitive factors have been suggested as better predictors of skilled performance in adults than physiological attributes (cited in Ward & Williams, 2003). This claim has since been supported for youth ages 9 through 17 (Ward & Williams, 2003). Despite the emergence of critical perceptual and cognitive skills that underlie the performance of all motor skills, motor learning is still primarily defined and measured in terms of observable motor behavior. Although a strong theoretical grounding exists in perception and cognition, studies are only beginning to measure these areas.

Decision Training (DT; Vickers et al., 1996a, 1996b, 1996c; Vickers et al., 1999a; Vickers, 1999, 2000, 2003; Vickers, Reeves, Chambers, & Martell, 2004) is a coaching model that focuses on increasing athlete cognitive effort, self-direction, and decision making within the practice environment through enhanced cognitive training. It differs from motor learning in that learning is not inferred solely from changes in behavior but also "when there is evidence that the performer is able to think and make effective decisions while physically performing" (Vickers et al., 2004, p. 103). Decision Training consists of seven tools that can be adapted by coaches to train specific perceptual and cognitive abilities of athletes in various performance contexts. Fundamental to the acquisition, improvement, and mastery of any skill (or ability) is feedback. Bandwidth feedback is one DT tool that specifically targets issues related to information regarding performance.

Sherwood (1988) was one of the first to test a “bandwidth” method, where feedback was provided only if performance was outside of preset criteria. Using a simple motor task, three groups were tested. One group received feedback every trial, while the other two groups were provided information only when their performance exceeded +/- 5% and +/- 10% error. The bandwidth feedback schedules followed inadvertent “shrinking” schedules as participants required more feedback early in practice but less input as their skill level improved. The larger bandwidth resulted in superior performance on a transfer test.

Goodwin and Meeuwsen (1995) applied bandwidth feedback directly to sport with a golf putting experiment. Four bandwidth (BW) feedback schedules were compared, including a BW0 percent (feedback every trial), BW10 percent, shrinking BW (increasing amounts of feedback) and expanding BW (decreasing levels of feedback). Both the BW10% and expanding–BW groups performed significantly higher on retention tests.

Compelling support exists for bandwidth feedback. However, the studies are limited in a number of critical ways. First, only KR (knowledge of results) feedback, or information related to the outcome of a movement, was provided. Motor learning is also concerned with quality of movement execution, therefore requiring KP (knowledge of performance) or information about the process of a movement. KP is more common in “real world” sport environments (Schmidt, 1991).

Weeks and Kordus (1998) addressed this issue with a study that examined both execution (technique) and outcome (target hitting) of soccer throw-ins. One group received KP every trial, while the other group received KP 33% of the time. Interestingly, accuracy (target-hitting) results procured no significant differences, but the 33% KP group technically outperformed the 100% KP group on both acquisition and retention-transfer tests. The authors speculate that “infrequent KP assists in developing intrinsic abilities to maintain form in the absence of KP rather than developing dependencies on KP as an external referent” (p. 230).

Janelle, Barba, Frehlich, Tennant, and Cauraugh (1997) took the concept of dependency one step further and investigated the effect of personal control over feedback frequency on the performance of a non-dominant throwing skill. Both accuracy and form were evaluated. Participants were randomly assigned to one of four groups: (a) KR received no kinematic information, (b) summary KP (SUMMARY) received KP every five trials, (c) self-controlled KP (SELF) received KP only when requested, and (d) a yoked group (YOKE) received KP whenever the SELF group requested it. Results showed the SELF group scored better on form and accuracy in the transfer condition. They unknowingly created a faded feedback schedule, requesting less input as their performance improved. These results emphasized the importance of self-regulation, personal control, and active learning to efficient and heightened skill acquisition. The study by Janelle et al. (1997) also suggested that infusing instruction with techniques that increased athlete autonomy had the potential to temper negative effects of cognitive effort. Therefore, granting athletes control over their thought processes and development positively affected their performance.

