

**METACOGNITIVE KNOWLEDGE AND SKILLED SPORT PERFORMANCE**

By

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of the Ph.D. degree in Education

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### **Abstract**

This investigation sought to examine expert-novice differences in metacognitive knowledge about action and metacognitive skill functioning, as they relate to the performance of the basketball foul shot. Twenty-four female undergraduate students served as subjects in this investigation. Twelve of the 24 subjects were classified as basketball experts (Group one) and 12 as basketball novices (Group two). Classification as either an expert or novice was dependent upon the total number of seasons having played competitive basketball. Both groups of subjects performed three tasks, each designed to assess a different aspect of their metacognitive functioning. Task one sought to identify group differences in the declarative component of metacognitive knowledge about action through the collection and comparison of instructional verbal protocols. Task two sought to identify both between group differences and the within group relationship between one's actions and the corresponding verbal description of those actions through the collection and comparison of verbal and visual protocols. It was believed that such a comparison would serve to identify group differences in the procedural component of metacognitive knowledge about action. Finally, Task three sought to identify group differences in metacognitive skill functioning as determined through each subject's ability to monitor her performance, predict performance outcomes, and explain the predictions made.

When combined, the results obtained at these three tasks suggested that, specific to performance of the basketball foul shot, the level of metacognitive knowledge about

action and metacognitive skill possessed by the subjects within this investigation was a function of their level of expertise. The 'expert' subjects within Group one were seen to provide complete and accurate instruction in the proper execution of a basketball foul shot. Their ability to accurately describe the actions produced at Task two indicated that they possessed higher levels of the procedural component of metacognitive knowledge about action when compared to Group two subjects. Group one subjects were seen to make significantly more foul shots than Group two subjects at Task three and were also significantly better than Group two subjects with respect to their ability to monitor and successfully predict their performance outcomes. The results obtained at this investigation served to highlight the important, yet often overlooked, association between action and cognition.

## CHAPTER I

### INTRODUCTION

A number of investigators have attempted to develop frameworks for describing knowledge structures and their influence on performance (Anderson, 1976, 1982, 1983; Chi, 1978; Chi & Rees, 1983; Mitchell & Chi, 1986). The first such framework, developed by Anderson (1976), proposed two types of knowledge; procedural and declarative. The main distinction between these two forms of knowledge was said to be one of content. Declarative knowledge was said to emphasize the storage of facts about the world, "knowing that", while procedural knowledge was said to be a representation of one's ability to perform a skill, "knowing how" (Anderson, 1976; Mitchell & Chi, 1986; Winograd, 1975). Research within various problem solving domains has demonstrated that as problem solving skill increases one's domain knowledge moves from a declarative to a procedural form (e.g., Chi, Feltovich, & Glaser, 1981). Therefore, the manner in which knowledge is represented in memory is believed to influence one's problem solving ability. Similarly, McPherson (1993a) maintained that the representation of sport knowledge influences one's decision making ability during sport performance.

Wall, McClements, Findlay, Bouffard, and Taylor (1985) presented formal definitions for both declarative and procedural knowledge when discussed in relation to the motor domain. Within this context, declarative knowledge about action was said to refer to factual information stored in memory which may influence the development and execution of skilled movement (Wall et al., 1985). Likewise, procedural knowledge about action was said to underlie all aspects of action, including the perceptual, cognitive,

response initiation, and response execution phases (Wall et al., 1985). While it has been suggested that changes in an individual's knowledge base may result in changes in an individual's motor performance (e.g., Toward & Kerr, 1994b) there have been few studies that have attempted to directly illustrate this developmental aspect of the knowledge-performance relationship. The methodological difficulties involved in directly assessing the knowledge structure of skilled movers have been implied as contributing to the paucity of research in this area (Russell & Salmela, 1992).

Despite the apparent methodological difficulties, three researchers have attempted to identify how the cognitive and skill execution components of performance combine. French and Thomas (1987) and McPherson and Thomas (1989) studied the relationship between sport knowledge, sport skill, and sport performance in children's basketball and tennis respectively. They found that game performance was related to both the declarative and procedural components of knowledge and sport skill. In an investigation designed to examine the changes in cognitive and motor skill performance of beginning tennis players, across a semester of instruction, McPherson and French (1991) noted that the subject's cognitive components (i.e., factual knowledge and decision making skills) increased concurrently with skill improvement when instruction was skill oriented. The results of these investigations have begun to illustrate the important relationship that exists between the development of knowledge about action and the performance of motor skills. It is important that we understand this relationship more fully for the quality of motor development, as stated by Wall et al., (1985), is largely determined by the knowledge about action within one's possession.

