THE EFFECTS OF ATHLETIC EXPERIENCE ON COACHING SKILLS

THE EFFECTS OF PREVIOUS ATHLETIC EXPERIENCE ON ERROR DETECTION AND IDENTIFICATION ABILITIES IN NOVICE AND EXPERIENCED COACHES

By

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Abstract

Qualitative research exploring the development of coaching skills and knowledge suggests that this development begins with early athletic involvement. Unfortunately, the quantitative research exploring the association between athletic involvement and coaching abilities has not been able to identify a clear and causal relationship. This thesis investigates the relationship between previous athletic experience and current perceptual-cognitive coaching skills in novice and experienced gymnastics coaches using a quantitative experimental paradigm. Novice and experienced provincial and national level gymnastics coaches with and without experience competing at the provincial or national level participated in this study. In Experiment 1, twenty-three coaches completed a Knowledgebase Task and an Error Identification task. The data demonstrated that experienced coaches performed better on the knowledgebase task ($F(1,19)=7.113$, $p.=0.016$) and the Error Identification task than the novice coaches ($F(1,18)=14.916$, $p.=0.001$). While there were no performance differences on either task for experienced coaches with either significant or minimal athletic histories, novice coaches without previous athletic experience outperformed the novice coaches with previous athletic experience when asked to identify the initial error in a flawed gymnastics sequence ($F(1,18)=5.338$, $p.=0.03$). This counterintuitive result was further explored in Experiment 2. It was hypothesized that the nature of the knowledge on which the novice coaches rely differed based on their athletic histories. Specifically, novice coaches without athletic experience would rely to a greater degree on explicit knowledge whereas novice coaches with previous athletic experience would rely upon implicit knowledge acquired while an athlete. The results of Experiment 2 did not support this hypothesis. While this thesis was able to develop further insight into the relationship between previous athletic experience and current perceptual-cognitive coaching abilities, no clear and causal conclusions were drawn. Additional research is required to fully understand this complex and multi-dimensional relationship.

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Introduction

Coaching and Coaching Development

Coaches have been around since the introduction of organized sport; they are present in professional sports, private clubs, community teams, and schools (Woodman, 1993). At any level, and in any sport, the role of the coach, in a broad sense, is to assist athletes in attaining their optimal performance level. This is accomplished via physical, technical, tactical, and psychological preparation (Bompa, 1983). Thus, along with strong knowledge of the rules and techniques of the sport, good coaches also require knowledge in areas such as sport psychology, nutrition, physiology, anatomy, injuries and rehabilitation. The coaching process itself, is dynamic, organized, systemic, and deliberate (Fairs, 1987).

Coaching has become an area of interest in research over the past thirty years and has itself emerged as a scientific discipline (Woodman, 1993). One only has to look at the number of individuals who have become certified coaches within Canada to understand the importance of this line of research. Over one million people have become certified coaches in Canada through the National Coaching Certification Program (NCCP) since the program began in 1974 (Coaching Association of Canada). Coaching research spans many sub-areas such as the various roles of the coach (Cote, Salmela, Trudel, Baria, & Russell, 1995), the coach-athlete relationship, coaching expertise (Pinheiro & Simon, 1992; Leas & Chi, 1993), coaching efficacy (Fung, 2002), as well as coach development (Gould, Giannini, Krane, & Hodge, 1990; Erickson, Cote, & Fraser-Thomas, 2007; Werthner & Trudel, 2006).

Many models of coach development exploring the transition points throughout a coach's career have been proposed. For example, Salmela (1994) proposed a model based on twenty-one coaches from four team sports. This model was composed of three experiential stages beginning with early involvements in sport. This early involvement is followed by early career coaching and mature career coaching. Each of the stages of development in this model differ qualitatively from the previous. The importance of Salmela's research was that this was the first time that the notion that early athletic participation was formally considered as a foundational element in future coaching knowledge.

Based on these hypotheses, Salmela, Draper, and Desjardins (1994) proposed a six stage model of athletic and coach development based on 10 expert field hockey and ice hockey coaches (as recognized by their national governing bodies). This model suggests that coaching skills begin to develop when the coach is engaged in diffused participatory involvement in several sports. This multi-sport involvement is followed by a shift to a more focused involvement in one sport. Subsequent to this athletic involvement, "through a combination of careful planning, wise career and educational choices, and serendipity" (pg. 572), the individual progresses to an initial coaching role. This initial coaching role propels the individual to seek out sources of knowledge that may assist in their development. Such sources may include coaching courses, educational books and videos, or mentors. This knowledge acquisition represents the transition from a passive to an active acquisition of coaching knowledge and allows for the development of a skill specific knowledgebase that enables the coach to attain an established coaching role. This fourth stage of development, an established coaching role, is followed by a transition to specialist coach and then on to an eminent awareness stage. During these final two transitions, coaches focus on unique specializations that enable them to distinguish themselves from their mentors, and they begin mentoring other developing coaches.

The goal of the model proposed by Salmela, Draper, and Desjardins (1994) was to provide conceptual stages of coach *development*. Schinke, Bloom, and Salmela (1995) proposed a seven stage paradigm for athletic and coaching development which focused specifically on the evolution of a coaching *career*. This model was based on six Canadian basketball coaches who were considered the most successful basketball coaches in the country at the time by Basketball Canada. The seven proposed chronological stages of career development are: (1) early sport participation, (2) national elite sport, (3) international elite sport, (4) novice coaching, (5) developmental coaching, (6) national coaching, and (7) international coaching. Early sport participation begins at a young age when an individual is first introduced to sport, and ends with provincial or state level competition. During this time basic knowledge is acquired from their coaches, and a love for the sport is developed. This is followed by Elite sport involvement. During this period, the athletes are now competing at a level where they are representing their university or province in national events. The final stage of athletic involvement is characterized by international competition. Only the best athletes are able to compete at this level. Of the six basketball coaches who participated in this study, only two were players on a national basketball team. Similar to athletic involvement, initial coaching experiences begin at a non-competitive level and may take place in a variety of sports or in teaching academics at the primary level. Coaches remain in this 'novice' coaching stage long enough to acquire an adequate amount of technical knowledge to specialize in one sport. The transition to the developmental coaching stage was marked by two differences: first, coaches work with athletes at the high school level, and second, results begin to serve as a measure of their success in coaching. It is also during this second stage that coaches attempt to increase their sport specific knowledgebase through formal education and mentor coaches. The final two stages of coach development, national elite coaching and international elite coaching, are characterized by working with university or provincial teams who are competing successfully at national events, or working with national teams.

The most recent model for coach development was proposed by Erickson, Cote, and Fraser-Thomas (2007). Based on their observations of 19 high-performance, team and individual sport coaches, the researchers outlined five stages of development commencing with diversified early sport participation at around six years of age. This is followed by competitive sport participation at around age thirteen, and highly competitive sport participation and introduction to coaching at about age nineteen. They suggest that it is during this stage of their developmental model (while individuals are still engaged in a regular athletic training program) the first coaching experience is obtained. This stage is followed by part-time early coaching which typically begins at twenty-four years of age. During the part-time coaching phase individuals are typically engaged in graduate studies and still participate in the sport on a recreational basis. Also, most of the coaching is at the developmental level with a considerable amount of coach mentoring taking place. The final stage of development occurs at about twenty-nine years of age when the individual becomes a high-performance head coach. This is often characterized by a full time paid position.

The above studies, which have classified coach development into various stages of development and transition points, are based on the coaches' knowledge, abilities, roles, and learning at the various phases in their growth. Although they differ across several dimensions, a common aspect to each of the models is that coach development is believed to begin prior to an actual coaching role. Specifically, the acquisition of the skills required for coaching commences during early sport participation. This skill acquisition continues, allowing a coach to progress through the different stages of coach development until they reach the pinnacle of their domain. The knowledge and skills that are accrued during coach development are acquired through an assortment of media. These sources of information can include, structured courses, coaching experience, playing experience, occupational experiences, mentoring, video observation, books, educational videos, academic journals, university and college education, the internet, personal reflection, and discussions with other experienced coaches, top level athletes, and managers (Fleurance & Cotteaux, 1999; Wrights, Trudel, & Cluver, 2007; Irwin, Hanton, & Kerwin, 2004; Lemyre, Trudel, & Durand-Bush, 2007, Gould et al., 1990). While novice coaches learn from mentor coaches, trial and error/experimentation, past athletic experience, coaching courses, training camps, observation (video and more experienced coaches), coaching manuals, and coaches from countries that are more established in the sport, experienced coaches gain their knowledge from coaching manuals, coaching videos, videos of experienced performers, and more experienced coaches, with the method of choice being context dependent (Irwin et al., 2004). To explore the various resources utilized by coaches to expand their knowledgebase, Moon's generic view of learning (Moon, 1999, 2004) will be used as a guideline as proposed by Werthner and Trudel (2006).

Moon's generic view of learning (Moon, 1999, 2004), in which learning is considered to be a network of ideas[1], suggests that instruction is not the only source of knowledge accruement. As such, learning may take place in a number of different ways. Based on this view, each source of coach education as described above can be labeled as a mediated, unmediated, or internal learning situation. Internal learning situations occur when there is a reconsideration of existing ideas in the coach's cognitive structure, and thus may occur during both mediated and unmediated learning experiences. Mediated learning encompasses structured courses that are taught by an instructor. Structured coaching courses are a fundamental aspect of coach education as numerous sport organizations require their coaches to be certified before they are allowed to coach. Many countries have developed their own coach education systems. In Canada, formal coach-education courses are offered through the National Coaching Certification Program (NCCP). The NCCP model is made up of three streams: Community sport, Competition, and Instruction. Each stream is further divided into "contexts". For example, the Competition stream is divided into three contexts: Introduction, Development, and High Performance. Through training in their chosen stream, coaches are able to become certified at the various context levels (Coaching Association of Canada). Certification programs, such as the NCCP,

[1] The network of ideas includes knowledge, feelings, and emotions, with associated ideas grouped more tightly with each other. The network of ideas represents what an individuals knows at any given point in time.

were created to ensure coaching competence at quantifiable levels, leading to safety in sport at all levels (Coaching Association of Canada). This form of mediated learning has both pros and cons (Lemyre et al., 2007; Irwin et al., 2004; Wright et al., 2007). Along with providing information on skill technique, these courses also offer guidance and networking opportunities for coaches (Irwin et al., 2004). However, during structured coaching courses, the coaches have no influence over what material will be taught. This could result in the transfer of information that is too advanced for the coaches or that does not apply to the coaches' current coaching situation (Lemyre et al., 2007).

Moon's (1999, 2004) second class of learning situation, unmediated learning, is characterized by a learning situation where there is no instructor, and the learner takes the initiative and plans what will be learned (Werthner &Trudel, 2006). Informal education is very important in the development of elite coaches (Gould et al., 1990), and many coaches take the initiative to make their own learning situations (Werthner & Trudel, 2006). Resources for this form of learning include mentors, books, educational videos, academic journals, the internet, discussions with other coaches and top level athletes, as well as coaching and athletic experiences. Mentor coaches have been identified as the most important resource for coaches at the beginning of their development (Irwin et al., 2004), and the third most import resource in the overall development of an elite coach (Gould et al., 1990). Mentors are a multidimensional resource who are able to provide an initial level of knowledge (Irwin et al,. 2004) not only in terms of technique, but also organizationally and mentally (Fleurance & Cotteaux, 1999). Books, coaching manuals, academic journals and educational videos, are used differentially based on the level of experience of the coach (Wright et al., 2007; Lemyre et al., 2007). Specifically, beginner coaches tend to use these resources for information regarding drills and technique whereas more experienced coaches rely on books and videos for information on topics such as sport psychology, nutrition, physical fitness (Wright et al., 2007), stress management and motivation (Lemyre et al., 2007). A downfall to this resource is that books and manuals are not readily available and the information that they contain is of either poor quality or too specialized and often not practical (Irwin et al., 2004). The internet is most often used to order books or to browse coaching websites, but it is also used as a means of communication (Lemyre et al., 2007).

Coach-coach and coach-athlete interactions are another informal learning situation from which coaches can benefit. In this case, the coaches are able to learn through listening and asking pertinent questions (Wright et al., 2007). Four classes of coaches have been identified with whom interactions occur for youth ice hockey coaches: coaches on the same team, coaches in the same association, coaches outside the association, and elite coaches (Wright et al., 2007). Similar to the mentor coach philosophy, assistant coaches can learn a vast amount about various coaching issues through discussions with the head coach of their team as head coaches tend to have much more experience. Conversely, head coaches may learn through discussions with their assistant coaches as they have had different experiences which may be of benefit to the head coach (Wright et al., 2007). Coaches on the same team also generally work together to develop strategies for solving coaching issues, enabling learning for all parties involved (Lemyre et al., 2007). Coaches within the same association are a good resource for information as teams from the same association rarely play each other, and coaches often see each other at meetings (Wright et al., 2007); however, discussions between coaches outside of one's association or rival coaches result in a limited opportunity for learning via discussion as these coaches do not want to share their technique or strategies with the coaches of teams against whom they are competing (Wright et al., 2007; Lemyre et al., 2007). Discussions with elite coaches are a source of learning for coaches at all levels of development (Irwin et al., 2004). For experienced coaches, seeking knowledge from foreign coaches from countries that are considered powerhouses within their sport is a popular method for coach development, as these coaches tend to have a greater technical knowledge due to the educational and professional experiences offered in their country (Irwin et al., 2004). Coach-athlete discussions are another resource for coaches. While coaches rarely seek advice or involve their athletes in their coaching discussions, athlete comments may assist coaches in their reflections and learning from past experiences (Lemyre et al., 2007).

Previous coaching and athletic experiences are often noted as the most important source of coaching knowledge. International coaching experience was identified as the first most important experience to prepare elite coaches by 130 Olympic, Pan American, and National team coaches from a range of team and individual sports (Gould et al., 1990). Coaching experience enables hands-on experience, with each coaching scenario allowing for a new learning experience (Wright et al., 2007). Athletic experience is another source of valuable coaching knowledge, which may be especially beneficial at the beginning of a coaching career (Fleurance & Cotteaux, 1999). An analysis of 16 elite level men's gymnastic coaches found that past experience as a performer was listed as the third most important source of knowledge behind mentor coaches and trial and error (Irwin et al., 2004). Benefits include an understanding of the game, an opportunity to learn various styles of coaching from different coaches (Wright et al., 2007), understanding how skills feel to perform, a better understanding of how skills are learned and developed, a better understanding of fear and anxiety of performance, as well as a better understanding of the coach-athlete interaction (Irwin et al., 2004). Further benefits of previous involvement as an athlete include an increased coaching efficacy, as the perceived level of one's own playing experience in the sport they are coaching shapes their coaching efficacy (Lirgg & Smith, 1994).

All of these sources of knowledge enable the coach to transition from one stage of development to the next, moving from beginner or developing coach through to an elite-level head coach who has an eminent awareness of their sport. Following the development of their coaching skills and knowledge, and with sufficient coaching experience and athlete development, a certain level of skill may be attained.