Based on the research, bandwidth feedback appeared to be a highly effective method of improving long-term performance, particularly when self-regulation was emphasized and participants were encouraged to ask for their own feedback. However, in our extensive use of bandwidth feedback in the real world of coaching

(Vickers, Bales et al., 1996a, 1996b, 1996c; Vickers et al., 1999; Vickers, 2000; Vickers et al., 2004), three problems surfaced that required a solution. First, because bandwidth feedback was a technique that affected long-term retention and transfer performance, successful transfer performance required increased cognitive effort, and engaged mental work over time. Just as early studies neglected to uncover the efficacy of such methods because the techniques did not produce immediate results, coaches were hesitant to employ techniques that did not produce rapid improvements in athlete performance (Lee et al., 1994; Vickers, 2000). Second, bandwidth feedback resulted in a gradual reduction of input from external sources (e.g., the coach) and increased the responsibility of the athletes to monitor and modify their personal performance. Based on this reasoning, one might assume that athletes would grow more autonomous through increased perceptions of self-responsibility and control. Although this did occur with some athletes, others felt neglected when their coaches employed reduced and delayed feedback. Coaches who used bandwidth feedback techniques experienced communication problems with some athletes who reported feeling ignored. In some instances, this grew to include parents and administrators who interpreted a reduction in observable feedback as a failure on the part of coaches to provide the continual support long associated with traditional methods of coaching. Finally, when a coach withdraws feedback, and an athlete engages cognitive processes designed to maximize their motor performance, how can a coach determine if athletes are, in fact, making correct decisions and solving relevant problems? Athletes may not involuntarily initiate thought processes related to their performance. The evidence above suggests that athlete cognitive effort may well focus on the coach's lack of interaction—not on improving sport performance. A method is needed that enables coaches to ascertain whether their athletes are cognitively engaged in the skills and tactics being trained.

Questioning techniques have the potential to remedy the problems cited above. Methods of inquiry are used extensively to elicit cognitive effort, problem solving, creativity, and critical thinking in other domains (Bereiter & Scardamalia, 1985; Fenwick & Parsons, 2000; Hammerman et al., 1994; Knight et al., 1997; Metzler, 2000; Otero & Graesser, 2001; Sachdeva, 1996; Thomas, 2000). Motor learning has been described as a problem solving activity (Guadagnoli & Lee, 2004), and consistent with this the DT model defines learning as occurring when there is evidence that both decision-making skills and motor performance have improved. Questioning provides coaches with a method of encouraging active learning through problem solving, discovery, and performance awareness. As external information about performance is reduced, coaches can elicit intrinsic awareness through questioning while maintaining, even increasing, productive communication with athletes.

Perception of control has been positively correlated with both physical and psychological states in areas of psychology, health, wellness, and related areas (see Taylor, 1995). Questioning is a direct technique designed to share control with patients and their families in the case of health research. Self-reflection, self-regulation, and superior problem solving abilities have been linked to the use of questioning in nursing and health counseling (Dozier, Hicks, Cornille, & Peterson, 1998; Poskiparta, Kettunen, & Liimatainen, 1998). These outcomes are similar to the goals of decision training where athletes are encouraged to analyze their own performance and engage in a dialogue with their coaches in terms of potential solutions to performance problems and shared strategies for competition. We have found that in order to engage this process, coaches must deliberately delay and reduce feedback and replace this with insightful questions designed to increase cognitive effort.

Although these relationships are theoretically logical, the effects of a Bandwidth Feedback-Questioning (BF-Q) partnership have not been directly studied in terms of its effects on the performance of athletes. An earlier study in our laboratory (Vickers et al., 2004) showed that coaches will use the BF-Q method both in the short and long term when not supervised or monitored; however, this study did not determine effects of the method on improving athlete performance. In physical education, medical, dental, and coaching resources, questioning has long been endorsed as an effective instructional method (e.g., Hunkins, 1976; Knight et al., 1997; Martens, 2004; Mosston & Ashworth, 1994; Sachdeva, 1996; Schell, 1998; Wink, 1993). However, it has not been directly studied in relation to bandwidth feedback in an applied sport setting. The present study investigated the effectiveness of BF-Q on competitive swimming performance in a field-based context. The effects of a BF-Q intervention on swimming technique, practice times, and competition results were measured over one winter swim season. It was hypothesized that the BF-Q group would demonstrate less improvement than the Control group from Pre-Post (intervention period), but significantly more improvement from Post-Transfer (transfer period) on all three performance measures (swim technique, cTECH; practice swim times, pTIME; competitive swim times, cTIME.