To fully understand the knowledge-performance relationship as it specifically relates to the motor domain requires that we consider the contribution made by that branch of cognition referred to as metacognition. Metacognition is said to refer to a person's knowledge of his/her own, or others, psychological, social, and physical behaviour and abilities (Brown, 1978; Newell & Barclay, 1982). Metacognition may be examined from two perspectives: metacognitive knowledge and metacognitive skills (Wall et al., 1985). Specific to its application within the motor domain, metacognitive knowledge about action has been defined as "knowing about knowing how to move" (Wall et al., 1985, p. 31). It is said to refer to a person's awareness of both procedural and declarative knowledge about action, representing a conscious awareness of the facts and skills within one's possession. Metacognitive skill, on the other hand, refers to the operationalization of this metacognitive knowledge about action.

Research conducted by Toward and Kerr (1994a) has suggested that skilled individuals may possess more metacognitive knowledge than their less skilled counterparts. In fact, "Wall has argued that the individual's level of metacognitive knowledge is a major discriminating factor among performers of differing skill level and expertise" (Russell & Salmela, 1992, p. 10). However, despite its suggested relationship to skilled performance and its apparent superordinate relationship to both declarative and procedural knowledge, the exact nature of the relationship between metacognitive knowledge, metacognitive skill, and performance has yet to be demonstrated empirically within the domain of sport. It was the purpose of this investigation to begin to address this apparent oversight in the research literature.

A knowledge-based approach to studying skilled performance was adopted for this investigation. This approach to studying learning and performance proposes that experts differ from novices with respect to the functioning of their cognitive abilities. Within this approach the sport expert is seen as someone who not only possesses superior motor skills and abilities but also possesses more task specific knowledge and is better able to use that knowledge to assist in moving (Toward & Kerr, 1994a). Thomas, French, and Humphries (1986) have emphasized that understanding the specific sport knowledge base is essential to the study of skilled sport behaviour.

### **Objectives**

The primary objective of this investigation was to examine expert-novice differences in metacognitive functioning. Specifically, this study sought to examine expert-novice differences in metacognitive knowledge about action and metacognitive skill functioning, as they both relate to the performance of the basketball foul shot. This was accomplished through the collection and comparison of verbal protocols, visual protocols, and actual skill performance data.

### **Hypothesis**

The research hypothesis tested within this investigation was stated as follows:

The level of metacognitive knowledge about action and metacognitive skill possessed by an individual is a function of the level of expertise, relative to the performance of that action, of that individual.

To thoroughly test this hypothesis several experimental techniques were utilized. Verbal protocols were collected and compared in an attempt to investigate expert-novice differences in the declarative component of metacognitive about action and metacognitive

skill. Verbal protocols were also collected and compared to visual protocols in an attempt to identify the within group relationship between one's actions and the corresponding verbal description of those actions, believed representative of the procedural component of metacognitive knowledge about action.

### **Educational Implications**

As suggested by Russell and Salmela (1992), research that examines the nature of the sport performer's metacognitive knowledge base and repertoire of metacognitive skills, as well as aspects of both that serve to differentiate athletes of varying skill levels, may provide valuable information to both the researcher and practitioner. At a practical level, any identified differences in metacognitive functioning between individuals of varying skill levels creates the potential for application to the issues of movement/skill training and educating encountered by coaches, athletes, teachers, and students. Identification of the expert's possible metacognitive advantage in sport may assist in the development of possible teaching or coaching interventions that would serve to assist skill acquisition and performance.

### **Definition of terms**

The following terms were operationally defined within the context of this study.

#### **Declarative Knowledge about Action:**

Factual information stored in memory that may influence the development and execution of skilled action (Wall et al., 1985).

#### **Declarative Component of Metacognitive Knowledge about Action:**

A reportable conscious awareness of the factual information stored in memory that

may influence the development and execution of skilled action.

**Expertise:**

Representative of both the range of skill and levels of knowledge that exist between and include the extremes of expert and novice (Blais, 1989).

**Expert:**

Those individuals, within this investigation, found to have significantly greater levels of experience as determined through analysis of the number of years having played competitive basketball.