The Development of General Expertise and Expertise in Coaching

Research exploring expertise has been conducted for over a century. For instance, Sir Francis Galton published work on expertise at the end of the nineteenth century (Galton, 1896/1979). Galton (1896/1979) thought that superior performance was a function of heredity. This conclusion was based on the observation that within the British Isles, an individual was more apt to demonstrate superior abilities in any domain if they had a close relative who also demonstrated superior abilities. This increased potential was not domain specific, rather an individual could excel in another area than their close relative. Galton believed that three inherited traits led to this eminence: a vast intellectual ability, eagerness to work, and the power of working. Further evidence for the general abilities view of expertise came in the 1930s, when the study of intelligence emerged (Woodrow, 1946). It was during this time that the measures of IQ were developed, and it was believed that these measures of innate intelligence were a valid measure of a child's capacity for "success" in society (Woodrow, 1946). During this time, analogous to the concept of IQ, within the field of motor performance, it was a common belief that each individual possessed a general motor ability that defined their ability to perform in any given motor task. The general abilities view of expertise was largely based on intuition, however work by researchers such as Galton (1896/1979) provided a scientific basis for the idea that an individual did not possess abilities to excel in certain domains but rather possessed general abilities which encompassed their potential for all domains.

This view came under scrutiny in the 1950s and 1960s with the work of Henry (1958/1968) and Fleishman (1964, 1965, 1967) who conducted research exploring individual differences and individual differences in aviation, respectively. Henry (1958/1968) believed that each individual possessed a vast number of independent abilities that were of differing levels (strong, weak, average). The performance of any skill is the summation of many of these abilities, and thus those individuals that excel in the abilities required for a skill will excel in the performance of that skill. Further support for this specific motor abilities comes from factor-analytic studies. Factor-analytic studies use the factor analysis statistical method to examine which abilities are crucial in the performance of given skills. Examples of these abilities include: Control precision, multi-limb coordination, response orientation, reaction time, speed of arm movement, rate control, manual dexterity (Fleishman, 1964, 1965, 1967).

Although it is still commonly thought that individuals are born with an innate talent for certain activities, the current view in the literature is based on the concept of nurturing rather than a nature viewpoint. This approach suggests that expertise is achieved primarily through practice directed at specific skill rather than a more global natural ability.

Using this specific abilities approach as a general principle, Ericsson and colleagues (Ericsson, Krampe, & Tesch-Romer, 1993) described a framework supported by two studies that explained the acquisition of expert performance in terms of deliberate practice. Using expert violinists and pianists as participants, Ericsson proposed that the difference between expert performers and typical adults is determined almost exclusively by years of deliberate effort to improve their abilities in a specific domain. The main concept behind Ericsson's framework is the "monotonic benefits assumption" which states that the amount of time an individual is engaged in deliberate practice activities is linearly related to that individuals acquired performance. Based on Simon and Chase's (1973) examination of expertise in chess, as well as the results from their own two studies (Ericsson et al., 1993), the deliberate practice model suggests that it takes a minimum of ten years (or 10,000 hours) to attain an expert performance level. However, as it is proposed that deliberate practice is the primary determinant of expertise, deliberate practice must be present and increasing throughout the ten-year period. There are three main predictions made by Ericsson's (1993) framework. The first is that the largest improvements in performance, and subsequently the highest attained performance is associated with the largest weekly amounts of practice. The framework also suggests that deliberate practice would be rated very high to relevance to performance and effort and low on inherent enjoyment. Finally, individual differences in performance at a given age are a function of acquired characteristics, which in turn are directly related to the accumulated amounts of deliberate practice.

Ericsson's framework on expertise also suggests that the acquired skills are very specific to the domain that is practiced throughout that period. Further evidence for this specificity of practice in terms of expertise, comes from a study exploring "software" and "hardware" skills in elite, mid-level, and novice field hockey players (Starkes, 1987). Software skills were defined as those that correspond to knowledge and strategies that can be readily changed as a function of training and learning, and thus specific to the domain of expertise. Hardware skills are those that are innate and general in nature, and cannot be changed with training. This study found that the elite players demonstrated superior abilities in the software skills than the mid-level and novice players, and the mid-level players out-performed the novice group. On the hardware tests, no group differences were seen. From these results, it can be concluded that practice leads to expertise in those cognitive skills related to the specific area that was practiced, but does not affect global skills such as general reaction time.

Along with the specificity of the skills that are acquired, expertise is also highly related to the role within the domain in which the participation occurs. In sport there are players, coaches, and referees. Each of these positions requires the participant to excel at different sub-tasks within the global sport. When compared in basketball for example, officials are best at identifying rules, signals, fouls, and violations, while coaches are able to recall most accurately real versus random play scenarios. Finally, players are best at recalling plays following a very brief (five second) exposure (Deakin & Allard, 1992).

Within the coaching domain, however, there is no set definition of expertise and no concrete criteria for being considered an expert coach. This is due to the wide range of coaching behaviours and personalities that have led to success in coaching, as well as the difficulty in finding appropriate criteria to define expertise in this domain (Dodds, 1994). Unlike an athlete's performance, which may be easily quantified, measured, and assessed, a coach's performance is very difficult to assess. Due to the lack of defined criteria to delimit expertise in coaching, various standards have been used to select expert coaches in research. Typically, expertise is defined by a combination of several measures including: the number of years of coaching experience, the performance levels attained by their athletes, the level they attained when in professional competition, and the recognition of expertise by their peers (Cote, Salmela, Trudel, Baria, & Russell, 1995).

Although no set definition of an expert coach is universally agreed upon, it is still possible to look at the differences between novice coaches and coaches with substantial experience, as experience and practice are vital to Ericsson's framework of expertise. Differences between novice and experienced coaches are apparent in the coaches' behaviour during practice sessions (Alhgren, Housner, & Jones, 1998), the coaches' knowledgebase (Leas & Chi, 1993), and in their fine discrimination abilities (Pinheiro, 1989 as cited in Pinheiro & Simon, 1992). An exploration of behaviour demonstrated by novice and experienced coaches during practice sessions has demonstrated some key differences. Both novice and experienced coaches tend to stick with their practice plans. However, when problems arise, inexperienced coaches are significantly more reluctant to alter their plans (Alhgren et al., 1998). Also, during practice sessions, experienced coaches verbalize significantly more technical instructions, whereas novice coaches exhibit a significantly higher frequency of silent observation (Ahlgren et al., 1998). Further, while novice coaches tend to make their athletes practice tasks that are unrelated to the objectives of the lesson and may permit their athletes to demonstrate marginal performance levels, experienced coaches tend to design progressive lessons that include goal relevant tasks (Ahlgren at al., 1998).

The differences between expert and novice performance on knowledge tests have been demonstrated in a number of domains (eg. Abernethy, Neal, Konig, 1994; Ste-Marie, 1999). In a study conducted by Abernethy and colleagues (1994), it was demonstrated that expert snooker players had a greater depth and breadth in their ability to process task specific information as demonstrated through the consideration of alternative plays, and planning plays further in advance relative to their novice counterparts. Further evidence for the differences in the knowledgebase of novice and experts comes from gymnastics judges, where it has been shown that experienced judges have a larger knowledgebase than their novice counterparts (Ste-Marie, 1999). In an examination of the discrepancies between novice and experienced coaches' declarative knowledge, Leas and Chi (1993) showed that experienced coaches demonstrate a superior knowledgebase as reflected by their greater amount of skill specific knowledge, the greater degree of linkage within their knowledge, and depth (Leas & Chi, 1993). For example, when a group of swimming coaches were asked to analyze the freestyle stroke for error identification, experienced coaches elaborated on each component of the stroke (body position, arm stroke, kick, and breathing), and connected each of their ideas. Novice coaches on the other hand, demonstrated a narrow focus of attention by only critiquing the arm stroke, and were not able to connect their ideas into a fluid explanation (Leas & Chi, 1993).

In coaching, offering feedback to one's athletes is vital in error correction and promoting the acquisition of proper techniques. In order to provide feedback, coaches may rely on quantitative or qualitative analyses. While quantitative analysis utilizes sophisticated electronic devices that allow objective evaluations, qualitative analysis is based on simple visual observation. Due to time constraints, qualitative analysis is typically employed during training sessions. Many studies have shown that in qualitative skill analysis, the differential threshold between two performances, or a performance and the ideal, may be lowered (improved) through practice. For example, while examining a videotape of shot put throws, experts detected 40% of the errors while novices were only able to detect 13.3% (Pinheiro, 1989 as cited in Pinheiro & Simon, 1992). This increased success at identifying errors is the result of the experts acquiring more cues, making more cue interpretations and diagnostic decision, as well as showing better diagnostic accuracy than did the novice coaches. The novice coaches also diagnosed the performance on a more superficial level causing them to miss some key errors. This differential in performance by the two groups may be related to the fact that any level of processing beyond detection (i.e., the awareness that a stimulus is present) requires a comparison between the stimulus and the information that is stored in our long-term memory. Pinheiro and Simon (1992) suggested an operational model of motor skill diagnosis that incorporates three major processes: cue acquisition, cue interpretation, and diagnostic decision. These three processes are not discrete but rather closely intertwined. During the first step of motor skill diagnosis, cue acquisition, information is acquired that can trigger recognition processes. The second stage of the model, cue interpretation, consists of finding possible meanings for the cues by extrapolation. This is based on information that is stored in long-term memory from our previous experiences. One's ability to interpret cues is positively related to diagnostic accuracy (Pinheiro, 1989 as cited in Pinheiro & Simon, 1992). The diagnostic process terminates with a judgment or opinion about the performance.

Of course, any assessment of the depth and breadth of any knowledgebase is predicated upon the mediating influence of memory. Our long-term memory serves as a reference against which novel stimuli may be compared. Thus, as we become more experienced in a task, our long-term memory, or internal reference, becomes strengthened, allowing for an improved ability in fine discrimination. For example in Pinheiro's (1989 as cited in Pinheiro & Simon, 1992) shot put study described above, following the presentation of a single performance of a skilled shot-putter, expert coaches were able to detect an average of twelve cues to error in performance while the novices only indicated seven. Numerous resources can assist in the development of the internal reference through increased procedural and declarative knowledge. As described previously in the section exploring the acquisition of knowledge in coaches, coaches may acquire knowledge through an ideal technique from a textbook, evaluation based on one's own experience as an athlete and coach, norms from professional journals and from theoretical evaluations by other coaches, knowledge of the world record holder's technique, a statistical norm of the techniques built on empirical data from the highest quality performances, and scientific data based on biomechanical analysis.

A further discrepancy between the skills of novice and experienced coaches is evident in an examination of eye-gaze patterns while watching an athlete perform. Eye-gaze patterns are an important source of information as it is assumed that our attention is directed towards that upon which we are fixated. Moreno and colleagues (Moreno, Reina, Luis, & Sabido, 2002; Moreno, Saavedra, Sabido, & Luis, 2006) explored the effects of coaching experience on eye-gaze patterns in swimming and gymnastics coaches. In both studies, novice and experienced coaches were asked to watch videos of their respective sports while wearing an eye-tracker to analyze their eye gaze patterns and measure their fixations. Eye movements are divided into fixations and saccades (when the eye gaze pauses in a certain location and when it is moving, respectively). Analysis of the eye-gaze patterns of the swimming coaches revealed that the experienced coaches allocated a different proportion of their attention on various body segments relative to the novice coaches. For example, when examining a video of a swimmer doing the front crawl, experienced coaches spent more time fixated on the athlete's hand and the area where the hand entered the water as compared to the novice coaches (Moreno et al., 2006). While examining the eye-gaze patterns of gymnastics coaches, the researchers found that national-level gymnastics coaches made significantly less eye fixations while watching a gymnastics sequence relative to first-year gymnastics students (Moreno et al., 2002). The researchers concluded that the decrease in the number of eye fixations, and subsequently longer eye fixations, demonstrates that experienced coaches may exhibit a more selective and non-active searches, as they are assumed to know the most informative areas of the stimulus. On the other hand, novice coaches are required to perform extensive searches to find errors. This study demonstrated that over time, gymnastics coaches are able to define their error-detection skills, and select which areas will be of greater importance during the cue acquisition stage.

The Transfer of Skill in Sport and Pedagogy

The transition from athlete to coach, athlete to official, referee, or judge, and the transition from coach to judge occur frequently within the domain of sport. Once athletes retire from athletic competition, they frequently turn to coaching or refereeing to give back to their sport. Active coaches are also often certified referees or judges; or once an individual retires from coaching, they remain active within the sport as a referee or judge. Researchers have explored these transitions to examine what skills, if any, these individuals bring with them to a new role within the same sport from their prior experiences. This line of research has found no clear conclusions on the relationship between previous experience in one role within a sport and current performance in another role. To explore this relationship, researchers have turned to two domains: sport and physical educator training. In sport, researchers explore the relationship between athletes, coaches and referees (MacMahon, Helsen, Starkes, & Weston, 2007; Rodgers & Allard, 1990; Schorer, Baker, & Bernd, 2007). While in teacher education, the relationship between the skills taught during teachers college (physical education teachers are taught how to perform the skills which they will be teaching once they enter the work force) and the ability to teach these skills is explored (Girardin & Hanson, 1967; Osborne & Gordon, 1972).

The relationship between previous athletic experience and current judging or refereeing expertise has been explored in diving, figure skating, and soccer. In 1990, Rodgers and Allard explored this phenomenon within the sports of figure skating and diving. The results of this study confirmed a significant relationship between performing and subsequently judging at either a World Championships or the Olympic Games, arguably two of the most important competitions on the international stage. This study explored the correlation between previous performance as an athlete and selection to judge at these prestigious international events. The authors suggest this leaves much room for discussion regarding the cause of this relationship. For example, although the superior performance as a judge may be the potential causality of this relationship, other factors such as an increased knowledge of the politics within the sport, more connections within the sport governing bodies, superior motivation, or a better work ethic may also be the cause of this relationship (Rodgers & Allard, 1990). A second study, exploring this relationship in soccer found opposing results. MacMahon, Helsen, Starkes, and Weston (2007) demonstrated that elite soccer referees are not simply retired coaches and athletes who have taken on another role within their sport. Rather, the researchers concluded that FIFA referees specialized early on in that role, and have committed a great deal of time in developing the necessary skills. The goal of the studies conducted by Rodgers and Allard (1990) and MacMahon and colleagues may be at the root of the opposing results. While Rodgers and Allard simply looked to find a correlation between competing and subsequently judging at prestigious competitions, MacMahon and colleagues (2007) looked to see if the skills required to excel as a referee were also possessed by participants in other roles within soccer (i.e., players & coaches), as well as the forms of training that were undertaken by the referees. Rodgers and Allard (1990) were able to demonstrate that there is a link between excelling as an athlete and subsequently excelling as a judge, however MacMahon and colleagues (2007) were able to demonstrate that this relationship was not the result of the skills acquired whilst training as an athlete.

The relationship between previous athletic experience and current coaching expertise has also been explored. Schorer, Baker, and Bernd (2007) conducted a study which explored the relationship between previous experience as an athlete and current perceptual-cognitive coaching abilities. For this investigation, the researchers used soccer coaches with varying degrees of experience as a coach, and varying degrees of previous playing experience. The participants were asked to complete a pattern-recognition task as well as a decision-making task. The results showed that although there was a clear relationship between coaching experience and pattern-recognition, no other significant correlations emerged: previous experience as an athlete did not have an effect on current coaching abilities.

In the late 1960s and early 1970s, a series of studies were conducted to explore if there was a relationship between the ability to perform and the ability to diagnose execution errors in the realm of pedagogy. These studies were based on the notion that in university level physical education curriculums there is a lot of time spent on learning how to perform the basic elements from various sports. However, when the graduates from these programs become physical education teachers, their job is based on error detection rather than on skill performance. The participants used in these studies were all novices, as they only had a limited amount of experience with the given sports in their university curriculums. One study conducted by Girardin and Hanson (1967), explored if a relationship existed between the ability to perform eleven tumbling skills and the ability to diagnose errors of execution in the same skills. Thirty-two male physical education majors participated in this study. First, the subjects' performance of the eleven skills were video-taped and evaluated by a panel of expert judges. Then, the participants were asked to diagnose errors in the execution of each of the eleven skills from a video presentation of a demonstrator. The results of this study revealed a significant positive relationship between the participants ability to perform a skill and their ability to diagnose execution errors.