Method

Participants

Participants consisted of 24 swimmers, 9 males and 15 females, with one to three years of competitive experience in two prominent swim clubs based in Calgary, Alberta. They ranged in age from 14 to 17 years. The two swim teams were randomly selected from the five available. One team was a Control and the second was the BF-Q (Bandwidth Feedback-Questioning) group. Initially, the Control and BF-Q groups consisted of 18 and 20 swimmers respectively. Attrition was greater in the Control group, with 10 swimmers (eight female and two male) completing the study, compared to 14 (seven female and seven male) in the BF-Q condition. A preliminary 400m freestyle timed swim before the study confirmed there were no significant differences between the two groups. Mean times were 363.25 seconds ($SD = 26.86$) for the Control group and 361.22 ($SD = 29.55$) for the BF-Q group.

Participation was voluntary; permission of the swim clubs, coaches, parents, and swimmers was granted before the study began, and ethics approval was received from the conjoint medical ethics committee of the University of Calgary. Both coaches were males under the age of 35 who swam competitively as youth athletes. Both had NCCP (National Coaching Certification Program) and an average of three years coaching experience. The study spanned four months, or one short-course (25 meter pool events) swim season, and included seven two-hour practices per week. The frequency and duration of all practices were consistent across the two groups.

Procedure

Adherence to Coaching Style. The coaches were videotaped at a practice to establish baseline feedback and questioning levels. Feedback and questioning levels were measured throughout the study using a Questioning Coding Sheet, adapted from the Decision Training (DT) Instrument (Vickers, 2000; Vickers et al., 2004).

In order to train the BF-Q coach, a booklet was created by the first author (Chambers, 2000) that outlined the theory behind the BF-Q intervention and practical suggestions for applying bandwidth feedback and effective questioning techniques. The BF-Q coach participated in a two-hour instructional session using the booklet. During the next week, three practices were videotaped, coded, and used to provide feedback to the BF-Q coach on their effectiveness of their techniques. Debrief sessions followed each videotaped practice and an additional summary session concluded the training. The Control coach received equivalent time in swim discussion but no training in BF-Q.

Both coaches were videotaped at two randomly selected practices per week throughout the intervention period (Pre-Post) and assessed on amount and type of feedback and questioning they used in practices. This served two purposes: first, to monitor compliance of the BF-Q coach in using the BF-Q techniques and second, to ensure the Control coach maintained their original style of feedback.

Experimental Design and Measurement of Variables. The study followed a Pre-Post-Transfer design. The dependent variables included competitive swim times (cTIME), a 400m free practice swim time (pTIME), and swim technique (TECH). The BF-Q coach was instructed to employ BF-Q methods throughout the intervention period (Pre-Post), which lasted six weeks. Transfer tests followed 10 weeks after the Post tests. All dependent variables were tested at Pre, Post, and Transfer times.

Competitive Swim Times (cTIME). Swim times for 100m, 200m, and 400m events were collected from meet (competition) results for each swimmer in their stroke of specialization. Changes in swim times were determined by calculating difference scores (d-scores) for each swimmer in each event from Pre-Post and Post-Transfer. D-scores represented the change in time during the Pre-Post and Post-Transfer and were obtained by subtracting the Post from Pre swim times and Transfer from Post swim times, respectively. Overall cTIME was the sum of the d-scores for each swimmer across the three events. D-scores were calculated for the intervention period (Pre-Post) and the transfer period (Post-Transfer).

Practice Swim Times (pTIME). A 400m free swim was timed in practice under controlled conditions for pTIME measurements. According to competitive swimming regulations, all swimmers were required to achieve a minimum time in the 400m free event in order to compete in other strokes and distances. Therefore, it represented a universal training goal for all athletes. Changes in pTIME were determined by calculating d-scores for Pre-Post and Post-Transfer. All swimmers were videotaped during Pre, Post, and Transfer tests. These videos were used for the technical analysis described below.