**Metacognitive Knowledge about Action:**

A reportable conscious awareness about the cognitive aspects of moving consisting substantively of propositionally based declarative knowledge about action and performance oriented procedural knowledge about action.

**Metacognitive Skill:**

The dynamic process of translating metacognitive knowledge about action into action using such higher level executive strategies as predicting, checking, monitoring, reality testing, coordinating, and controlling.

**Novice:**

Those individuals, within this investigation, found to have significantly lower levels of experience as determined through analysis of the number of years having played competitive basketball.

**Procedural Knowledge about Action:**

Underlies all aspects of the execution of skilled action including perception,

stimulus identification, cognition, response initiation, response execution, and the evaluation of feedback (Wall, 1986; Wall, et al., 1985).

**Procedural Component of Metacognitive Knowledge about Action:**

A reportable conscious awareness of those aspects that underlie the execution of skilled action including perception, stimulus identification, cognition, response initiation, response execution, and feedback evaluation.

**Verbal Protocols:**

Those verbalizations that were recorded and ultimately transcribed and believed reflective of the knowledge possessed by each subject, as well as the ongoing mental processing activity that occurred within each subject, during the performance of the three tasks used in this investigation.

**Visual Protocols:**

Those physical movements and actions that were recorded during the performance of Task two and believed reflective of the procedural knowledge about action, specific to foul shot performance, possessed by each subject.

## CHAPTER II

### REVIEW OF LITERATURE

The purpose of this chapter was to incorporate both theory and empirical research from a variety of different domains in an attempt to identify what is currently known about the relationship between knowledge, metacognitive knowledge in particular, and skilled motor performance. Thomas, French, and Humphries (1986) have indicated that if one wishes to examine skilled sport behaviour an understanding of the specific sport knowledge base is essential. However, before one may come to understand the sport knowledge base and its relationship to skilled motor performance one must first understand how knowledge is represented within memory, how this knowledge develops, as well as how this knowledge may best be assessed. In an attempt to address these and other issues relevant to this investigation this review is divided into three main sections.

The first section addresses the issue of knowledge representation from an information processing perspective. This section will review the theory and empirical research on knowledge representation, indicating how the representations discussed influence information processing and task performance within the larger domain of verbal skills.

The second major section of this review mirrors the first in that similar representational issues will be addressed. However, the focus within this section will be on the representation of knowledge about action within the larger domain of sport/motor skills. Much like the first section, this section will review the theory and empirical research on knowledge representation, indicating how the representations discussed

influence information processing and task performance within the larger domain of sport/motor skills.

The third and final section of this review is an articulation of the problem investigated as well as a discussion of previously completed pilot work.

### **REPRESENTATION OF KNOWLEDGE**

The last two decades have born witness to an increased interest in the study of skill acquisition from, what can best be described as, a knowledge-based, information-processing perspective. This research has sought to identify how knowledge is represented within memory, how this knowledge is related to skilled performance, and how to best access and assess this knowledge. The roots of this type of enquiry can be traced back to the mid- to late sixties where researchers within the fields of artificial intelligence and cognitive psychology were concerned with identifying and replicating human problem solving abilities (Glaser & Chi, 1988). The early attempts at creating "intelligent", "thinking" programs, capable of conducting limitless searches using powerful search heuristics, were largely unsuccessful as they were not yet not capable of approximating human problem solving abilities (Glaser & Chi, 1988). As demonstrated in the early work of deGroot (1965) and Chase and Simon (1973), humans, rather than attempting to execute massive searches through memory, rely more on specialized structures of knowledge (Glaser & Chi, 1988) when engaged in problem solving activities. However, the nature of these knowledge structures and their relationship to problem solving heuristics was not initially well understood.

To aid in the understanding and discussion of knowledge, its development, and its

application across various domains a representational system had to be adopted. As was noted by Anderson (1993), a method of notation was needed to represent mental objects if researchers wished to develop a theory in which these objects could undergo transformations (i.e., knowledge could change). Newell and Simon (1972) believed that the organization of human programs, representative of the knowledge utilized by the information processing system when problem solving, closely resembled the production system organization utilized by artificial intelligence researchers of the day. Like Newell and Simon (1972), Anderson (1983) also believed that production systems provided the appropriate computational architecture for achieving a unitary mental system. In fact, Anderson was one of the first to develop a theory of memory and learning based on the production system model (Johnson-Laird, 1988).