A second study, which explored the effects of the participants own skill upon their accuracy in error detection (Osborne & Gordon, 1972) utilized tennis as their domain of study. The participants in this study were ninety male college students who were enrolled in a beginner tennis course. The participants were asked to rate six specific movements involved in the performance of the eastern forehand stroke. The sequences were presented on video in slow motion. Unlike the study conducted by Girardin and Hanson (1967), this study was unable to find a relationship between the participants ability to diagnose error and their skill level.

Coaching science research has enabled a better understanding of the processes involved in excelling as a coach. Through the proposed coach development models (Salmela, 1994; Salmela et al., 1994; Schink et al., 1995; Erickson et al., 2007), it has been shown that the coach's knowledgebase is ever evolving, and this enables the coach to propel themselves through the various phases of coach development, beginning with early sport involvement and terminating at the pinnacle of their domain. Numerous resources are utilized by the coaches in expanding their knowledgebase, including: structured courses, mentors, books, educational videos, academic journals, the internet, discussions with other coaches and top level athletes, as well as coaching and athletic experiences. Research on coach development and coaching knowledge acquisition have demonstrated the importance of athletic involvement, especially at the beginning of a coaching career. However, research on the transfer of skills in sport have found no clear relationship between performing and coaching a given set of skills.

Intuitively, one may think that individuals with previous athletic experience would make better coaches. During one's athletic career, much knowledge pertaining to the sport can be acquired which may assist in the coaching role. However, there is also the old adage: "those who can't do, teach" which opposes this view. The academic literature does not assist in finding a clear understanding of this relationship as no consistent conclusions may be found. This is because researchers have not investigated this relationship in an in-depth fashion.

Researchers have explored coaching science via many paths, however, this research has remained distinct and incomplete. For example, researchers have explored the development of coaching skills and knowledge, as well as the traits possessed by highly experienced coaches, however, researchers have not conducted any studies which have linked the current knowledge from both of these sub-areas. If the underlying question: Does previous athletic experience lead to superior coaching abilities? was answered, this would assist in linking the current research in the coaching science discipline as information from many areas of research would be used in such an investigation. Along with filling the gap in the current body of knowledge, discovering the nature of the relationship between athletic and coaching experience and abilities would also assist in creating learning resources which would be applicable to the development of coaches with and without previous athletic experience.

Experiment 1

Introduction

Research on the relationship between athletic and coaching experiences can be found in two distinct literatures: coach development and the transfer of skill in sport and pedagogy. The first, coach development, has been studied qualitatively and in a retrospective manner. Researchers have sought out experienced coaches, and via interviews and questionnaires, have determined the various stages of coach development and the forms of knowledge acquisition utilized in each of these phases. These studies have found that the benefits of prior experience as an athlete include an understanding of the game, an opportunity to learn various styles of coaching from different coaches (Wright et al., 2007), an understanding how skills feel to perform, a better understanding of how skills are learned and developed, a better understanding of the fear and anxiety felt during performance, as well as a better understanding of the coach-athlete interaction (Irwin et al., 2004).

The second line of research, the transfer of expertise in sport and pedagogy, has utilized various quantitative experimental and correlational design protocols to study the relationship between knowing how to perform a skill and knowing how to teach a skill. Unfortunately, studies in this area have not been able to derive a clear and causal relationship between previous experience as an athlete and current coaching abilities. For example, Schorer, Baker, and Bernd (2007) concluded that there was no relationship between previous experience as an athlete and current perceptual-cognitive coaching abilities in soccer coaches with varying athletic and coaching abilities. However, Girardin and Hanson (1967) discovered a significant relationship between the ability to perform eleven tumbling skills and the ability to diagnose errors of execution in the same skills in a group of physical education students who were both novices in terms of athletic experience and coaching experience.

The first experiment in this thesis aims to bridge the gap between these two lines of research, and answer the underlying question: Does a demonstrable relationship exist between previous athletic experience and current coaching abilities? This study focused on the coaches' knowledgebase and error detection and identification abilities. Based on the coach development literature, participants were divided into novice and experienced coaches, as these two groups have been shown to both possess a differing knowledgebase (Leas & Chi, 1993) and use different opportunities for knowledge acquisition (Fleurance & Cotteaux, 1999). This division of the novice and experienced coaches takes the quantitative research conducted in the transfer of skill literature to a new level since none of the prior research has concurrently explored two groups with differing levels of coaching experience. Unlike the majority of the studies aimed at exploring coach development, the present experiment employed a quantitative approach similar to those proposed in the transfer of skill literature. Participants were further divided into those with and without prior athletic experience. These experiential divisions thus resulted in four groups of participants (see Method section).

It was hypothesized that the experienced coaches would outperform the novice coaches on all tasks. This prediction was based on research from the expertise literature which assumes, based on the "monotonic benefits assumption" that practice leads to superior performance (Ericsson et al., 1993). Further evidence for this hypothesis is found in the coaching science literature where it was found that experienced coaches have a more in-depth knowledgebase (Leas & Chi, 1993), as well as superior error diagnosis skills (Pinheiro & Simon, 1992). Based on the coach development literature, it was also hypothesized that novice coaches with prior experience as an athlete would demonstrate a superior performance as they have had a greater exposure to the skills they are coaching through their athletic participation. However, for experienced coaches, it was predicted that no differences would emerge based on their athletic histories, as their domain specific training as coaches would negate any previous athletic experiences.

Method

Participants

Twenty-three elite gymnastics coaches from the Southern Ontario region volunteered to participate in this experiment. All of the participants were currently working with gymnasts who were competing at the provincial or national level, and were minimum level 2 NCCP certified coaches. The participants were divided into four groups defined by their athletic and coaching histories. Experienced coaches were defined as having at least seven years experience coaching competitive gymnastics (provincial and national level athletes), while novice coaches were defined as those with less than 3 years of competitive coaching experience. This maximal value of three years is in accord with the selection criteria for the novice coaches in a study examining error diagnosis by competitive swimming coaches (Leas & Chi, 1990). To define previous athletic experience, the criteria were having a minimum of ten years experience as an athlete with a minimum of three years competing at the provincial or national level for those considered to have previous playing experience, versus no experience competing at a provincial or national level for those without previous playing experience.

Thus, Group 1 (Novice/Novice) consisted of five novice coaches (4 female, 1 male; age: mean = 34.6, sd = 14.6 years) with no previous experience as a competitive gymnast. These coaches had an average of 2.2 (+/- 1.1) years of coaching experience at the provincial or national level, and 3.5 (+/- 1.9) years experience as a gymnast at a recreational or high school level. Group 2 (Novice/Experienced) consisted of seven novice coaches (4 female, 3 male; age: mean = 22.4, sd = 3.5 years) with 7.9 (+/- 2.3) years of experience as a gymnast competing at the provincial or national level. The participants in this group had been coaching at the provincial or national level for 2.3 (+/- 1.1) years. Group 3 (Experienced/Novice) consisted of five experienced coaches (4 female, 1 male; age: mean = 35.8, sd = 8.3 years) with no previous experience as a competitive gymnast. These coaches had an average of 15.0 (+/- 5.0) years experience working with elite level athletes, and 4.0 (+/- 0.7) years of athletic experience at the recreational or high school level. Group 4 (Experienced/Novice)consisted of six experienced coaches (4 female, 2 male; age: mean = 32.8, sd = 14.3 years) with 8.0 (+/-3.2) years of experience competing at the provincial or national level. These participants had been coaching at the competitive level for 15.7 (+/-10.7) years.

Data from one of the participants in the Error Identification task were removed as this participant was unable to complete the task. This participant was from Group 2 (Novice/Experienced), thus leaving this group with 6 participants for that portion of the experiment.

Apparatus and Procedure

This study analyzed performance across three tasks: Simple Reaction Time (RT), Skill Specific Error Identification (EI), and Knowledgebase (KB). The first two tasks of the experiment (RT, EI) were completed on a laptop computer that was programmed to present video images of different gymnastics sequences. The third task (KB) was completed using pen and paper.

The gymnastics footage was taken from both the 2006 Elite Ontario and the 2007 Canadian Championships. Athletes' competition levels ranged from provincial level 6 (Ontario Competitive Program ranges from level 2-9 with athletes becoming provincial eligible at level 5) to National Open. The video clips were chosen from the digitally recorded competition tapes, and converted to a format compatible with standard video playback software. The videos were then cropped into seven second lengths using *Adobe After Effects 6.5*. *E-Prime* v2.0 computer software was used to build a customized program which allowed for a randomized presentation of the video clips as well as response time logging.

The participants were tested at the gymnastics club at which they coach in a quiet room. They were seated at a desk at a comfortable distance from the laptop. To ensure the participants were able to focus on the experiment, only the coach being tested as well as the tester were in the room while the experiment was being completed. For all three tasks, the coaches were presented with written instructions prior to commencing on the laptop (See appendix A). If the participants were unclear on the process, they were allowed to ask for clarifications from the tester who was in the room.

<u>Reaction Time</u>:

Because performance on later experimental trials was determined in part by the speed of stimulus identification, it was important to verify that there were no differences in Simple Reaction Time between groups. For this reason, participants were required to complete a Simple Reaction Time test. Participants were presented with a series of video clips of gymnastic sequences on either uneven bars, balance beam, or floor exercise. During the presentation of this video, a solid yellow circle appeared over the athlete's hip for 300 ms. The yellow circle was inserted into the video clips using *Adobe After Effects* 6.5. The participant was asked to stop the video as soon as the yellow circle appeared over the athlete's hip by pressing the space bar. A total of 15 trials were conducted, using 5 different video sequences. The yellow dot appeared at one, two, three, four or five seconds into the seven second video clip. Videos were presented to the participants in a randomized order. During this phase of the experiment, reaction time was measured in milliseconds.

<u>Error Identification</u>:

Participants were presented with seven second video clips of gymnastic sequences on uneven bars, balance beam, or floor exercise. Eight video sequences from each event were used, and each video clip was presented twice, in a randomized order. The gymnastic sequences contained either none, one, or multiple technical errors, with these errors occurring at various points throughout the video clips. In five of the videos, the error occurred in the first third (0-2.33 seconds), in seven of the clips the error occurred during the middle segment of the video (2.33-4.67 seconds), and in six videos the error occurred during the last third of the gymnastic sequence (4.67-7 seconds). The remaining six video clips had no technical errors[2].

Following presentation of the video clip, participants were prompted with the question: "Was there a technical error during the performance of this gymnastic sequence?" This question was presented visually on the laptop, and the participants were given the option to answer 'Yes' or 'No'. If the participant believed that the performance was flawless, they proceeded to the following video clip. If the participant believed that there was a technical error in the performance, they were presented with the video a second time. The second presentation of the video was in slow motion (half time). During the second presentation, the participants were asked to stop the video when they believed the first technical error occurred. For this portion of the experiment, the variables that were measured were error perception, and, if they perceived a technical error, the time at which that error occurred (ms).

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[2] Prior to data collection, two experienced gymnastics coaches watched the videos frame by frame for error analysis. The first coach had 35 years of coaching experience and had coached athletes at the international level. The second coach had ten year of experience working with provincial and national level athletes. Only the video clips in which both experienced coaches believed there were errors and agreed on the initial error were used in this study.

Knowledgebase:

Following the completion of the Error Identification stage, the participants completed a knowledgebase test to determine if athletic or coaching experience affects a coach's declarative knowledge (see Appendix B). During this phase of the experiment, participants were presented with a list of nine common acrobatic gymnastic elements. The list included three elements from uneven bars: Kip, Giant, and Layout Flyaway; three elements from balance beam: Round-off, Back Handspring, Aerial Cartwheel; and three elements from floor exercise: Front tuck, Back Layout Full Twist, and Whip back. The participants were asked to list as many technical errors as they could that were associated with each of the listed elements. As the nine elements during this portion of the experiment were selected from those presented during the Error Identification stage of the experiment, this phase was completed last to avoid any primacy effects during the video phase. The number of errors listed was used as the dependent measure for this portion of the experiment.

It took the participants approximately forty minutes to complete all three phases of the experiment, and the testing took place at a time and place that was convenient to the participants.

Data Reduction and Analysis

All collected data are presented in Table 1. Two separate analyses were conducted on these data. To compare mean performance across groups on each of the dependent variables, analyses of variance were conducted using a 2 (coaching experience: novice vs. experienced) by 2 (athletic experience: no experience vs. competitive athletic experience) design. For all of these initial analyses, as well as all post hoc analysis procedures, alpha was set at .05. In order to further interpret these results, signal detection procedures were employed to determine group specific measures of perceptual sensitivity and response bias.

Insert Table 1 about here

Reaction Time

Analysis of variance, revealed no significant main effects for coaching experience ($F(1,19)=0.284$, $p.=0.600$) or athletic experience ($F(1,19)=0.331$, $p.=0.572$) and no significant interaction ($F(1,19)=0.280$, $p.=0.603$) (See Table 1).

This result suggests that neither previous coaching nor athletic experience reliably affected participant's performance on the detection of, and response to, a non-sport specific stimulus. Thus, any reaction time differences observed in the later Error Identification task can legitimately be considered to arise from condition specific variables rather than from any "global" reaction time advantages or disadvantages associated with coaching experience or athletic participation levels.

Error Identification Task

The first step in the Error Identification task was for the participants to detect if an error was present in the viewed clip (See Table 1). In keeping with other studies in this vein, performance data are presented as percent correct (e.g., Pinheiro, 1989 as cited in Pinheiro & Simon, 1992). The experienced coaches were 13.3% more accurate in detecting the flawed videos relative to their novice counterparts. Whereas experienced coaches were able to correctly detect flawed videos 74.8% (+/- 4.7%) of the time, novice coaches were only able to correctly detect 61.4% (+/- 9.9%) of the videos with technical errors. Analysis of variance revealed that this coaching experience percentile difference in error detection performance was significant, ($F(1,18)=14.916$, $p.=0.001$). There was, however, no effect for athletic experience ($F(1,18)=0.0007$, $p.=0.980$), nor was there an interaction of coaching and athletic experience ($F(1,18)=0.163$, $p.=0.691$) (See Figure 1) .

Insert Figure 1 about here

Because the temporal order of errors is an important aspect of coaching, an examination of the coaches' ability to identify the first error in the videos which contained one or more technical errors ensued. Each gymnastic element can be divided into distinct phases. For example, the Giant swing on bars can be divided into three phases: the downswing, the tap, and the up swing. To be considered a correct response, the coach had to identify the error in the same phase of the skill in which the error actually occurred. Results of this analysis revealed a significant main effect for coaching experience ($F(1,18)=22.715$, $p.=0.0002$) and a significant interaction of athletic and coaching experience ($F(1,18)=5.338$, $p.=0.03$). Specifically, the experienced coaches were 16.6% more accurate in identifying the first error in a video than were the novice coaches. Although the experienced coaches were able to correctly identify the initial error in 43.1% (+/- 10.6%) of the flawed videos, the novice coaches were only able to identify 26.5% (+/- 9.3%) of the initial errors in the videos with technical errors. Tukey's HSD Post Hoc analysis of this interaction revealed that although there were no differences for athletic experience for the experienced coaches, in the novice coaches, the participants without previous experience as an athlete (Group 1) demonstrated a superior performance than those who were previously competitive level gymnasts (Group 2) (See Figure 2).