Technique (TECH). Using the 400m free pTIME videos, the technical ability of each swimmer was coded using a Stroke Evaluation Form (adapted from Haljand, 1996) containing 13 items graded on a 5-point Likert scale. Coders were certified Level 3 NCCP (National Coaching Certification Program) swim coaches working at the Junior National level. An overall TECH score for each swimmer was calculated as the mean of the 13 items. Changes in TECH were determined by calculating d-scores from Pre-Post and Post-Transfer.

Data Analysis

Because detecting changes in the dependent variables was central to the purpose of the study, d-scores were determined for the three dependent variables: pTIME, cTIME, and TECH. The d-scores were analyzed separately for each variable using a 2 × 2, Group (BF-Q, Control) × Test, Pre-Post, Post-Transfer ANOVA with repeated measures on the last factor. Scheffe contrast of means was used for all post hoc analyses. All data were analyzed using Statview 5.0 (SAS Institute, Inc., 1998). Effect sizes were calculated for significant main effects, and omega squared (W^2) when more than two means were involved. An alpha level of .05 was used for all statistical tests.

Results

Table 1 presents the means and standard deviations for cTIME, pTIME, and TECH d-scores during the intervention (Pre-Post) and transfer (Post-Transfer) periods.

Table 1 Mean d-Scores (With Standard Deviations) for cTIME (Seconds), pTIME (Seconds), and TECH (13-Item, 5-Point Likert Means)

	BF-Q		Control	
	Pre-Post	Post-Transfer	Pre-Post	Post-Transfer
cTIME	4.05	–17.00	–15.47	–5.00
	(8.55)	(12.03)	(12.57)	(7.25)
pTIME	–11.78	–5.67	–8.29	–5.43
	(22.92)	(8.32)	(3.45)	(12.37)
TECH	.27	.04	.10	.14
	(.39)	(.14)	(.09)	(.16)

Negative values denote improvements in cTIME and pTIME d-scores. TECH values represent the change in mean values on Likert scale rankings with a range of one to five.

cTIME. The two-way interaction of Test × Group for cTIME was significant: $F(1, 22) = 18.21$, $p. <.0003$. Post hoc contrast of means indicated that cTIME improvements were significantly greater from Post-Transfer compared to Pre-Post for both groups: $F(1, 1) = 7.91$, $p < .04$, $w^2 = .42$. The BF-Q group did not improve their times in competition from Pre-Post, while the Control group made their greatest gains at this time. From Post-Transfer, the BF-Q group demonstrated the greatest improvements, decreasing their swim times by an average of 17.00 seconds. Figure 1 displays the interaction between group cTIME changes from Pre-Post and Post-Transfer.

pTIME. Both the BF-Q and Control groups improved their practice times from Pre-Post and Post-Transfer. The BF-Q group improved by a greater margin Pre-Post, decreasing time by an average of 11.78 seconds compared to 8.29 seconds for the Control group. From Post-Transfer both groups cut an average of 5.67 (BF-Q group) and 5.43 (Control group) off their times in practice. There were no significant differences between groups for pTIME.

TECH. Inter-observer agreement. An Observer (1, 2) × Test (Pre-Post, Post-Transfer) ANOVA with repeated measures on the last factor on the TECH d-scores found no significant differences: $F(1, 33) = .01$, $p < .92$ between coders' mean scores.

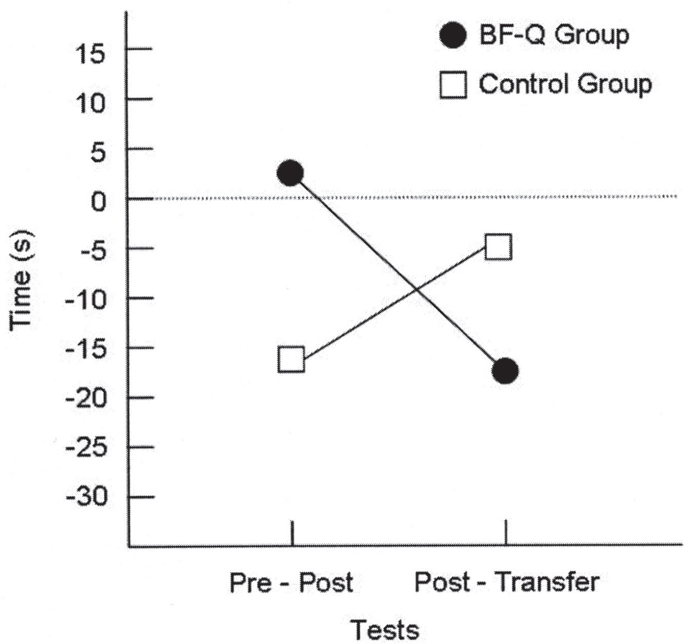

Figure 1—Mean differences in cTIME d-scores during intervention (Pre-Post) and transfer (Post-Transfer) periods.