### **Declarative and Procedural Knowledge**

Anderson's ACT line of theories; progressing from ACTE (Anderson, 1976), to ACT\* (Anderson, 1983), and culminating in ACT-R (Anderson, 1993) were all based on the production system model and stressed the same fundamental distinction between two long-term stores of knowledge: a declarative memory and a procedural memory. Examined at its most basic level, the main distinction between knowledge represented within declarative memory and knowledge represented within procedural memory is one of content. Declarative knowledge has been defined as one's knowledge of facts, 'knowing that', and procedural knowledge as one's knowledge of how to do something, 'knowing how' (Anderson, 1976; Millward, 1980).

The most commonly accepted model of declarative memory is an associative

network model (Mitchell & Chi, 1986). An associative network model consists of nodes representing concepts, and arcs representing the linkages between concepts (French & Thomas, 1987; Mitchell & Chi, 1986). The linkages between some nodes may vary in strength resulting in some concepts being more strongly associated than others. Mitchell and Chi (1986) stated that an activation process is responsible for the retrieval of information from a network model. The process involves the activation of specific nodes with the activation spreading to other linked nodes. If the activation threshold is exceeded at a specific node the contents of that node will be recalled. The activation of further nodes depends on the strength of the association between the activated node and the nodes with which it is linked. The nodes most strongly associated with the activated node are most likely to be activated next.

The structure of procedural memory is generally said to be conceptualized in terms of a production system consisting of a series of condition-action rules (Anderson, 1976, 1982, 1983; French & Thomas, 1987; Mitchell & Chi, 1986; Neves & Anderson, 1981; Suppes, Pavel, & Falmagne, 1994). Suppes et al. (1994) state that production rules are essentially IF-THEN statements in which the IF statement defines a particular condition while the THEN statement defines a particular action, or set of actions, that is executed when the condition is met. The conditions are generally based on the contents of short-term memory or activated information from long-term memory, while the actions consist of either actual behaviour or the manipulation of contents within short-term memory (Mitchell & Chi, 1986).

So that we may better understand the declarative-procedural distinction, Anderson

has attempted to operationally define this distinction. The most common operational definition was said to involve verbalization (Anderson, 1976, 1993). Knowledge that may be verbally communicated is declarative, while knowledge that must be inferred from one's performance or behaviour is said to be procedural. An individual is able to verbally communicate declarative knowledge because he/she is said to have conscious access to that information. However, an individual is said to have no such access to procedural knowledge (Mandler, 1989). Rather, procedural knowledge is said to be knowledge that one may only display through performance (Anderson, 1993). However, Anderson (1993) does state that the same abstract knowledge can have both procedural and declarative embodiments. By way of illustration, he states that declaratively one may have memorized the layout of a typewriter keyboard, while procedurally one may know the keyboard as part of his/her typing skill.

The manner in which both types of knowledge are obtained also serves to define the distinction between declarative and procedural knowledge. Declarative knowledge is said to be obtained in an all or nothing manner, while procedural knowledge may be only partially obtained (Anderson, 1976). To elaborate, an individual may not possess only partial knowledge of a fact, declarative knowledge, unless it is a chain of related facts. However, an individual may possess only partial knowledge of how to perform an act, procedural knowledge. With respect to the rate of acquisition of each type of knowledge it is believed that declarative knowledge may be acquired suddenly while procedural knowledge may only be acquired slowly, over time, as a result of practice or continuous exposure through one's daily living experiences (Anderson, 1976).

While his attempts to operationally define declarative-procedural differences have provided some insight, Anderson (1993) believed that the only satisfactory way to truly define the declarative-procedural distinction was within the production system framework. He stated that, "The distinction between declarative and procedural knowledge turns on the fundamental mode of operation of a production system" (Anderson, 1993, p. 19). Productions are said to function by either reading information from working memory, or writing information to working memory. The information within working memory is declarative knowledge while the information within the productions is procedural knowledge (Anderson, 1993; Mitchell & Chi, 1986).