Insert Figure 2 about here

Of course, it is possible that participants in the different groups may have adopted different strategies to complete the task that may have influenced these results. For example, it is possible that novices coaches may have been more likely to respond "yes" to whether an error was present than would experienced coaches (i.e., they would adopt this more liberal bias to counteract a smaller knowledgebase). Thus, to further explore the group differences in the Error Identification task, a simple Signal Detection analysis (on measures of sensitivity and bias) was conducted following which Analysis of Variance was carried out on individual sensitivity and bias data. Individual sensitivity and bias scores were calculated using individual 'hit' and 'false alarm' rates which were then computed into sensitivity and bias scores using a Standard Normal Curve with a mean of zero and a standard deviation of one. Results of the analysis for sensitivity revealed no significant main effect for coaching experience ($F(1,18)=1.652$, $p.=0.215$) or athletic experience ($F(1,18)=0.142$, $p.=0.711$). There were also no significant main effects for bias (Coaching experience ($F(1,18)=2.766$, $p.=0.114$); Athletic Experience ($F(1,18)=1.631$, $p.=0.218$)). The lack of significant results may be attributed to the large variability within and between groups. However, group means were examined to further explore the sensitivity and bias displayed by the coaches. Group sensitivity and bias values were calculated using the mean 'hit' rate and 'false alarm' rate for each group. Although not significant, experienced coaches were marginally more sensitive to errors than novice coaches ($d'=1.066$ vs. $d'=0.788$). Experienced coaches also exhibited a slightly more liberal bias toward error detection when compared to novice coaches ($\beta=0.722$ vs. $\beta=1.180$). Further analysis of the difference between the novice coaches without previous athletic experience (Group 1) versus novice coaches with prior athletic experience (Group 2) showed that, although no differences emerged in terms of sensitivity to errors ($d'=0.847$ vs. $d'=0.730$), there were experience specific marginal differences in response bias. Specifically, Group 2 was slightly more conservative in their detection of errors ($\beta=1.284$ vs. $\beta=1.085$) when compared to Group 1. For the experienced coaches, previous experience levels as athletes did not influence either sensitivity (Athletic experience, $d'=1.165$ vs. No athletic experience, $d'=1.032$) or response bias (Athletic experience, $\beta=0.646$ vs. No athletic experience, $\beta=0.762$).

Knowledgebase

A total of 179 errors were identified across all nine gymnastic elements by the participants on the Knowledgebase task. Each participant's performance was measured as the percentage of identified errors relative to all of the identified errors. Analysis revealed a significant main effect for coaching experience ($F(1,19)=7.113$, $p.=0.016$). No significant main effect for athletic experience emerged, nor was there a significant interaction. On this task, the experienced coaches were able to identify more technical errors associated with the nine listed gymnastic elements relative to the novice coaches. On average, experienced coaches were able to list 6.2% more of all identified errors than the novice coaches or 23% more errors (See Figure 3).

Insert Figure 3 about here

Discussion

Novice versus Experienced coaches

The findings of this experiment revealed that experienced gymnastics coaches (Group 3 and 4) have a greater declarative knowledge of potential errors and superior error detection and identification abilities than do novice gymnastics coaches (Group 1 and 2). These results are in agreement with previous findings in coaching science research as well as in the expertise literature. Based on the "monotonic benefits assumption" proposed by Ericsson and colleagues (1993), it is expected that the experienced coaches who have more domain specific experience would demonstrate superior coaching skills as they have accumulated more hours of deliberate practice. More specifically, research on coaches' declarative knowledge has previously found that experienced swimming coaches demonstrate a superior knowledgebase as reflected by their greater amount of knowledge, the greater degree of linkage within their knowledge, and the greater depth of their knowledge (Leas & Chi, 1993). Although the current experiment did not examine the degree of linkage or depth of the coaches knowledge, the current results are in agreement with the those found by Leas and Chi (1993), with the experienced coaches citing a significantly higher number (23% more) of technical errors than the novice coaches. Coaching experience also leads to improved error diagnosis skills. Based on Pinheiro and Simon's (1992) operational model of motor skill diagnosis, it is thought that through practice, coaches are able to strengthen their internal reference against which they compare the incoming stimulus, leading to superior fine discrimination skills. The demonstrated improved performance is the summation of superior abilities in cue acquisition, cue interpretation, and diagnostic decision.

The results from the Error Identification task revealed that the experienced coaches were only able to identify the initial error in 43.1% (+/- 10.6%) of the videos with technical errors. Although this value may seem quite low, it is in agreement with previous coaching studies exploring error diagnosis. In an examination of shot put coaches, expert coaches were only able to identify 40% of the errors on the initial viewing of shot put throws (Pinheiro, 1989 as cited in Pinheiro & Simon, 1992). However, on subsequent viewings of the videos, the expert coaches were able to pick up another 44% of the errors. If the experienced coaches in this experiment were allotted more than two viewings of each gymnastic sequence, perhaps they would also demonstrate an increased error identification accuracy.

Although no significant differences emerged in an Analysis of Variance, presumably due to the large individual and group variability, group means were used as a means to explore the sensitivity and bias displayed by the coaches in this experiment. The Examination of the sensitivity and the bias of the novice and experienced coaches gives further evidence of the superior error detection abilities in the experienced coaches. The experienced coaches demonstrated a marginally greater sensitivity relative to the novice coaches (d'=1.066 vs. d'=0.788). This suggests that the experienced coaches were generally more apt to detect an error than the novice coaches, suggesting that the experienced coaches have developed a superior eye for error detection. As suggested by Moreno and colleagues (2002), who found that experienced gymnastic coaches make fewer fixations while examining gymnastics videos. Presumably, through practice, the experienced coaches have learned the important areas for error detection, and can thus fixate on those areas while watching a gymnastic element. This in turn leads to a superior cue acquisition, which is the first step in Pinheiro and Simon's model for error detection (1992).

There was also a slight differential in the bias. The experienced coaches set a marginally more liberal bias than the novice coaches (β=0.722 vs. β=1.180). While the slight differential in the sensitivity can be explained by the individuals ability to detect errors, the differential in the bias may be explained by the level of perfection expected by the coaches. Through practice, the experienced coaches might understand the importance of perfection in gymnastics. As the performance of gymnastics skills and sequences is complex and includes many degrees of freedom, if an error occurs early, many subsequent technical errors may follow that result from that initial error. Therefore, as a coach, it is vital to pick out the first error in the sequence, as this is typically the cause of all the other errors. Even slight errors at the beginning of a gymnastic element or sequence can have detrimental effects on it's overall performance.

Athletic experience versus no athletic experience

Prior experience as an athlete differentially affected the coaches' performance based on their degree of coaching experience as well as the task which they were completing. As expected, the experienced coaches level of athletic experience did not have an effect on their performance on any of the tasks. There were no differences in performance on the Error Identification task or the Knowledgebase task in the two groups of experienced coaches. Group 4 identified the initial error in 43.0% (+/- 8.9%) of the flawed videos, Group 3 identified 43.3% (+/- 13.4%) of the initial error in the flawed videos. In the Knowledgebase task, Group 4 identified 27.6% (+/- 5.8%) of all identified potential errors, Group 3 identified 27.3% (+/- 6.5%) of all the identified potential errors. It may be assumed that their domain specific practice as a coach supercedes any previous athletic experiences, as expertise has been shown to be domain specific (Deakin & Allard, 1992). Although coaches may still draw on their experiences as an athlete later in their career, coaching experiences become of greater value in their skill development (Fleurance & Cotteaux, 1999).

Novice coaches may be able to draw on their previous experiences as an athlete since they have not yet acquired substantial domain specific experience as a coach. As suggested by Fleurance and Cotteaux (1999) previous athletic experiences are of greater importance for coach development during the initial years of coaching. Based on this suggestion, it may be hypothesized that the novice coaches with previous athletic experience would outperform the novice coaches without this experience. However, the results of the current experiment do not support this hypothesis. No differences were observed in the novice coaches' knowledge of potential technical errors on the Knowledgebase test, with Group 1 naming 21.7% (+/- 5.8%) of all the identified errors, and Group 2 identifying 20.8% (3.8%) of the identified errors. There were also no differences in detecting flawed videos in the Error Identification task. Group 1 detected 62.1% (+/- 10.0%) of the flawed videos, and Group 2 detected 60.8% (+/- 10.7%) of the flawed videos. Although these results are not supported by certain coach development models in which coach development is thought to begin during athletic involvement (I.e., Erikson et al., 2007), these results are in accord with other studies based on the transfer of skills in sport which have explored the relationship between prior athletic experience and current coaching abilities (Ie., Schorer et al., 2007) that found no relationship.

Of further interest are the results from the second portion of the Error Identification task where the participants were asked to identify the initial error in the flawed videos. Surprisingly, the analysis of these results indicated that the coaches in Group 1 outperformed the coaches in Group 2; the novice coaches without prior experience as an elite athlete were able to identify 34.4% (+/- 4.2%) of the initial errors in the flawed videos whereas the novice coaches with prior athletic experience were only able to identify 18.5% (+/- 4.5%) of the initial errors in the flawed videos. As there was no differential in performance on either the Knowledgebase task or the first portion of the Error Identification task between Group 1 and Group 2, this differential in performance cannot be attributed to an overall superior level of coaching in the novice coaches without previous athletic history. Rather, some specific aspect of performing gymnastic skills has a detrimental effect on the future ability to break down those skills for error identification while coaching.

This unexpected negative transfer effect demonstrated in identifying the initial error in a gymnastic sequence may be attributed to the level of skill acquisition attained by the experienced athletes. Research on skill performance has found that one trait of expertise is the shift to a proceduralized thought process while performing a skill (Fitts & Posner, 1967). A proceduralized thought process is one that requires little online attention and control and works mainly outside of working memory. On the other hand, novice skill performance is thought to be governed in a step-by-step hierarchical fashion in which learners systematically progress through several well defined stages in the skill acquisition process (Fitts & Posner, 1967). This concept may also be explained in terms of implicit and explicit knowledge. While explicit knowledge is made up of facts and rules of which individuals are aware, implicit knowledge is made up of what one 'knows', but is not aware. Novice performance is regulated by explicit knowledge, leading to slow and erratic movements which require much attention. Expert performance is regulated by implicit knowledge, which leads to a smooth effortless performance. For example, when examining generic putting descriptions and episodic memories of specific putting experiences in novice and experienced golfers, it is seen that although novice golfers are only able to list a few steps required for a successful putt, they have a greater episodic memory. That is, they are able to list more steps that they completed during a specific putting experience. However, while the experienced golfers are able to list more items on a generic description of the golf putt, they are not able to give a full description of specific putts they have completed (Beilock & Carr, 2001). Along with fewer identified items on the episodic recall test, the experienced golfers also made fewer references to the mechanics of the golf swing relative to the novice golfers (Beilock & Carr, 2001). This impoverished performance on the episodic memory test demonstrates that experienced golfers do not manage their well learned movements via step-by-step online control. This notion has been termed "Expertise induced amnesia" (Beilock & Carr, 2001).

Further, when experienced athletes do attend to individual steps of a movement, they demonstrate an inferior performance relative to a control situation (Beilock, Carr, MacMahon, & Starkes, 2002; Gray, 2004). When experienced golfers were asked to say "stop" at the end of their golf swing, a task which requires skill-focused attention, they demonstrated less accuracy in their putting ability relative to putting under normal conditions (Beilock et al., 2002). This phenomenon has also been demonstrated in experienced soccer players performing a dribbling drill (Beilock et al., 2002). The soccer players were asked to say which side of their foot was in contact with the ball when a tone sounded. The results of this experiment showed that the experienced soccer players were slower at completing the drill when they were asked to focus on foot contact with the ball than when they were simply performing the dribbling task. This decrement was not present when novice soccer players performed the same task (Beilock et al., 2002). Finally, the same results were demonstrated in baseball players (Gray, 2004). In a simulated baseball batting tasks, when experienced players were asked to indicate the direction the bat was moving when a tone sounded, they demonstrated increased variability and more errors than when they were batting without a skill-focused attention (Gray, 2004).

If these findings were to hold when athletes are not performing the skill, but rather watching the skill, it could be proposed that the novice coaches without prior experience outperformed the novice coaches with prior playing experience, as the task of identifying errors in a given skill set requires the break down of those skills. Error identification could thus be defined as a skill-focused attention situation. The implicit nature of the knowledge relied upon by the novice coaches with prior experience as a gymnast could lead to the negative transfer seen in the error identification phase of this experiment. On the other hand, the explicit nature of the knowledgebase upon which the novice coaches without prior experience as an athlete depend may be beneficial to them in the biomechanical analysis of skills.

Conclusion

This experiment was able to assess the knowledgebase and error identification skills of novice and experienced gymnastics coaches with and without prior athletic experience by using a quantitative experimental design. The experimental design of this experiment allowed for further insight into the research on coach development and knowledge acquisition which is typically conducted qualitatively via retrospective research. Although qualitative research has allowed for an understanding of which factors experienced coaches believe have propelled them to their current coaching position, this experiment was able to examine in an experimental fashion if these predictions made by the coaches are correct.

Previous research on coach development has suggested that prior athletic experience is an important source for coaching knowledge, especially during the first few years of coaching (Fleurance & Cotteaux, 1999; Irwin et al., 2004). The current experiment did not find support for this conclusion. In terms of the coaches' knowledge of technical errors, this experiment did not find that previous experience as an athlete was an asset. There was no differential in the depth of the coaches knowledgebase based on their athletic histories. Previous athletic experience also had no positive impact on error detection skills. In fact, for novice coaches, prior athletic experience resulted in poorer error identification abilities.

Research exploring the transfer of skills in sport and pedagogy has been unable to clearly define the relationship between athletic participation and coaching abilities. While certain studies have demonstrated a positive relationship between athletic and coaching abilities (Girardin & Hanson, 1967), others have found no significant relationship (Osborne & Gordon, 1972; MacMahon et al., 2007; Schorer et al., 2007). The current experiment supports the view that there is no relationship between athletic experience and coaching ability in terms of a coaches knowledgebase as well as in the detection of flawed performances. However, the current experiment suggests that there is a negative relationship between athletic experience and error identification in novice coaches. The negative relationship demonstrated in this experiment is a novel finding in this line of research, which requires further examination to understand the underlying factors that lead to this phenomenon.

Overall, this experiment was able to tie together research from two lines of study (coach development and the transfer of skill in sport and pedagogy) to get a better understanding of the role that previous playing experience plays in novice and experienced coaches. Although the current experiment only touched on a small subset of the skills required in coaching (primarily focusing on the technical aspect of the skills themselves) it is evident that, in this case at least, prior experience as an athlete is not crucial and, paradoxically, may be detrimental to coaching abilities in novice coaches.

Given the somewhat counterintuitive nature of these findings, important questions are raised as to the nature of the underlying perceptual processes that result in such experience specific deficits. In other words, what is it about the nature of athletic participation that adversely affects a novice coaches' ability to reliably identify errors with which they should, on the basis of numerous hours of participatory training, be intimately familiar? One possibility may lay in the ways in which attentional resources are distributed across the task. To explore this, a second experiment was conducted.

Experiment 2

Introduction

Fifty years ago, Donald Broadbent developed a model of human attention that suggested all "incoming" stimulus information gains access in parallel to a sensory buffer where they are held for a very short period of time. Broadbent's (1958) model holds that one, and only one, of these stimuli are then allowed through a hypothetical filter while the remaining stimuli are held in the buffer for later processing. This "single-channel" model of attention was widely accepted for the better part of 15 years until Allport and colleagues showed that experienced pianists were able to concurrently complete an auditory task and sight read piano music with little to no decrease in performance level on either task (Allport, Antonis, & Reynolds, 1972). Based on the results of this study, Allport and colleagues developed a 'multi-channel' model for processing sensorimotor information. This multi-channel hypothesis suggests that there are a number of independent "special purpose computers (processors and stores)" (pg. 233) within the brain that are capable of performing simultaneously and that each of these processors has a maximal amount of information that they are able to work with at any given time. Based on the notion of the multi-channel hypothesis, individuals are able to complete two tasks simultaneously if they use two separate processors. If, however, both tasks use the same processor, a decrease in performance level will ensue. As well, if one task draws all of the available processing resources, the addition of any secondary task will lead to a decreased performance level as there is an overload on the attentional resources.