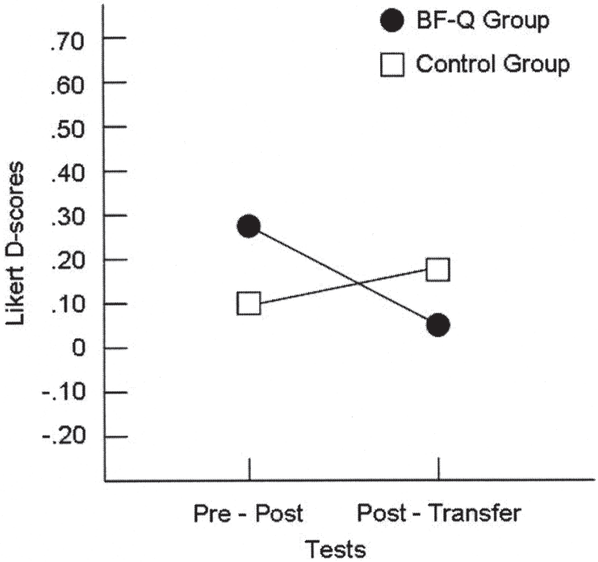

Figure 2—Mean differences in swim TECH d-scores during the intervention (Pre-Post) and transfer (Post-Transfer) periods.

Figure 2 displays the interaction between group d-scores for TECH Pre-Post and Post-Transfer. Changes in TECH followed an opposite trend to changes in cTIME. The BF-Q group demonstrated the greatest improvement in swim TECH during the intervention, with little improvement in the latter part of the season. They also experienced the greatest overall improvement over the short-course season, increasing Likert scale mean d-scores across the group by a total of .31. In contrast, the Control group showed less improvement overall, with an increase of .24 on Likert scale mean d-scores. Their greatest gains appeared in the Post-Transfer period. There were no significant differences between groups for TECH.

Discussion

This study investigated the effects of bandwidth feedback and questioning on athlete performance. Hypotheses predicted that the BF-Q group would demonstrate less improvement than the Control group from Pre-Post (intervention period), but significantly more improvement from Post-Transfer (transfer period) in cTIME, pTIME, and TECH. These expectations were upheld in respect to cTIME performance. An interesting reversal was evident in both TECH and cTIME results for the BF-Q and Control groups. From Pre-Post, cTIME improved only for the Control group. However, TECH gains were greatest for the BF-Q group during the same period. Conversely, from Post-Transfer TECH, improvements were more pronounced for the Control group yet still did not exceed the gains made by the

BF-Q group during the intervention. From Post-Transfer, the BF-Q group had superior results in competition (cTIME), exceeding gains made by the Control group from Pre-Post.

These relationships suggest that the BF-Q intervention positively affected TECH in the BF-Q group early in the season by stimulating cognitive effort related to finding solutions to technical problems. Changes were not manifested in competition performance (cTIME) until the transfer period.

This information is powerful in two ways. First, it demonstrates that swimmers were aware of their ability to affect gains in personal athletic development. Janelle et al. (1997) contended that research on feedback focused on extrinsic sources while "neglecting the active role of the learner" (p. 270). According to the authors, self-regulation strategies should increase perceived self-control and enhance learning through deeper information processing. These results emphasize the importance of self-regulation, personal control, and active learning to efficient and heightened skill acquisition. In the current study, data suggest these elements may have prevailed in the BF-Q coaching/athlete environment.

The second powerful message emerging from the results involves another aspect of athlete-coach interaction. Although swimmers described increases in mental work encouraged by their coach, the improvement in communication seemed to override any negative effects of the cognitive load. Improving coach-athlete interaction was one goal of combining questioning with bandwidth feedback. The present study supported the combined use of questioning and bandwidth feedback to enhance learning and maintain effective coach-athlete relationships.