Both declarative and procedural representations of knowledge are believed to be required because an individual needs different knowledge structures for the flexible use of knowledge than for the efficient use of knowledge (Anderson, 1993). Millward (1980) stated that representing knowledge declaratively means storing it independently of the initial use made of it. As a result, declarative representations do not have to anticipate how a piece of knowledge will be used allowing the system to be more flexible in the type of deductions it will be able to make. Greater flexibility consequently results in economy of representation, making multiple uses of a single declarative statement (Bobrow, 1975, Winograd, 1975). Procedural representations of knowledge then allow the system to optimize the application of that declarative knowledge for a specific use (Anderson, 1993). The need for both flexibility and efficiency are believed to motivate the declarative-procedural distinction (Anderson, 1993). This 'need' is perhaps best illustrated when one examines the process of knowledge acquisition and the role that both declarative and

procedural representations are purported to play.

It has been theorized that the process of acquiring domain specific knowledge proceeds from a less sophisticated declarative form to a more sophisticated procedural form consisting of IF-THEN (condition-action) rules (Anderson, 1982; McPherson, 1993a). The processes by which knowledge undergoes this 'declarative to procedural' transformation is best illustrated in the three stage model of learning presented by Anderson (1982). At the first stage, entitled the declarative stage, information is both received and encoded as a set of facts about how to perform a skill. Anderson (1982) used the example of learning to drive a car to illustrate this process. When first learning to drive a standard car an individual learns exactly what physical actions must be performed to change gears and to maintain control of the car. When performing the task the individual must then continually access this declaratively represented knowledge. At this first stage of learning the individual is also believed to have access to a repertoire of general interpretive procedures (i.e., general procedural knowledge) which serve to interpret the new information received allowing for some of the desired skill or action to be generated (Hughes, 1987). Quite often a beginning driver, although possessing no specific procedural knowledge for driving a car, as a result of never having done so, may possess a pool of general procedural knowledge for basic driving mechanics which serves to assist the individual in developing the skills needed to drive a car.

At the second of Anderson's (1982) three stages, the procedural stage, the skill being learned is now represented by a series of IF-THEN rules in a production system. It is at this stage that the individual may perform certain actions, such as shifting gears,

without conscious selection of the series of actions that need to be performed. Anderson (1982) stated that it is at this point that individuals no longer have access to these specific procedures except when executing them. Initially, a number of IF-THEN rules are used when performing a skill. However, as a result of continued practice a single IF-THEN rule will develop and become representative of that skill (Anderson, 1982). At this point the skill has become automatic requiring little conscious attention and time for its execution.

Between the declarative and procedural stages is a process called knowledge compilation that is responsible for the translation of declarative knowledge into procedural knowledge (Anderson, 1982). The knowledge compilation process, as described by Anderson (1982), produces three phenomena; speed up, dropout of verbal rehearsal, and elimination of piecemeal application. These phenomena are accomplished through the two subprocesses of composition and proceduralization. Composition is responsible for taking sequences of productions that follow each other in solving a problem and combining them to create one single production sequence (Anderson, 1982). The composition of multiple steps into one single production sequence produces the speed up effect and also leads to the unitary rather than piecemeal application of productions. The second process, entitled proceduralization, builds new versions of the productions which no longer require the domain specific declarative knowledge to be entered into working memory, thereby facilitating the dropout of verbal rehearsal because the essential products of the retrieval operations are now built right into these new productions (Anderson, 1982, 1990).

Much learning still goes on after a skill has been compiled into a task specific procedure. One such type of learning is said to involve an improvement in the method

chosen for performing the task. Anderson (1982) states that for most tasks there are many paths of steps which may be used to approach the problem, and the individual must, therefore, search amongst these paths in an attempt to solve the problem. A fundamental observation of much of the expert-novice research is that individuals possessing a high level of expertise within a particular domain are more judicious in their choice of paths and may alter the method of search if needed (Anderson, 1982).

### **Representation, Decision Making, and Task Performance: Verbal Skills**

As implied within the previous sentence, much of the knowledge representation research has focussed upon identifying representational differences in individuals identified as being either expert or novice performers within a specific domain. The study of expertise attempts, on the most general level, to understand what distinguishes outstanding individuals in one domain from those less skilled in that same domain (Ericsson & Smith, 1991). As this relates to the study of knowledge representation the aim becomes one of trying to understand how the knowledge representations possessed by an expert within one domain differ from those of a novice within the same domain, and how those differences may influence performance.