The premise that individuals are able to complete certain multiple tasks simultaneously allows researchers to examine the attentional processes required for successful performance in novice and experienced performers. For example, using a hockey skating drill Leavitt (1979) demonstrated that while the addition of concurrent visual and motor tasks affected the performance of novice players, it did not effect the skating performance of experienced hockey players. Similar results have been shown in a group of novice, intermediate, and expert soccer players (Smith & Chamberlin, 1992). In this study, the primary task was running through a slalom course, with soccer ball dribbling and geometric shape identification used as the secondary tasks. The addition of these cognitively demanding tasks resulted in a detrimental effect in the performance of the primary task across all skill levels, but, the degree of detriment increased as the playing level decreased (Smith & Chamberlin, 1992). These results suggest that as performers become more experienced with a given skill, they require less online attention to perform the skill successfully. This leaves more attentional resources for the performance of additional concurrent tasks.

A second series of studies, examining 'choking' while performing under pressure, have also used dual-task experimental designs to understand the phenomenon (Gray, 2004; Beilock, Carr, MacMahon, & Starkes, 2002; Masters, 1992). Most studies exploring this concept utilize an experimental paradigm with three phases: a control task, a skill-focused condition, and a dual-task condition (Gray, 2004; Beilock et al., 2002). These studies have shown that while novice performers demonstrate superior performance on the skill-focused condition, expert performers excel in the dual-task condition. For example, Beilock and colleagues (2002) examined a group of novice and experienced soccer players performing a dribbling drill. For the skill-focused condition, the players were asked to say aloud which side of their foot was in contact with the ball when they were cued with an auditory tone. In the dual-task, the participants were required to monitor a list of words presented auditorily for a target word, and then to repeat the target word every time it was presented. The results showed that while the novice players were more successful in the skill-focused condition, the experienced players demonstrated opposing results with a superior performance in the dual-task condition. The researchers explain these results in terms of the representation of knowledge. As the performance of novices is defined by explicit knowledge, focusing on the step-by-step requirements of the skill assists the performers. However, as the experienced performers rely on implicit knowledge of the skill, focusing on the individual aspects of the skill leads to a poorer performance. Thus, the addition of a secondary auditory task ensures that the experienced performers are not focusing on the skill itself, leading to a superior performance level. This phenomenon has also been demonstrated in golfers performing a putting task (Beilock et al., 2002) and baseball players performing a batting simulation task (Gray et al., 2004).

In Experiment 1 of this thesis, it was demonstrated that novice coaches with previous experience as an athlete have greater difficulty analyzing gymnastic sequences to identify errors than do novice coaches without previous athletic experience. This was evident in their degraded ability to identify the initial error in gymnastic sequences with one or more technical errors. These results were explained in terms of the nature of the knowledge upon which the experienced athletes relied. While experience athletes possess, and perhaps rely to a greater degree upon, an implicit knowledge of the gymnastic skills being analyzed, the novice coaches without this athletic experience (and the well developed level of implicit knowledge that comes with this experience) likely rely to a greater degree upon explicit knowledge. To test this possibility, the coaches participating in the Experiment 2 performed a concurrent secondary auditory task while examining the gymnastics video footage for errors.

The reason for conducting this experiment is to specifically assess two hypotheses related to the degree to which the focus of attention mediated performance in Experiment 1. These hypotheses are framed as follows: (1) For the experienced coaches, regardless of their athletic history, it is predicted that they will outperform the novice coaches since these participants have a level of experience with skill analysis and error detection and identification to the degree that the addition of the dual-task should not lead to the overload on attentional resources that would result in a poorer performance. (2) Error recognition performance will deteriorate for novice coaches without prior experience as an athlete with the addition of the secondary task when compared to the novice coaches with athletic experience. This is predicted because the coaches without athletic experience have little experience with the skills being performed either as a coach or as an athlete. Presumably, these coaches are still relying on an explicit knowledgebase of the skill being performed in the video footage. Thus, for optimal performance, the novice coaches without prior athletic experience must allocate the majority of their attentional capacity to the on-line control of the individual steps of the skills being analyzed. When performing both tasks concurrently, these coaches will have insufficient attentional resources to perform both tasks to their potential. On the other hand, as the novice coaches with prior experience as a gymnast have substantial experience as an athlete with the gymnastic elements being analyzed, they will depend upon an implicit knowledgebase of these skills. Due to the implicit nature of their knowledge, the novice coaches with prior experience as an athlete will not demonstrate a decreased ability to detect the initial error in a gymnastic sequence when the secondary auditory task is added, leading to a superior performance relative to the novice coaches without an athletic history.

Method

Participants

The same criteria as Experiment 1 were used for participant selection and group division in Experiment 2. Twenty-two elite gymnastics coaches from the Southern Ontario region volunteered to participate in this experiment. Nineteen of the coaches also participated in Experiment 1, with five in Group 1, five in Group 2, five in Group 3, and four in Group 4. The remaining three coaches were new to the experiment, ensuring an equal cohort relative to Experiment 1.

Thus, Group 1 (Novice/Novice) consisted of six novice coaches (5 female, 1 male; age: mean = 32.5, sd = 14.1 years) with no previous experience as a competitive gymnast. These coaches had an average of 1.9 (+/- 1.2) years of coaching experience at the provincial or national level, and 4.0 (+/- 2.0) years experience as a gymnast at a recreational or high school level. Group 2 (Novice/Experienced) consisted of six novice coaches (4 female, 2 male; age: mean = 23.1, sd = 4.8 years) with 7.3 (+/- 2.3) years of experience as a gymnast competing at the provincial or national level. The participants in this group had been coaching at the provincial or national level for 2.2 (+/- 1.2) years. Group 3 (Experienced/Novice) consisted of five experienced coaches (4 female, 1 male; age: mean = 35.8, sd = 8.3 years) with no previous experience as a competitive gymnast. These coaches had an average of 15.0 (+/- 5.0) years experience working with elite level athletes, and 4.0 (+/- 0.7) years of athletic experience at the recreational or high school level. Group 4 (Experienced/Novice) consisted of five experienced coaches (2 female, 3 male; age: mean = 39.4, sd = 15.6 years) with 9.6 (+/-2.3) years of experience competing at the provincial or national level. These participants had been coaching at the competitive level for 18.4 (+/-11.5) years.

Apparatus and Procedure

The apparatus and procedure for Experiment 2 were identical to those used in Experiment 1 with the following exceptions.

Experiment 2 analyzed performance across three tasks: Reaction Time (RT), Non-Specific Dual-task (ND), and Error Identification (EI). All of the tasks (RT, ND, and EI) were completed using video images on a laptop computer. For the ND and EI portions of the study, silent video images were presented with auditory stimulus overlaid. While the video images were of gymnastic sequences for the RT and EI tasks, they were of various scenic shots for the Non-specific Dual-task. Once again, directions were presented to the participants via written instructions on the laptop prior to commencing each task (See Appendix A).

The auditory stimuli used for the secondary task was a list of two syllable words presented aloud by the laptop. The auditory stimuli were overlaid onto the video clips using *Adobe After Effects* 6.5. For each seven second video clip, three words were inserted. The words were inserted at one, three, and five seconds into the video clips.

Reaction Time:

The Reaction Time task used in Experiment 2 used the same task and protocol as the Reaction Time task in Experiment 1.

Word Practice:

Prior to the initiation of the final two tasks (VP, EI) the participants were given the chance to practice the auditory task separately. For the auditory task, the participants were presented with a series of two syllable words. Following the presentation of each word, the participants were asked to say a word aloud that began with the last letter of the presented word. This task was used to ensure that sufficient demands were placed on the participants attentional processing. Participants were given twenty-five practice words. The first ten words were presented with 2.5 second intervals of silence and the last fifteen were presented with two second intervals of silence. The initial longer interval duration was to allow for a learning phase, while the former interval time reflected that of the silence intervals in the ND and EI tasks. No variables were measured during this phase of the study.

Non-specific dual-task

The participants were presented with three, 7 second video clips of scenic images. During this presentation, the participants were also required to perform a dual-task (Auditory task described above). To avoid modality-specific interference, the word list was presented auditorily and responses were said aloud, whereas the concurrent task used visual stimuli and manual responses. Following the completion of each video, the participants were asked two yes/no questions regarding the material seen in the video clip. During this phase of the study, the variables that were measured were the percentage of correct answers to the questions, as well as the percentage of words on which the participants made no errors. Word errors were considered those for which the participant failed to come up with a word during the silence interval, and trials on which the participant came up with a word that began with the wrong letter. Participants were not told which of the two tasks was of primary importance.

Error Identification:

The participants were presented with twenty-four video clips twice, in a randomized order. In four of the videos, the error occurred in the first third (0-2.33 seconds), in six videos the error occurred during the middle segment of the video (2.33-4.67 seconds), and in seven videos the error occurred during the last third of the gymnastic sequence (4.67-7 seconds). The remaining seven video clips had no technical errors.

During the presentation of the video clips, along with watching for technical errors, the participants were required to simultaneously perform the auditory task described above. No auditory stimuli were presented during the second, slow motion, presentation of the video clips. For this portion of the experiment, the variables that were measured were if the participant perceived an error, and, if they perceived a technical error, the time at which that error occurred (in milliseconds) as well as the percentage of correct words said aloud for the auditory task. As in the Non-Specific Dual-task, the participants were not told which task was of primary importance.

To complete all the phases of the experiment, it took the participants a total of twenty-five minutes, and the testing took place at a time and place that was convenient to the participants.

Data reduction and analysis

Similar analyses were conducted on the data in Experiment 2 as in Experiment 1. Following these analyses, a comparison of the results from the error identification tasks in Experiment 1 and Experiment 2 was carried out based on the nineteen coaches who participated in both experiments. All data are presented in Table 2 and Table 3.

<u>Reaction Time</u>

As in Experiment 1, Analysis of Variance revealed no significant main effects for coaching ($F(1,17)=1.091$, $p.=0.300$) or athletic experience ($F(1,17)=0.093$, $p.=0.765$) and no significant interaction ($F(1,17)=0.171$, $p.=0.684$). This result again confirms that neither previous coaching nor athletic experience reliably affected the participants performance on the detection of, and response to, a non-sport specific stimulus.

Non-specific Dual-task

Two measures were taken during the Non-Specific Dual-task: percentage of correct answers and the percentage of successful words. Analysis of variance for the percentage of correct answers on the questions revealed no significant main effects for coaching ($F(1,17)=0.191$, $p.=0.670$) or athletic experience ($F(1,17)=0.657$, $p.=0.430$) and no significant interaction ($F(1,17)=0.004$, $p.=0.950$). This suggests that coaches were able to attend to the non-specific video on a similar level with the addition of an auditory task. The second dependent measure was the percentage of successful words. Once again, analysis of variance revealed no significant main effect for coaching experience ($F(1,17)=0.428$, $p.=0.522$) or athletic experience ($F(1,17)=0.098$, $p.=0.758$), and no significant interaction ($F(1,17)=0.428$, $p.=0.522$). This result suggests that neither previous coaching nor athletic experience reliably affected the participants performance on the secondary auditory task while attending to a non-sport specific video stimulus.

Insert Table 2 about here

Error Identification Task

As in Experiment 1, the first step in the Error Identification task in Experiment 2 was for the participants to detect if an error was present in the viewed clip. The experienced coaches were 13.7% more accurate in detecting the flawed videos relative to their novice counterparts. While experienced coaches were able to correctly detect flawed videos 66.4% of the time, novice coaches were only able to correctly detect 52.7% of the videos with technical errors. Analysis of variance revealed that this coaching experience specific proportional difference in error detection performance was significant, ($F(1,17)=6.901$, $p.=0.018$). There was, however, no effect for athletic experience ($F(1,17)=0.183$, $p.=0.674$), nor was there an interaction of coaching and athletic experience ($F(1,17)=0.305$, $p.=0.588$). During this portion of the experiment, the coaches were also required to perform a secondary auditory task. On average, the coaches correctly responded to 73.9% of the presented auditory stimuli. Analysis of variance revealed that there were no group differences based on coaching experience ($F(1,17)=0.074$, $p.=0.89$) or athletic experience ($F(1,17)=1.544$, $p.=0.231$), nor was there a significant interaction ($F(1,17)=0.009$, $p.=0.926$).

Insert Figure 4 about here

An analysis of the identification of the initial error in the flawed videos ensued. Results of this analysis revealed a significant main effect for coaching experience ($F(1,17)=7.993$, $p.=0.012$). Specifically, the experienced coaches were 21.3% more accurate in identifying the first error in a flawed video than were the novice coaches. Although the experienced coaches were able to correctly identify the initial error in 46.9% of the flawed videos, the novice coaches were only able to identify 25.6% of the initial errors in the videos with technical errors. There was no significant main effect for athletic experience ($F(1,17)=0.429$, $p.=0.521$), nor was there an interaction of coaching and athletic experience ($F(1,17)=0.296$, $p.=0.594$).

Insert Figure 5 about here

To gain more insight into the group differences observed in the Error Identification task, measures of sensitivity and bias were again calculated. Once again, Analysis of Variance revealed no significant main effects or interactions for the individual sensitivity and bias data. No significant main effect for coaching experience (Sensitivity: ($F(1,18)=1.580$, $p.=0.225$); Bias: ($F(1,18)=0.000002$, $p.=0.997$)) or athletic experience (Sensitivity: ($F(1,18)=0.050$, $p.=0.825$); Bias: ($F(1,18)=0.563$, $p.=0.465$)) emerged. Once more, large variability was present within and between the groups for individual sensitivity and bias values. Thus group means were used to explore Signal Detection in coaches. As expected, although not significant, experienced coaches were marginally more sensitive to errors than novice coaches ($d'=0.811$ vs. $d'=0.463$). Further analysis of the group means of the novice coaches without previous athletic experience (Group 1) versus novice coaches with prior athletic experience (Group 2) showed that previous athletic experience had no effect on either sensitivity ($d'=0.429$ vs. $d'=0.507$) or bias ($\beta=1.214$ vs. $\beta=1.121$). For the experienced coaches, previous experience levels as athletes also had no influence on either sensitivity (Athletic experience, $d'=1.165$ vs. No athletic experience, $d'=1.032$) or response bias (Athletic experience, $\beta=0.646$ vs. No athletic experience, $\beta=0.762$).

Experiment 1 and Experiment 2 - A comparison

To further understand the nature of the knowledge relied upon by novice coaches with differing athletic backgrounds, the performance of the nineteen coaches who participated in both Experiment 1 and Experiment 2 was analyzed using a 2 (coaching experience: novice vs. experienced) by 2 (athletic experience: no experience vs. competitive athletic experience) by 2 (Experimental paradigm: Experiment 1 vs. Experiment 2) mixed design ANOVA, with coaching and athletic experience as between subject factors and experiment as a within subject factor. Analysis of Variance of the coaches' ability to detect flawed gymnastic performances revealed a significant main effect for coaching experience ($F(1,15)=11.371$, $p.=0.004$) as well as for experimental paradigm ($F(1,15)=8.984$, $p.=0.009$). The significant main effect for coaching experience was expected as the experienced coaches significantly out performed the novice coaches in both Experiment 1 and Experiment 2. The significant main effect for experimental paradigm demonstrates that the participants performed significantly better on Experiment 1 than Experiment 2 in detecting technically flawed video clips. No significant interactions emerged suggesting that group specific difference remained consistent across experiment with all groups, similarly affected by the additional demands on attentional resources occasioned by the dual task procedure employed in Experiment 2.