Maintenance of the coach-athlete relationship may be a critical component of utilizing methods that encourage long-term development. Despite substantial cTIME improvements by Control group swimmers in the early part of the season, BF-Q group swimmers had slower times in competition. It was not until the transfer period that the BF-Q swimmers improved and surpassed gains of the Control group in cTIME. According to research in motor learning and transfer of learning, methods that encourage long term retention and transfer of skills are not as successful in the short term (Halpern, 1998; Hekseth, 1997; Lee et al., 1994). Improved communication may have helped to buffer the effects of delayed performance gratification. More research is required in this area to examine the effects of these methods on coach-athlete relationships and long-term development.

In the present study, cTIME represented the long term measure of transfer performance. Competition represents a transfer condition; swimmers are required to implement strategies and techniques from practice in a competitive environment (swim meet). Interestingly, swim times in practice (pTIME) improved consistently for both BF-Q and Control groups, with no significant differences between them. This is logical when considered from the transfer of learning perspective. Practice does not represent a transfer condition in respect to competition. Therefore, the effects of BF-Q would not necessarily affect practice performance to the same degree as a pure transfer situation.

Finally, TECH did not follow the hypothesized pattern of delayed performance. However, upon closer scrutiny of the research cited, these results align with those of Weeks and Kordus (1998) and their study of soccer throw-ins. Technique improvements for the delayed feedback group were superior at the post test. This suggests methods encouraging long term transfer of skills to an outcome or competitive situation may have different or more immediate effects on technical or process performance. Also, Decision Training, although originally developed as a universal model of training, has been used primarily with older elite athletes (with the exception of one study, Vickers et al., 1999). The present study shows that the method is also effective with younger developmental level athletes.

As an inaugural investigation into the effects of using a combination of questioning and bandwidth feedback in coaching, this study unveiled some fascinating issues worthy of further scrutiny. There were also limitations to the present investigation. More studies are required to isolate bandwidth feedback and questioning in the laboratory and field employing stricter control over the dependent variables. This study did not delineate between types of feedback or questioning. Research on questioning in other areas, for example education and medicine (Dozier et al., 1998; King, 1994; Knight et al., 1997; Poskiparta et al., 1998), specify types of questions that are more or less effective for encouraging problem solving, self reflection, and autonomous learning. It is recommended that future research in this area apply different methods of questioning to sport contexts.

In respect to coach training, this study highlighted several important points. First, the one-week training did result in long-term application of the bandwidth feedback and questioning techniques by the BF-Q coach, when accompanied by the twice weekly video collection that was required to ensure compliance. The current study therefore ensured that the BF-Q coach used the method continually. This raises the question of whether coaches will continue to use BF-Q in the long term without monitoring. An earlier study (Vickers et al., 2004) suggests they will, but additional evidence is needed for all age and ability level of coaches and athletes. Training included theoretical and practical experiences in combination with feedback and reflection by the coach based on methods of teaching Decision Training. Without the measurement of both coach and athlete behaviors, no valid relationships could have been assumed between coaching practice and athlete achievement. It is recommended that researchers in coaching education take into account not only the coach behaviors that manifest post training, but subsequent changes in athlete performance.

Second, the measurement of coaching behaviors was maintained throughout the study, not restricted to isolated periods such as pre and post tests. Longitudinal designs are therefore recommended that focus on the effects of coach education and training over an extended period of an athlete's development. This study illustrated positive, long term effects of using bandwidth feedback and questioning with athletes. Future research should investigate the effects of using these methods in coach education. Increasing autonomy, problem solving, and self regulation of learners are viable goals at all levels of education.

The use of instructional methods that promote long term retention, transfer, and learning are still emerging as viable tools in the coaching realm. Results of this study suggest exciting outcomes that may represent consistent products of these methods. Bandwidth feedback and questioning methods may have the power to affect positive advances in performance, athlete-coach relationships, and overall development of athletes of all levels.

References

Adams, J.A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behaviour*, **3**, 111-150.