**Pattern-Recognition and Recall.** Cognitive theory suggests that the mental representation of problems influences how people perceive problems. It would follow then, that as experience results in better problem solving, the quality of problem representation should improve with a concomitant improvement in problem perception (Schoenfeld & Herrmann, 1982). As problem perception is believed to be an important component of problem solving performance, the change in problem perception with the

acquisition of expertise has been subject to a great deal of research. Recall that at the start of this section reference was made to the work of deGroot (1965) and Chase and Simon (1973). The early work of these authors was amongst the first to explore the concept of expertise and attempt to relate expert task performance to cognitive functioning. This early line of research into expertise and expert functioning was interested in identifying how one's perceptual skills related to one's decision making skills and, ultimately to performance. Using a perceptually based pattern-recognition and recall paradigm Chase and Simon (1973) were able to expand upon deGroot's (1965) initial findings that chess masters were able to reconstruct meaningful chess positions after viewing them for only five seconds. In their study, Chase and Simon (1973) were able to demonstrate that the amount of information extracted from a briefly exposed chess position varies with the level of expertise. The superior performance of master players was said to derive from their ability to encode position information into larger perceptual chunks, each consisting of a familiar sub-configuration of pieces. It has been suggested that this ability to encode position information into larger chunks occurs as a result of the master chess player's ability to represent the perceived information in an abstract manner within long-term memory aiding both recall and recognition, and ultimately performance (Adelson, 1984; Charness, 1976) .

The interaction between skill and stimulus information observed by Chase and Simon (1973) has since been demonstrated in a number of other problem solving areas (e.g., bridge, Charness, 1979; computer programming, McKeithen, Reitman, Rueter, & Hirtle, 1981; genetics problem solving, Hackling & Lawrence, 1988). Charness (1979)

found that such tasks as planning the play of a contract, rapid bidding, incidental learning, and the recall of briefly presented bridge hands depended to a large extent upon the level of skill displayed by the players. McKeithen et al. (1981) observed that the classic expert-novice difference in the short-term recall of visually presented meaningful information could be replicated in the domain of computer programming. Hackling and Lawrence (1988) found that expert pedigree problem solvers resembled expert chess players in their ability to encode meaningful chunks within a larger pattern of data and use these to select the next move. Together these results suggest that the superior recall of individuals labelled as expert performers within a specific performance domain is a function of their experience with the subject matter (Garland & Barry, 1990). However, with respect to chess playing, Holding and Reynolds (1982) indicate that move selection continues to increase with increased levels of expertise, while after a certain level of expertise recall performance is not related to move selection. As a result, they have stated that the use of perceptual paradigms may not be totally effective when attempting to predict chess players' selections in game situations. Rather, it has been suggested that it may be most logical to examine how one's search and problem solving strategies are represented within one's knowledge base (McPherson, 1993a).

Knowledge Base. Research in such domains as physics (Chi, Feltovich, & Glaser, 1981; Hardiman, Dufresne, & Mestre, 1989) and mathematics (Schoenfeld & Herrmann, 1982) has indicated that experts tend to focus upon the deep structures of problems (e.g., underlying principles and concepts) when deciding whether or not two problems would be solved in a similar manner. The findings from the research performed within these

semantically rich domains suggests that, when attempting to solve a problem, experts begin by considering what principles apply most appropriately to the situation, and then decide upon a strategy or procedure that will be used to operationalize those principles (Larkin, McDermott, Simon, & Simon, 1980). Hardiman et al. (1989) found, when comparing experts and novices on a similarity judgement task, that the experts predominantly relied upon the problems' deep structures when deciding upon the similarity of solution, while the novices relied predominantly upon the surface features.

A number of researchers have observed that, when asked to categorize problems into types according to similarity of solutions, novices tend to rely upon the surface features of the problem as the primary criterion of similarity (Chi et al., 1981; Hardiman et al., 1989; Schoenfeld & Herrmann, 1982). When asked to state the general problem solving approach they would take to solve a problem, novices usually relate detailed information, rather than more general principles and concepts (Chi et al., 1981). Therefore, within a variety of domains, the organization of expert knowledge appears to reflect an appropriate 'deep structure', while the organization of novice knowledge often reflects a reliance upon 'surface structure' (Miller & Stigler, 1991). As noted by Hardiman et al. (1989), as problem solving skills develop, the reliance on deep structure to categorize problems increases. Through the comparison of groups of novices at the same level of experience who differed with respect to the types of reasoning employed when making similarity judgements, Hardiman et al. (1989) were able to demonstrate similarities between the problem categorization skills of novices and experts. They found that novices who made greater use of principles, compared to novices who relied predominantly on

surface features, tended to categorize problems similarly to how experts categorized them, as well as score high in problem solving. These results support the claim made by Schoenfeld and Herrmann (1982) that problem perceptions change as individuals acquire greater levels of problem solving expertise.