Insert Table 3 about here

As anticipated, Analysis of Variance of the coaches' ability to identify the initial error in the flawed videos revealed a significant main effect for coaching experience ($F(1,15)=15.142$, $p.=0.001$) with experienced coaches outperforming the novice coaches. No other main effects were found to be significant nor did any significant interactions emerge. Following Analysis of Variance, planned comparisons were used to evaluate if the novice coaches with and without prior athletic experience performed significantly differently on Experiment 1 and Experiment 2. A one-way within subject ANOVA exploring the performance of the novice coaches with prior athletic experience demonstrated that the performance level of these coaches did not significantly improve from Experiment 1 to Experiment 2 ($F(1,4)=2.244$, $p.=0.209$). A second one-way within subject ANOVA based on the novice coaches without prior athletic experience demonstrated that the performance level of these coaches did not decrease from Experiment 1 to Experiment 2 ($F(1,4)=2.646$, $p.=0.179$).

Discussion

The results from Experiment 1 suggest that previous athletic experience has a negative effect on novice coaches in terms of their error recognition abilities. This result can be taken to be both counterintuitive and inconsistent with previous studies in coaching development (Erickson et al., 2007; Girardin & Hanson, 1967). To try to resolve this issue, and to see if the nature the knowledge (implicit versus explicit) upon which the novice coaches rely was at the root of this discrepancy, a dual-task paradigm was introduced in the Experiment 2. The nature of the dual-task was such that participants were required to simultaneously perform an auditory task concurrent with an error identification task.

Auditory Task

In this experiment a secondary auditory task was used to stress the participants' attentional resources. To ensure that each group had an equal ability to simultaneously perform an auditory task while attending to video images, a non-sport specific video dual-task was completed prior to commencing the gymnastics Error Identification task. There was no differential in performance level across any of the groups on this task. This equal performance level was also demonstrated during the Error Identification phase of the study. Although group differences based on experience level do tend to emerge in the primary task in dual-task studies, it is common that no group differences emerge in the secondary task. For example, this trend was observed in soccer players who were asked to perform a geometric shape identification task while concurrently performing a soccer dribbling task (Smith & Chamberlin, 1992). In the soccer players, there was no difference across experience levels on the performance of the secondary shape identification task (Smith & Chamberlin, 1992). This result also demonstrates that the coaches were not differentially attending to the auditory task based on their coaching or athletic histories. All coaches attended equally to the secondary task even though the coaches were not told which task (auditory task or video error identification task) was of primary importance.

Novice versus Experienced coaches

As in Experiment 1, the experienced coaches outperformed the novice coaches on both aspects of the Error Identification task. While the novice coaches were only able to detect 52.7% of the flawed videos and identify 25.6% of the initial errors in the flawed videos, the experienced coaches were able to detect 66.4% and identify 46.9%. Although not statistically significant (potentially due to the large individual and group variability), the experienced coaches also worked with a marginally greater sensitivity and a slightly lower bias (Experienced coaches, d'=0.811, β=0.954; Novice Coaches, d'=0.463, β=1.174). These results demonstrate that error detection skills improve with practice. This is expected based on Ericsson's model of expertise which suggests that expert performance is attained through years of deliberate practice (Ericsson et al., 1993), as well as Pinheiro and Simon's operational model of error diagnosis (1992), which suggests that through practice, the coach's internal reference (against which they compare novel skill performance) is improved, leading to an improved error diagnosis ability.

When comparing the results of the Error Identification task in Experiment 1 and Experiment 2, it can be seen that the performance level demonstrated by the novice and experienced coaches decreased significantly with the addition of the auditory task in terms of detecting the flawed gymnastic sequences. The experienced coaches were 8.4% less accurate in detecting the flawed videos and the novice coaches were 8.7% less accurate. Although there was a significant drop in performance level in detecting the flawed videos, this discrepancy disappeared when the participants were asked to identify the initial error in the flawed video clips. The experienced coaches were 3.8% more accurate and the novice coaches were 0.9% less accurate with the addition of the concurrent task. Similar to the results demonstrated by Smith and Chamberlin (1992), the addition of the auditory task had a significant effect on the performance of all the coaches. This effect was consistent across the coaches regardless of their coaching experience. Such a finding conflicts with the results of Smith and Chamberlin

(1992) who found that the addition of a concurrent task has a greater impact on novice performers than experienced performers.

Athletic Experience versus No Athletic Experience

The results of Experiment 2 demonstrated that the performance level attained by the participants in a dual-task paradigm was not effected by their athletic history. For the experienced and novice coaches there was no significant group differences based on previous playing experience in both detecting flawed videos and identifying the initial error in the flawed videos. The experienced coaches (Group 3 & 4) were able to detect 66.7% and 66.1% of the flawed videos, and identify 46.5% and 47.3% of the initial errors in the flawed videos, respectively. The novice coaches (Group 1 & 2) were able to detect 50.1% and 55.3% of the flawed videos, and identify 21.1% and 30.1% of the initial errors in the flawed videos, respectively. These results do not support the hypothesis which proposed that under the dual-task constraints the novice coaches with athletic experience would perform significantly better that the novice coaches without prior athletic experience due to the nature of the knowledge upon which they depend.

Further evidence opposing the hypothesis that novice coaches rely on differing knowledge structures based on their athletic history comes from the comparison of the results from the Error Identification task in Experiment 1 and Experiment 2. In this analysis no significant interaction between coaching experience, athletic experience, and experimental paradigm (which would support the rationale that novice coaches rely on either explicit or implicit knowledge based on their athletic exposure) was found. The results of the planned comparisons also opposed the hypothesis that novice coaches rely on differing knowledge structures. The novice coaches with prior athletic experience did not demonstrate an improved performance on Experiment 2 relative to Experiment 1, and the novice coaches without prior athletic experience did not demonstrate an improved performance on Experiment 2 relative to Experiment 1.

Additional discrepancies between the results of Experiment 1 and 2, and the results of studies that advocate a different nature of knowledge in novice and experienced performers (Beilock et al., 2002; Gray, 2004) can be found. For example, in an examination of novice and experienced soccer players Beilock and colleagues (2002) found that while the performance level of novice and experienced soccer players was similar on a skill-focused dribbling task, when asked to perform under a dual-task condition, the experienced players performed better and the novice players performed worse. This lead to a large differential in performance level in the dual-task condition. Similarly, in an examination of novice and experienced baseball players, Gray (2004) found that while the performance level of novice and experienced players was similar under skill-focused constraints, experienced players demonstrated a superior performance with the addition of the extraneous secondary task and novice players performed poorer under these conditions. This led to a large differential in performance level between the novice and experienced players on the dual-task condition. However, opposing results were found in Experiment 1 and Experiment 2. A similar performance level was demonstrated under dual-task constraints between the novice coaches with and without previous athletic experience (Experiment 2), but, on the skill-focused condition (Experiment 1) there was a significant difference between the performance levels of the two groups of novice coaches.

Thus, the results of Experiment 2, along with those of Experiment 1, do not support the hypothesis that novice coaches with previous athletic experience rely entirely upon an implicit knowledgebase while novice coaches without previous athletic experience depend upon an explicit knowledgebase. However, it is important to note that the discrepancy between the two groups of novice coaches disappeared due to an improved performance by the novice coaches with previous athletic experience when the coaches were asked to perform under dual-task constraints. This suggests that further research is required to understand the effects of stressing a coach's attentional resources as it may assist in the development of training tools designed to support novice coaches with previous athletic experience. These training resources could assist novice coaches with previous athletic experience in overcoming the negative effects of their athletic experience in terms of error recognition abilities.

Conclusion

The goal of this thesis was to further examine the relationship between previous athletic experience and current coaching abilities in novice and experienced coaches. Based on the results of Experiment 1, a dual-task paradigm was introduced in this experiment to get a better understanding of the attentional resources required for error detection and identification in novice and experienced coaches with and without previous athletic experience, as well as the nature of the knowledge relied upon by these coaches. As anticipated, the results of this experiment supported the first hypothesis: the experienced coaches outperformed the novice coaches. This finding lends support to numerous frameworks including Ericsson and colleagues (1993) framework on the development of general expertise as well as Pinheiro and Simon's (1992) operational model of motor skill diagnosis. However, there was a decrease in performance level demonstrated by all coaches with the addition of the concurrent auditory task, and this negative effect was consistent across all coaches regardless of their level of coaching experience. This result is counterintuitive as one would expect that a secondary task would have less bearing on experienced coaches as they have had more practice in error detection and identification, thus resulting in a lesser cognitive load when performing an error diagnosis task.

The results of Experiment 2 did not support the second hypothesis: the novice coaches with previous athletic experience did not significantly outperform the novice coaches without previous athletic experience. This suggests that the results of Experiment 1 cannot be explained by the rationale that the nature of the knowledge relied upon by the novice coaches was based on their athletic history. Further investigation is required to find the cause at the root of the discrepancy found in the novice coaches in Experiment 1.

General Discussion

Throughout Experiment 1 and Experiment 2, the experienced coaches demonstrated a significantly superior performance relative to the novice coaches. In Experiment 1, it was shown that experienced gymnastics coaches possess a greater knowledgebase pertaining to technical errors associated with gymnastic elements as well as a superior ability to detect and identify these errors when viewing video clips of gymnastics sequences. Superior error detection and identification skills relative to novice gymnastics coaches were also demonstrated in Experiment 2. In addition, it was demonstrated throughout Experiment 1 and Experiment 2 that previous experience as an athlete differentially affects novice coaches, with novice coaches without previous athletic experience having superior error diagnosis skills when asked to identify the initial error in a flawed gymnastic sequence. Although it was hypothesized that these results were caused by the nature of the knowledge relied upon by the two groups of novice coaches, no clear and causal conclusions may be drawn based on the results of Experiment 1 and Experiment 2. The results of this investigation on the relationship between current perceptual-cognitive coaching abilities and previous athletic experience adds further insight into research on coach development, expertise in coaching, as well as the transfer of skill in sport and pedagogy.

Coaching and Coach Development

Various models of coach development examining a range of stages and transition points of a coaching career have been proposed (Salmela, 1994; Salmela et al., 1994; Schinke et al., 1995; Erickson et al., 2007). Each of these models suggest that coaching is not a stagnant process, but rather one in which knowledge is continuously evolving through a variety of experiences and via knowledge acquisition. The superior performance level of the experienced coaches relative to the novice coaches in Experiment 1 and Experiment 2 are in support of these models. Especially since most models of coach development are based on qualitative analyses and the current research is based on quantitative investigations. For example, Salmela and colleagues (1994) six-stage model for athletic and coaching development, propose that, following athletic involvement, four conceptual stages of coaching are proposed: an initial coaching role, an established coaching role, specialist coach, and eminent awareness. The novice coaches who participated in Experiment 1 and Experiment 2 would fall in the established coaching role category, as they are currently working with provincial and national level athletes, but they have not yet accumulated a substantial amount of coaching experience. The experienced coaches, however, would be considered specialist coaches and coaches with eminent awareness. Through the results of Experiment 1 and 2, it can be seen quantitatively that the technical perceptual-cognitive skills possessed by the coaches in the various stages of development are significantly different. Specialist gymnastics coaches and gymnastics coaches with eminent awareness have an increased knowledgebase in terms of technical errors associated with gymnastics elements and they are better able to detect and identify errors when viewing gymnastic sequences relative to gymnastics coaches in an established coaching role.

A second model of athletic and coach development that is supported by the findings of Experiment 1 and Experiment 2 is that proposed by Erickson and colleagues (2007). This paradigm suggests that following athletic involvement there are three stages of coaches development, starting with an introduction to coaching, followed by part-time early coaching, and finally high-performance head coach. The novice coaches in Experiment 1 and Experiment 2 fall in the part-time early coaching category while the experienced coaches would be considered high-performance head coaches. Once again, through the results of Experiment 1 and Experiment 2, it is evident that the technical knowledge and the error recognition skills possessed by the coaches in the different stages of coach development differ significantly. Through substantial practice and knowledge acquisition, via mediated and unmediated learning situations, which occur during an established coaching role, coaches are able to acquire the necessary knowledge and skills to attain a specialist coaching position and eminent awareness.

Coaches acquire knowledge through a variety of sources including: structured courses, coaching experience, occupational experiences, mentoring, video observation, books, educational videos, academic journals, university/college education, the internet, personal reflection, discussions with other experienced coaches, top level athletes, and managers, as well as athletic experience (Fleurance & Cotteaux, 1999; Wrights et al., 2007; Irwin et al., 2004; Lemyre et al., 2007, Gould et al., 1990). Previous research has demonstrated that novice coaches are also able to benefit from previous experience as an athlete (Irwin et al., 2004). Through this experience, novice coaches gain an understanding of the game, an opportunity to learn various styles of coaching from different coaches (Wright et al., 2007), understanding how skills feel to perform, a better understanding of how skills are learned and developed, a better understanding of fear and anxiety of performance, as well as a better understanding of the coach-athlete interaction (Irwin et al., 2004). However, the results of Experiment 1 demonstrated that previous athletic experience in fact hampers coaches at the beginning of their coaching careers in terms of their ability to isolate errors in technically flawed performances.

The results of the current investigation did not identify the specific cause of the negative transfer between previous athletic experience and error identification skills in novice coaches. However, based on the results of Experiment 2 it was found that a differing representation of knowledge was not at the root of the discrepancy between the two groups of novice coaches. It was hypothesized that during their playing careers, athletes acquire substantial knowledge associated with the skills required in their sport. This acquired knowledge is initially represented in an explicit manor. Explicit knowledge produces movements which are slow and erratic in nature and require constant on-line control. However, through practice, there is a shift to an implicit knowledge of the skills in a given sport. Implicit knowledge is made up of what an individuals 'knows', but is not aware. Novice coaches with athletic experience rely on the knowledge they have acquired during their athletic career, thus, these coaches are to a great degree relying on an implicit knowledgebase. The nature of this knowledge leads to difficulty in breaking down skills for error identification as implicit knowledge does not rely on step-by-step control of movements. Novice coaches without previous athletic experience have to acquire knowledge pertaining to the skills they are teaching through a variety of other resources (coaching course, books, mentor coaches, etc.). This form of knowledge acquisition assists these coaches in the biomechanical breakdown of the elements they are coaching. This in turn leads to superior error identification skill relative to novice coaches with previous athletic experience.

Another potential explanation for the negative transfer identified in Experiment 1 within the group of novice coaches with previous athletic experience is the based on the knowledge that a gymnast acquires during their athletic career. To learn and perfect gymnastic elements, gymnasts must overcome the biomechanical errors within their own performance. During this process, the coach and athlete work close together, with the coach identifying the errors the athlete needs to correct and discussing these errors with the athlete. As there are numerous potential technical errors for each gymnastic element, all gymnasts do not make the same technical errors when performing the same skills. Thus, each athlete acquires a differential base of errors which they associate with each gymnastic element as each athlete is exposed to different errors during athletic training. If the novice coaches with previous athletic experience carry over the knowledge pertaining to gymnastic elements that they have acquired as an athlete into their coaching knowledgebase, this would result in novice coaches being more prone to pick out the errors which they have been exposed to as an athlete. Furthermore, as it is the athlete's coach who initially exposes the athletes' to their technical errors, thus, a novice coaches knowledgebase may be reflective of the knowledge which is passed on from their personal coach.