Allen, J.B. & Howe, B.L. (1998). Player ability, coach feedback, and female adolescent athletes' perceived competence and satisfaction. *Journal of Sport & Exercise Psychology*, **20**, 280-299

Amorose, J.A. & Weiss, M.R. (1998). Coaching feedback as a source of information about perceptions of ability: A developmental examination. *Journal of Sport & Exercise Psychology*, **20**, 395-420.

Bereiter, C., & Scardamalia, M. (1985). Cognitive coping strategies and the problem of inert knowledge. In S.F. Chipman, J.W. Sega, & R. Glaser (Eds.), *Thinking and learning skills, Vol. 2: Research and open questions* (pp. 65-80). Hillsdale, NJ: Lawrence Erlbaum Associates.

Chambers, K. (2000). *Questioning in coaching: An overview*. Retrieved February, 2006, from the Target Performance Education website: http://tpeg.ca/

Christina, R.W., & Bjork, R.A. (1991). Optimizing long-term retention and transfer. In D. Druchman & R.A. Bjork (Eds.), *In the mind's eye: Enhancing human performance* (pp. 23-54). Washington, DC: National Academy Press.

Claxton, D.B. (1988). A systematic observation of more and less successful high school tennis coaches. *Journal of Teaching in Physical Education*, **7**, 302-310.

Dozier, R.M., Hicks, M.W., Cornille, T.A., & Peterson, G.W. (1998). The effect of a Tomm's therapeutic alliance: A clinical analog study. *Family Processes*, **37**(2), 189-200.

Ericsson, K.A. (2003). Development of elite performance and deliberate practice: An update from the perspective of the expert performance approach. In J.L. Starkes, & K.A. Ericsson (Eds.), *Expert performance in sports: Advances in research on sport expertise* (pp. 49-83). Champaign, IL: Human Kinetics.

Farr, M.J. (1987). *The long term retention of knowledge and skills*. New York: Springer-Verlag.

Fenwick, T., & Parsons, J. (2000). *The art of evaluation: A handbook for educators and trainers*. Toronto, ON: Thompson.

Goodwin, J.E., & Meeuwsen, H.J. (1995). Using bandwidth feedback of results to alter relative frequencies during motor skill acquisition. *Research Quarterly for Exercise and Sport*, **66**, 99-104.

Guadagnoli, M., & Lee, T. (2004). Challenge point: A framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behaviour*, **36**(2), 212-224.

Haljand, R. (1996). *Methods of evaluation for competition analysis and technique in swimming*. Ontario, Canada: Swimming Natation Canada.

Halpern, D.F. (1998). Teaching critical thinking for transfer across domains: Dispositions, skills, structure training, and metacognitive monitoring. *American Psychologist*, **53**, 449-455.

Hammerman, D.R., Hammerman, W.M., & Hammerman, E.L. (1994). *Teaching in the outdoors*. Danville, IL : Interstate.

Hekseth, B. (1997). Dilemmas in training for transfer and retention. *Applied Psychology: An International Review*, **46**, 317-386.

Hunkins, F.P. (1976). *Involving students in questioning*. Boston, MA: Allyn & Bacon.

Janelle, C.M., Barba, D.A., Frehlich, L., Tennant, L.K., & Cauraugh, J.H. (1997). Maximizing performance feedback effectiveness through videotape replay and a self-controlled learning environment. *Research Quarterly for Exercise and Sport*, **68**, 269-279.

King, A. (1994). Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American Educational Research Journal*, **31**, 338-368.

Knight, G.W., Guenzel, P.J., & Feil, P. (1997). Using questions to facilitate motor skill acquisition. *Journal of Dental Education*, **61**(1), 56-65.

Lavery, J.J. (1962). The retention of simple motor skills as a function of type of knowledge of results. *Canadian Journal of Psychology*, **16**, 300-311.

Lee, T.D., Swinnen, S.P., & Serrien, D.J. (1994). Cognitive effort and motor learning. *Quest*, **46**, 328-344.

Lee, T.D., White, M.A. & Carnahan, H. (1990). On the role of knowledge of results in motor learning: Exploring the guidance hypothesis. *Journal of Motor Behavior*, **22**(2), 191-208.

Martens, R. (2004). *Successful coaching* (3rd ed). Champaign, IL: Human Kinetics.