As individuals acquire greater levels of problem solving expertise, accompanying changes in knowledge representation have also been noted. Researchers within a variety of domains have indicated that the acquisition of domain knowledge and problem solving skill proceeds from a less sophisticated declarative form, to a more sophisticated procedural form, to an intricate network of declarative knowledge that is manipulated and transformed by the appropriate procedural knowledge (e.g., problem solving in physics, Chi, Feltovich, & Glaser, 1981; de Jong & Ferguson-Hessler, 1986; studying physics texts, Ferguson-Hessler & de Jong, 1990; problem solving in biology, Lavoie, 1993). Glaser (1984) stated that the possession and utilization of an organized body of conceptual and procedural knowledge, as well as the possession of accessible and useable knowledge, differentiates those individuals who display more or less ability in thinking and problem solving.

The findings from this research on the expert-novice distinction have made important contributions to basic cognitive theory. Recall that in the early phases of this research (e.g., Chase & Simon, 1973) it was not known whether domain-independent skills (i.e., general problem solving skills, overall aptitude) or domain-specific knowledge and skills (i.e., content or subject matter knowledge) would prove most important in distinguishing experts and novices. However, work by researchers in the domains of chess,

bridge, and problem solving failed to confirm any type of 'general superiority' hypothesis, instead finding that experts and novices differed in the quantity and quality of the domain specific knowledge possessed (Walker, 1987). Walker (1987) contends that this theoretical position, implying that change from novice to expert status can be achieved by acquiring identifiable domain-specific knowledge and skills, is far more encouraging than a theory that assumes that intellectual functioning is based solely on aptitude and general processing skill. In an earlier, and perhaps stronger, declaration in support of this position Glaser (1984) stated the following:

This suggests that improvement in the skills of learning, such as those required on aptitude and intelligence tests, takes place through the exercise of conceptual and procedural knowledge in the context of specific knowledge domains. Learning and reasoning skills develop not as abstract mechanisms of heuristic search and memory processing. Rather, they develop as the content and concepts of a knowledge domain are attained in learning situations that constrain this knowledge to serve certain purposes and goals. (p.99)

Research has shown that domain expertise (i.e., domain specific declarative and procedural knowledge) can in fact compensate for an overall lack of aptitude by providing a 'domain specific aptitude' that allows low-aptitude/high-knowledge individuals to perform in ways similar to their high-aptitude/low-knowledge counterparts. In a study designed to determine whether domain-specific expertise could compensate for low overall aptitude when acquiring domain related information (i.e., a baseball passage), Walker (1987) found that performance was a function of baseball knowledge rather than

aptitude level. Schneider, Kőrkel, and Weinert (1989) also found that domain-specific knowledge could compensate for low overall aptitude on domain-related cognitive tasks. They compared the memory performance and text comprehension of groups that were equivalent on domain-specific knowledge but differed in overall aptitude and found no differences between high-aptitude and low-aptitude experts on any of the memory performance and comprehension measures obtained.

The greater underlying domain specific knowledge possessed by experts, and illustrated in the above studies, may benefit the expert performer in another way. It has been suggested that the greater domain specific knowledge possessed by experts may also manifest itself as a form of enhanced self-knowledge allowing the expert to, among other things, better monitor his/her skilled performance (Glaser & Chi, 1988). To do so requires that the domain specific knowledge be represented in yet another way. While emphasis within both cognitive theory and research has traditionally been placed upon declarative and procedural representations of knowledge, it is believed that if we are to understand how knowledge is developed and applied across various performance domains a third type of knowledge representation, metacognitive knowledge (i.e., metacognition), must also be understood (Dillon, 1986).

### **Metacognitive Knowledge**

While frequently described as a fuzzy concept (Wellman, 1983), and often said to suffer from variability in its use within both theory and research (Yussen, 1985), metacognition is generally thought of as referring to that body of knowledge that reflects upon cognition itself (Brown, 1978; Flavell, 1976, 1979; Wellman, 1985; Yussen, 1985).