This rationale is able to explain the poor performance of the novice coaches with previous athletic experience when asked to identify the initial error in a gymnastic sequence, as the ability of these coaches to perform this task would be washed out when examined across a group of coaches and a set of skills. Each coach would be more prone to identify the errors which they have been exposed to as an athlete, however, this error may not be the initial error in the presented videos. On the other hand, the novice coaches without previous athletic experience would not be biased towards certain errors as they have not had added exposure to those technical errors. Thus, as a group, these coaches would be able to demonstrate a superior performance when asked to identify the initial error in a flawed gymnastic sequence. Further investigation is required to identify if this explanation can account for the difference in performance level between novice coaches with and without previous athletic experience identified in Experiment 1.

Expertise in Coaching

The development of certain skills has been demonstrated in experienced coaches (Ahlgren et al., 1998; Leas & Chi, 1990; Pinheiro & Simon, 1992). Differences between novice and experienced coaches may be seen in their coaching behaviour, the depth of their knowledgebase, as well as their ability to detect technical errors while examining skill performance.

Through experience, coaches acquire a larger declarative knowledgebase (Leas & Chi, 1990). This has been demonstrated in swimming coaches, with experienced swimming coaches possessing a greater knowledge in terms of proper stroke biomechanics (Leas & Chi, 1990). The results of the Knowledgebase task in Experiment 1 further demonstrate the superior knowledgebase possessed by experienced coaches, with the experienced gymnastics coaches identifying significantly more errors associated with nine gymnastic elements than novice coaches. This knowledge is acquired through an array of learning situations (i.e., coaching experience, mentor coaches, books, educational videos, structured courses, etc.), however, previous experience as an athlete does not appear to effect a coach's capacity to acquire technical knowledge. As demonstrated by the results of Experiment 1, there was no differential in the depth of the coaches knowledge pertaining to technical errors associated with gymnastic elements based on the coaches athletic histories. Thus, a coach's technical knowledgebase is primarily developed during one's coaching career. This is consistent with Ericsson's framework for the development of expertise (Ericsson et al., 1993) which suggests that expertise is domain specific, as well as work by Deakin and Allard (1992) who demonstrated that expertise is specific to the role within a domain of expertise in which participation occurs.

Although an athlete might acquire certain knowledge during their athletic career, this knowledge is not transferred over to the knowledgebase used when coaching. The knowledge required for coaching is simply acquired during practice and learning situations specific to coaching as during these situations are specific to the coaching role.

An alternative explanation is that while experienced coaches have acquired substantial role-specific coaching knowledge through coaching experience and unmediated learning opportunities throughout their coaching career, novice coaches with previous athletic experience carry over some knowledge from their athletic participation as a base of knowledge to build on. As novice coaches without such athletic experiences do not have a base knowledge when they begin coaching, they engage in a more active acquisition of coaching knowledge to overcome any deficits, resulting in an equivalent depth of declarative coaching knowledge. Further investigation in required to fully understand where the novice coach acquire their initial coaching knowledge.

Experienced coaches also possess superior error diagnosis abilities relative to novice coaches (Pinheiro, 1989 in Pinheiro & Simon, 1992). According to Pinheiro and Simon's (1992) operational model of motor skill diagnosis, coaches are able to detect errors in a novel performance through a comparison with a reference which is stored in their long-term memory. This reference may be strengthened through experience, leading to an improved error detection ability. Pinheiro and Simon (1992) supported their model with evidence from shot-put coaches: while novice coaches were able to detect 13.3% of the present technical errors while viewing shot-put throws, experienced coaches recognized 40% of the errors. The results from Experiment 1 and Experiment 2 lend further support to Pinheiro and Simon's operational model for motor skill diagnosis. In both experiments, the experienced coaches outperformed the novice coaches on the Error Identification tasks. Similar to the experienced shot-put coaches, the experienced gymnastics coaches in Experiment 1 and Experiment 2 identified 43.1% (+/- 10.6%) and 46.9% (+/- 18.1%) of the initial error in the flawed videos, respectively. This performance level was superior to the novice coaches who were able to identify 26.5% (+/- 9.3%) and 25.3% (+/- 14.5 %) of the initial errors in the flawed videos, respectively.

Transfer of Skill in Sport and Pedagogy

Studies exploring the relationship between performing a skill and teaching or evaluating that skill have turned to two domains: sport (MacMahon et al., 2007; Rodgers & Allard, 1990; Schorer et al., 2007) and physical educator training (Girardin & Hanson, 1967; Osborne & Gordon, 1972). To date, this line of research has found no clear and causal relationship between the ability to perform a set of skills, and the ability to teach those skills. The results of Experiment 1 and Experiment 2 add further insight into this discussion as the negative transfer between previous athletic experience and current error identification abilities in the novice coaches described in the results of Experiment 1 is a novel finding. Previous research has found either a positive relationship or no significant relationship between these two factors. A positive correlation between previous competitive level and current judging level (Rodgers & Allard, 1990), as well as a positive relationship between skill performance and error detection in physical education majors (Girardin & Hanson, 1967) have been reported. These results suggest that skills that are acquired in one role within a domain of expertise are transferable to another role. However, other studies have found no significant relationship (MacMahon et al., 2007; Schorer et al., 2007; Osborne & Gordon, 1972), suggesting that expertise is very specific to the task which is practiced. Unfortunately, each of these studies have explored this concept using different populations and different tasks, making it difficult to generalize the results of each study which would allow clear conclusions to be drawn.

The opposing results found between the experiments in this thesis and previous studies may be explained by either the aims of these studies, or the cohort they investigated. Rodgers and Allard (1990) explored the relationship between performing and subsequently judging at either a World Championships or the Olympic Games. However, the Rodgers and Allard (1990) study did not explore the specific relationship between previous athletic experience and current judging abilities. As a result, the authors were able to discuss potential reasons for the positive correlation in terms of the level attained in both roles by the participants but could offer no insight as to the effects of prior athletic performance on judging. Although superior performance as a judge may be the causal factor in this relationship, other factors such as an increased knowledge of the politics within the sport, more connections within the sport governing bodies, superior motivation, or a better work ethic may also be the cause of this relationship (Rodgers & Allard, 1990). Thus the skills acquired as an athlete did not necessarily lead to a superior ability to evaluate a performance as a judge.

The examination of the relationship between athletic and coaching abilities undertaken in Experiment 1 and Experiment 2 explored this association in terms of perceptual-cognitive abilities. Two previous studies have also investigated this specific relationship. Girardin and Hanson (1967) found a positive relationship between the ability to perform gymnastic skills and the ability to diagnose errors within those skills. However, the argument that novice performers rely upon an explicit knowledge of the skills they are performing may be used to interpret the results of this study. The population used by Girardin and Hanson (1967) was a group of physical education majors. Their gymnastics background included an eight-week university level course in the sport. Thus, the participants would be considered novice in terms of their athletic development in the sport of gymnastics as well as their development as gymnastics coaches. As the participants were novice gymnasts, the nature of their knowledgebase would still be explicit. Their current utilization of the step-by-step explicit control of the gymnastics skills that were used in this study would assist the participants in their error diagnosis abilities, as breaking down a skill is required to find the errors. For the participants who were less able to perform the gymnastic skills, and subsequently performed poorer on the error identification task, it may be suggested that these individuals had an inferior understanding of the biomechanics behind the gymnastic elements used in the study which lead to the poor performance in both facets of the experiment.

A second study that investigates the relationship between previous athletic experience and current coaching ability in terms of perceptual-cognitive skills was conducted by Schorer, Baker, and Bernd (2007). This study used soccer as their domain of expertise. Schorer and colleagues showed that although there was a clear relationship between coaching experience and pattern-recognition, no other significant correlations emerged: previous experience as an athlete did not have an effect on current coaching abilities. However, Schorer and colleagues (2007) used soccer coaches with varying degrees of experience as a coach, and varying degrees of previous playing experience as participants. There was no distinct grouping based on the participants' athletic and coaching histories. Grouping the cohort based on their coaching experience is an important consideration. Previous research has demonstrated that depending on their level of experience as a coach, coaches base their current coaching knowledge on different experiences and learning opportunities, with novice coaches using their athletic experience as an important source of information (Irwin et al., 2004). As Schorer and colleagues (2007) did not differentiate their participants, it is difficult to see the effects of previous athletic experience as this relationship may only be present in novice coaches. Unlike the study conduct by Schorer and colleagues, the participants in Experiment 1 and Experiment 2 of this thesis were classified based on their athletic and coaching histories, with only novice and experienced coaches partaking in the investigation. This allowed for the negative relationship which was only present in the novice coaches to emerge.

Although this investigation was not able to fully understand the relationship between previous athletic participation and current perceptual-cognitive coaching abilities, it was able build on the previous coaching science research. Much research regarding knowledge acquisition and error detection and identification skills in coaches is needed to gain more insight into this complex relationship. Through this future research, proper learning resources may be developed to assist novice coaches in honing their coaching skills. As demonstrated by the findings of this investigation, novice coaches with and without previous athletic abilities possess different perceptual-cognitive skills. Thus the development of learning resources which are geared towards the weaknesses of these coaches will ensure suitable coach education and a positive introduction to coaching for retired athletes.

Conclusion

The current investigation of the relationship between previous athletic experience and current perceptual-cognitive coaching abilities was unable to draw clear and causal conclusions. The results from Experiment 1 demonstrated that previous athletic experience has a negative impact on the error identification skills of novice coaches. Specifically, novice elite gymnastics coaches who were previously provincial or national level competitive athletes demonstrated a decreased ability to identify the initial error in flawed gymnastic sequences relative to novice gymnastics coaches who have not had athletic experience at the provincial or national level. However, throughout this investigation, the cause of the negative transfer was not identified.

In the experienced coaches, it was clearly demonstrated that previous athletic experience was not associated with current coaching abilities. Throughout all of the tasks in both experiments, the experienced coaches with and without previous athletic experience demonstrated a consistently equal performance level. These results suggested that specific coaching experiences as well as learning opportunities in which coaches participated during their coaching career negate any previous athletic experience and are of greatest importance to the development of experienced coaches. Although it was clearly demonstrated that previous athletic experience has no effect on coaching abilities in experienced coaches, the results of Experiment 1 showed that previous athletic involvement differentially effect the perceptual-cognitive skills of novice coaches. While previous athletic experience did not define the depth of the novice coaches' knowledgebase, nor was it related to their ability to detect a technically flawed video clip, when asked to identify the initial error in a flawed gymnastics sequence, the novice coaches without previous athletic experience outperformed the novice coaches with previous athletic experience. This negative transfer between previous athletic experience and current coaching abilities in novice coaches was a novel finding, and was further explored in Experiment 2.

The goal of the second experiment of this thesis was to identify the cause of the negative transfer identified in Experiment 1. It was hypothesized that the nature of the knowledge relied upon by the novice gymnastics coaches was at the root of the discrepancy: as a result of their athletic involvement, novice coaches with prior athletic experience rely on implicit knowledge of gymnastic elements. Novice coaches without athletic experience on the other hand, rely upon an explicit knowledge when analyzing skills for error identification. Unfortunately, the results of Experiment 2 did not support this hypothesis. Thus, further investigation is needed to clearly identify the source of the negative relationship between previous athletic experience and current perceptual-cognitive coaching abilities in novice coaches.

Although the root of the poor performance demonstrated by the novice coaches with previous athletic experience identified in Experiment 1 remains unclear, it is important that this negative transfer is acknowledged, as it will allow for the promotion of proper training for athletes who wish to become coaches. The results of Experiment 1 demonstrate that there is a need for novice coaches with previous athletic experience to receive training in breaking down skills for error identification. One example of a training resource that focuses on breaking drown skills are 'criteria sheets' (Pinheiro, 1994, 2000). For each skill, a criteria sheet may be developed by the coach, providing them with a learning opportunity to explore each skill that they are coaching. Criteria sheets allow for the written breakdown of skills based on the important information pertaining to a particular skill, the phases of a skill that are crucial for performance, and the common errors that the performers tend to make (Pinheiro, 1994, 2000). They organize skills into tables with verbal descriptions as well as images of the body positions for each phase of a skill (Pinheiro, 1994, 2000). As a result, the ideal mechanics of a skill are on paper rather than in memory, and thus the coach can refer to the criteria sheet when they need to evaluate a skill that they are teaching (Pinheiro, 1994, 2000). The implementation of criteria sheets would be beneficial to novice coaches with prior athletic experience as they would encourage the full breakdown of the skills that these coaches are teaching to their athletes. The implementation of other educational resources such as criteria sheets, which assist coaches in learning and identifying the individual steps that make up a skill, would be of benefit to novice coaches who are transitioning into a coaching role from an athletic role.

The research in this thesis focused on perceptual-cognitive abilities possessed by coaches with differing degrees of athletic experience, and described a negative transfer between previous athletic experience and current error abilities in novice coaches with previous athletic experience. However, the investigation undertaken in this thesis only explored perceptual-cognitive coaching skills. Although perceptual-cognitive skills are important to the coaching role, they are only a small subset of the skills required to excel as a coach. Coaching is multi-faceted, thus, along with a strong knowledge of the techniques of a sport, coaches also require knowledge and skills in areas such as sport psychology, nutrition, physiology, anatomy, injuries and rehabilitation. Through ones' experience as an athlete, and through interactions with their own personal coaches, athletes may acquire knowledge in these areas. As a result, although novice coaches with previous athletic experience may have to overcome the negative transfer associated with error identification, they may possess other knowledge from their athletic experience which novice coaches without previous athletic experience may not benefit from. For example, novice coaches with previous athletic experience may be able to understand the fears and anxieties associated with performing (Irwin et al., 2004). This is something that those who have not had performing experience may never truly understand. Thus, although this investigation identified a weakness that novice coaches with previous athletic experience need to overcome, it can in no way conclude that novice coaches without previous athletic experience make better coaches during the initial years of a coaching career.

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Appendix A

Instructions: Experiment 1

Reaction Time

- You will be shown a video clip of a gymnastics element or sequence
- During the clip, a yellow circle will appear over the athlete's hip
- Press the Space Bar as soon as the yellow circle appears

Error Identification

- You are asked to watch a video clip of a gymnastics element or sequence on either bars, beam, or floor
- The gymnastics sequence may contain none, one, or multiple errors
- Following the presentation of the video clip, you will be asked if the athletic made a TECHNICAL ERROR
    * Technical error: error in the biomechanics or technique of the skills, not execution errors
- If you do not believe an error was made, you will pass on to the following video
- I you believe an error occurred, you will be shown the video again in slow motion
- During the second viewing of the video, you are asked to stop the video where you believe the FIRST error occurred
- To stop the video, you simply have to press the Space Bar
- Following the second presentation of the video clip, you will pass on to the following video

Knowledgebase

- Please fill out the provided questionnaire
- For each of the stated gymnastic elements, please provide a list of all the potential technical errors which may occur
- Once again, we are only looking for technical errors, and not execution errors

Instructions: Experiment 2

Reaction Time

- You will be shown a video clip of a gymnastics element or sequence

- During the clip, a yellow circle will appear over the athlete's hip
- Press the Space Bar as soon as the yellow circle appears

Word Practice

- You will be presented with a series of words
- Following the presentation of each word, you are asked to say a word that begins with the last letter of the presented word (i.e., cat = tiger)
- Try not to repeat words!