Metzler, M.W. (2000). *Instructional models for physical education*. Needham Heights, MA: Allyn & Bacon.

Mosston, M., & Ashworth, S. (1994). *Teaching physical education* (4th ed.). Columbus, OH: Merrill.

Otero, J., & Graesser, A.C. (2001). PREG: Elements of a model of question asking. *Cognition and Instruction*, **19**, 143-175.

Poskiparta, M., Kettunen, T., & Liimatainen, L. (1998). Reflective questions in health counseling. *Qualitative Health Research*, **8**, 682-693.

Sachdeva, A.K. (1996). Use of effective questioning to enhance the cognitive abilities of students. *Journal of Cancer Education*, **11**(1), 17-24.

Salmoni, A.W., Schmidt, R.A., & Walter, C.B. (1984). Knowledge of results and motor learning: A review and critical appraisal. *Psychological Bulletin*, **95**, 355-386.

Schell, R.M. (1998). Organizational behavior management: Applications with professional staff. *Journal of Organizational Behavior Management*, **18**, 157-171.

Schmidt, R. A., & Lee, T.D. (2005). *Motor control and learning: A behavioral evidence*. Champaign, IL: Human Kinetics.

Schmidt, R.A. (1991). *Motor learning and performance: From principles to practice*. Champaign, IL : Human Kinetics.

Shea, J. & Morgan, R. (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.

Sherwood, D.E. (1988). Effect of bandwidth knowledge of results on movement consistency. *Perceptual and Motor Skills*, **66**, 535-542.

Taylor, S.E. (1995). *Health psychology* (4th ed.). New York: McGraw-Hill.

Thorndike, E. (1932). *The fundamentals of learning*. New York: Teachers College.

Thomas, P.F. (2000). On the art of questioning. *Horizon*, **27**(1), 1-3.

Vickers, J.N. (1994). Psychological research in sport pedagogy: Exploring the reversal effect. *Sport Science Review*, **3**(1), 28-40.

Vickers, J.N. (1999). Decision training : A new coaching tool. *Insight: The F.A. Coaches Association Journal*, **4**(3), 18-20.

Vickers, J.N. (2000). *Decision training: A new approach to coaching*. Vancouver: Coaches' Association of BC.

Vickers, J.N., Bales, J., Allison, T., Jensen, M., Cluff, M., & Bowman, L. (1996a). *Decision training in freestyle skiing*. Calgary: National Coaching Institute.

Vickers, J.N., Bales, J., Davidson, M., Curry, J., Johnson, M., & Rennie, T. (1996b). *Decision training in ice hockey*. Calgary: National Coaching Institute.

Vickers, J.N., Bales, J., Pike, R., Dolan, C., Lemieux, C., & Ryan, G. (1996c). *Decision training in volleyball*. Calgary: National Coaching Institute.

Vickers, J.N., Livingston, L.F., Umeris-Bohnert, S., & Holden, D. (1999). Decision training: The effects of complex instruction, variable practice and reduced delayed feedback on the acquisition and transfer of a motor skill. *Journal of Sport Sciences*, **17**, 357-367.

Vickers, J.N., (2003). Decision Training: An Innovative Approach to Coaching. Retrieved July, 2005, from the Canadian Journal for Women Coaches Online: http://www.coach.ca/WOMEN/e/journal/

Vickers, J.N., Reeves, M., Chambers, K.L., & Martell, S. (2004). Decision training: Cognitive strategies for enhancing motor performance. In A.M. Williams & N.J. Hodges (Eds.), *Skill acquisition in sport: Research, theory and practice* (pp. 103-120). New York: Routledge.

Ward, P., & Williams, A.M. (2003). Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. *Journal of Sport and Exercise Psychology*, **25**, 93-111.

Weeks, D.L. & Kordus, R.N. (1998). Relative frequency of knowledge of performance and motor skill learning. *Research Quarterly for Exercise and Sport*, **69**, 224-230.

Wink, D.M. (1993). Using questioning as a teaching strategy. *Nurse Educator*, **18**(5), 11-15.

Winstein, C.J., & Schmidt, R.A. (1990). Reduced frequency of knowledge of results enhances motor skill learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**, 677-691.

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