Non-Specific dual-task

- You will be presented with a series of video clips
- While watching the video clips, you will be presented with a series of words. Following each word, you are asked to say a word that begins with the last letter of the presented word (i.e., cat = tiger)
- Try not to repeat words!
- Following the presentation of each video clip, you will be asked a series of yes/no questions on the content of the video

Error Identification

- You are asked to watch a video clip of a series of gymnastic elements on either bars, beam, or floor
- The gymnastic sequence may contain none, one, or multiple errors
- During the video clips you will be presented with 3 words. Following each word, say a word that begins with the last letter of the presented word (i.e., cat = tiger)
- Following the presentation of the video clip, you will be asked if the athlete made a TECHNICAL ERROR (Y/N)
  *Technical error: errors in the biomechanics or technique of the skills, not execution errors
- If you do not believe an error was made, you will pass to the following video
- If you believe that an error occurred, you will be shown the video again in slow motion.
- During the second viewing of the video, you are asked to stop the video where you believe the first error occurred
- To stop the video, you simply have to press the space bar
- Following the second presentation of the video clip, you will pass on to the following video

Appendix B

Please list all potential technical errors for the following skills:

Bars

1. Kip

2. Giant

3. Layout Flyaway

Beam

1. Back Handspring

2. Round-off

3. Aerial

Floor

1. Front tuck

2. Back Layout Full Twist

3. Whip Back

Table 1

	RT		Error (Y/N)		Initial Error		KB		d'	β
Group	ms	(SD)	% CR	(SD)	% CR	(SD)	% total	(SD)		
Group 1	401.6	(29.4)	62.1	(10.0)	34.4	(4.2)	21.7	(5.8)	0.730	1.085
Group 2	401.1	(37.1)	60.8	(10.7)	18.5	(4.5)	20.8	(3.8)	0.847	1.284
Group 3	401.5	(22.3)	74.2	(5.0)	43.3	(13.4)	27.3	(6.5)	1.211	0.653
Group 4	395.6	(31.4)	75.4	(5.4)	43.0	(8.9)	27.6	(5.8)	1.097	0.687

Table 2

	RT		ND Video		ND auditory		EI Detection		EI identification		Auditory		d'	β
Group	ms	(SD)	% CR	(SD)	% CR	(SD)	% CR	(SD)	% CR	(SD)	% CR	(SD)		
Group 1	393.1	(33.5)	55.6	(20.2)	90.7	(8.4)	50.1	(9.0)	21.2	(13.1)	80.6	(10.8)	0.439	1.214
Group 2	397.2	(46.8)	63.9	(16.4)	85.2	(15.2)	56.5	(10.0)	29.5	(14.7)	72.5	(23.8)	0.598	1.170
Group 3	401.5	(22.3)	60.0	(25.3)	82.2	(14.9)	66.7	(17.6)	46.5	(24.7)	77.4	(12.5)	1.219	2.036
Group 4	403.0	(27.8)	66.7	(16.7)	84.4	(18.6)	66.1	(9.0)	47.3	(10.7)	67.3	(28.0)	6.48	0.674

Table 3

	Experiment 1				Experiment 2			
	Error (Y/N)		Initial Error		Error (Y/N)		Initial Error	
Group	% CR	(SD)	% CR	(SD)	% CR	(SD)	% CR	(SD)
Group 1	62.1	(10.0)	34.4	(4.2)	51.8	(8.9)	22.4	(14.2)
Group 2	58.3	(10.0)	18.9	(5.0)	56.9	(11.1)	27.8	(16.9)
Group 3	74.2	(5.0)	43.3	(13.4)	66.7	(17.6)	46.5	(25.0)
Group 4	77.6	(2.7)	48.8	(6.4)	66.0	(10.4)	47.4	(12.4)

Figure 1.

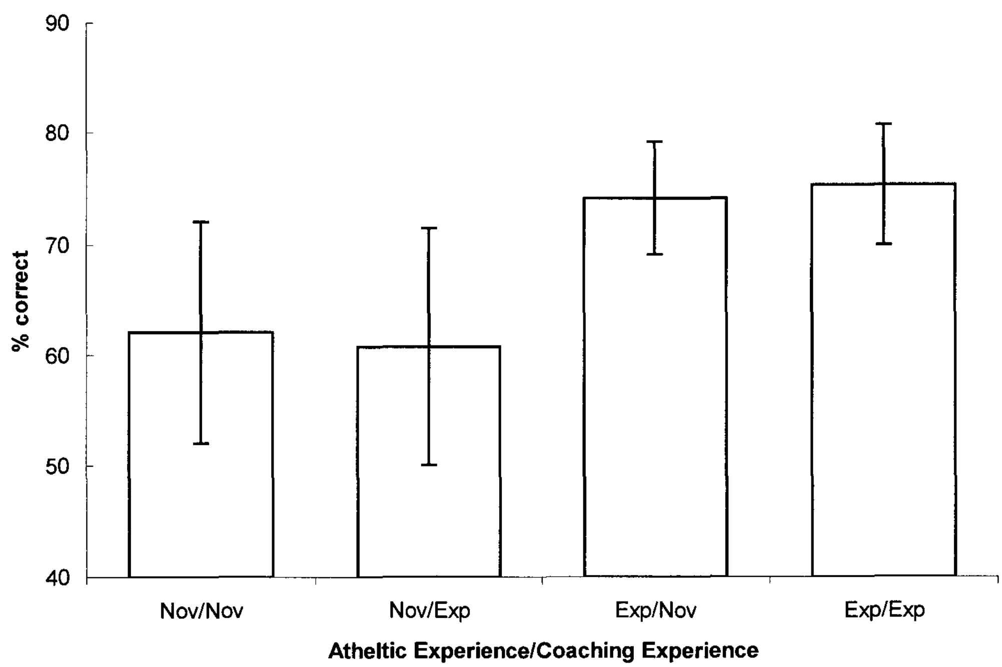

90
80
70
60
50
40
% correct
Nov/Nov
Nov/Exp
Exp/Nov
Exp/Exp
Atheltic Experience/Coaching Experience

Figure 2.

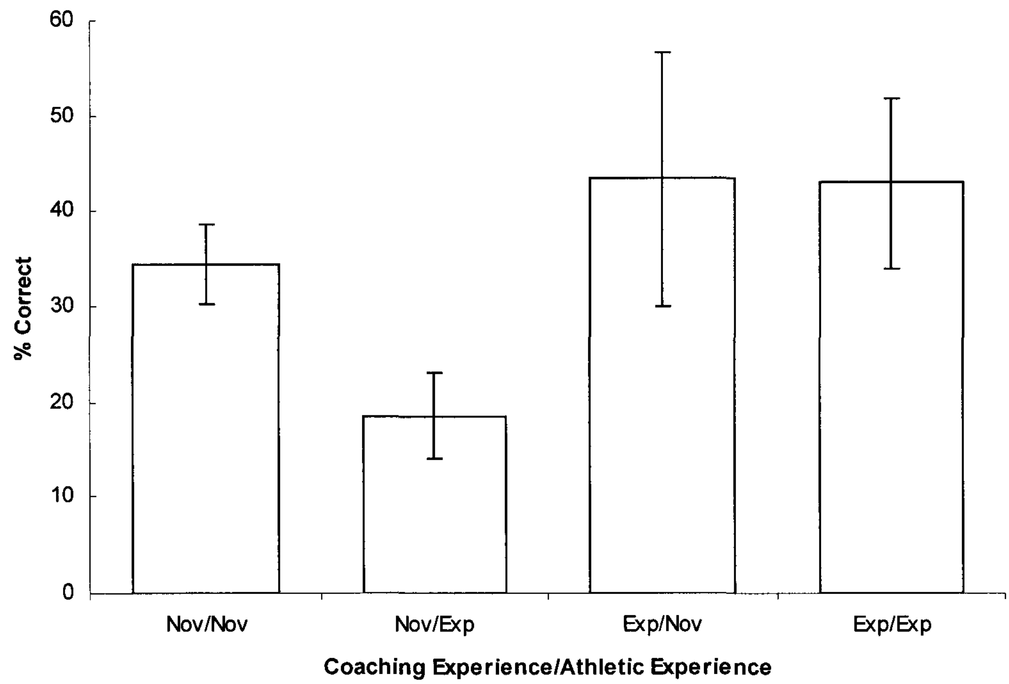

60
50
40
30
20
10
0
% Correct
Nov/Nov
Nov/Exp
Exp/Nov
Exp/Exp
Coaching Experience/Athletic Experience

Figure 3.

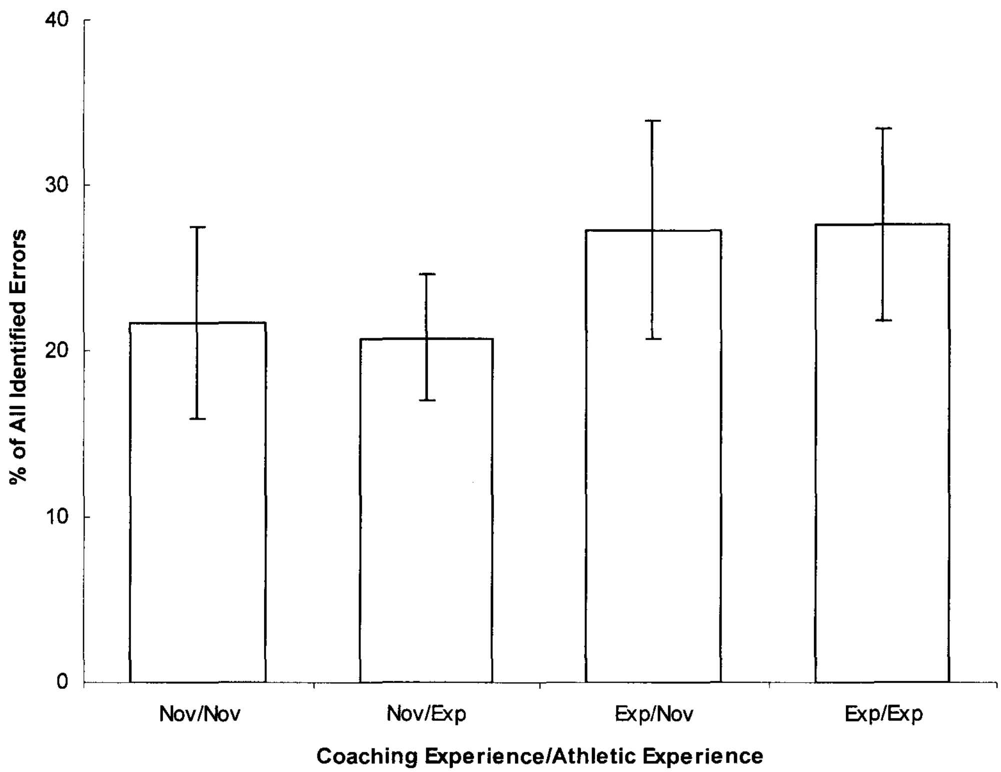

40
30
20
10
0
% of All Identified Errors
Nov/Nov
Nov/Exp
Exp/Nov
Exp/Exp
Coaching Experience/Athletic Experience

Figure 4.

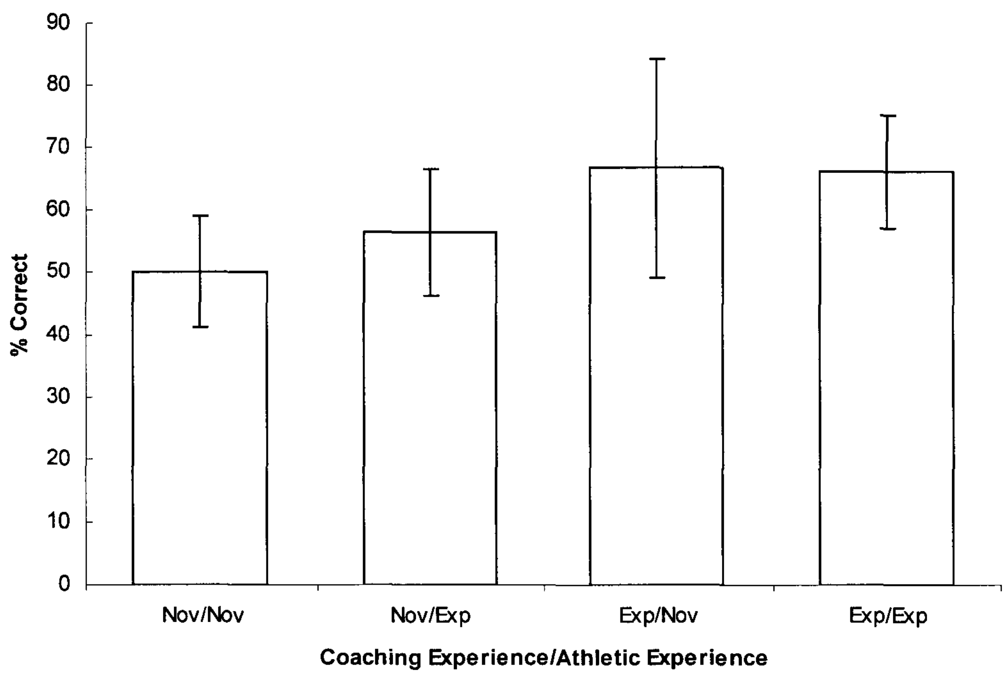
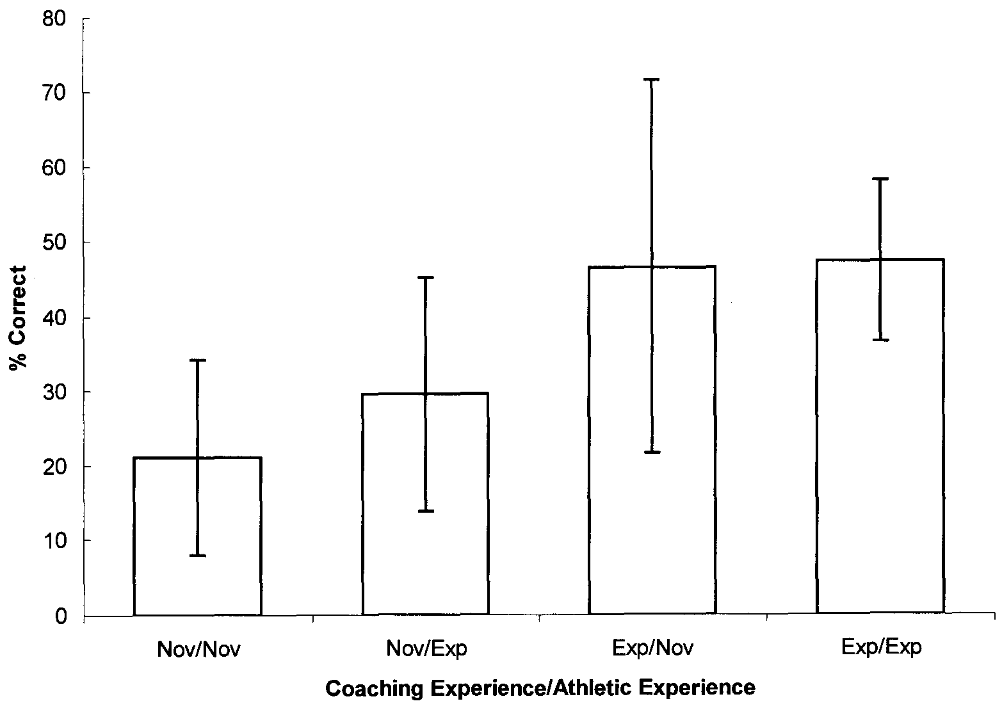

90
80
70
60
50
40
30
20
10
0
% Correct
Nov/Nov
Nov/Exp
Exp/Nov
Exp/Exp
Coaching Experience/Athletic Experience

Figure 5.



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