That is, it refers to an individual's knowledge about such cognitive processes and states as memory, attention, knowledge, conjecture, and illusion (Wellman, 1985). To illustrate, I am engaging in metacognitive activity if I highlight text as I am reading because I realize I may have difficulty remembering it; if I arrange my reference material according to content rather than alphabetically because I know this will make it easier to retrieve information at a later date; if I ask someone to proof-read my written work knowing that I may have missed something. Therefore, metacognition may be thought of as referring to, among other things, the active monitoring, regulation, and orchestration of one's information processing activities while in the service of some specified objective (Flavell, 1976). However, metacognitive knowledge is not just limited to one's knowledge of cognitive processes, rather it is also said to refer to a person's knowledge of his/her own or others' psychological, social, and physical behaviour and abilities (Newell & Barclay, 1982). One may, therefore, assume that metacognitive knowledge is, to some degree, reflected in all that we know and all that we do. In fact, Dillon (1986) has stated that metacognitive knowledge, or self-knowledge as she refers to it, pertains to the state of our declarative knowledge as well as our procedural knowledge.

Flavell (1971) was one of the first to explore the concept of metacognition, his research focussing upon the development of children's awareness of their own memory (i.e., metamemory). Since this time the term metacognition has grown to almost "buzzword" proportions (Gavelek & Raphael, 1985). Studies have explored the concept of metacognition in such areas as problem solving (e.g., Berardi-Coletta, Dominowski, Buyer, & Rellinger, 1995; Swanson, 1990) reading (e.g., Myers & Paris, 1978; Swanson

& Trahan, 1992), and memory (e.g., Yussen & Levy, 1975 ).

The work of John Flavell (1976, 1979) and Ann Brown (1975, 1977, 1978) has contributed greatly to our current understanding of metacognition. Both authors have presented complimentary, yet independent, sets of definitions and descriptions about metacognition that have helped shape and guide much of the empirical research in this domain (Yussen, 1985). Consequently, their work contributed significantly to how the concept of metacognition was defined and assessed within the present investigation. Therefore, this section of the review of literature will focus upon the concept of metacognition as defined and described by both Flavell and Brown.

First, let us examine Flavell's (1979) notion that a distinction exists between metacognitive knowledge and metacognitive experience. "Metacognitive knowledge is that segment of your (a child's, an adult's) stored world knowledge that has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences" (Flavell, 1979, p. 906). This factual knowledge about memory, as it is referred to by Wellman (1983), includes knowing that rehearsing an item will enhance one's chances of later recalling that item and that more time may need to be spent reading material that is unfamiliar to oneself if one wishes to gain an understanding of that material. This factual knowledge may also be personal in that one may come to understand that he/she has difficulty working within one cognitive domain (i.e., mathematics) yet is quite adept in another (i.e., science).

In contrast, one may, while engaged in the activities cited above, experience a relatively spontaneous awareness of his/her state of knowledge. For example, while

reading material previously encountered, an individual may react by saying to him/herself, "Ok, I've read this before, I know this", and proceed to skim the remaining text until new material is encountered. Likewise, an individual may encounter an unknown abbreviation while reading and react by thinking, "Hmm, what does that stand for?, I don't think I've seen that before." These reactions to one's cognitive functioning are referred to as metacognitive experiences. As described by Flavell (1979), metacognitive experiences refer to "any conscious or affective experiences that accompany and pertain to any intellectual enterprise" (p. 906). Yussen (1985) distinguishes between metacognitive knowledge and experience by stating that metacognitive knowledge consists of declarative and procedural knowledge used to guide cognitive activity while metacognitive experiences are the 'on line' reactions to that activity.

Flavell (1979) next described three categories of metacognitive knowledge variables believed to influence cognitive functioning. These three categories and examples of each include (1) person - knowledge about oneself and others as cognitive processors (e.g., knowing that you perform best when in a relaxing, non stressful environment); (2) task - knowledge about how the task characteristics influence performance on that task (e.g., knowing that you perform poorly on tests requiring essay type responses); and (3) strategy - knowledge about how best to enhance performance through the use of specific strategies (e.g., knowing that presenting material visually as well as verbally may enhance retention and subsequent recall). Flavell (1979) believed that most metacognitive knowledge involved the interactions amongst two or all three of these variable groupings. This 'interaction' is, in fact, considered the fourth metacognitive knowledge variable

category. An interaction involving the first three categories is illustrated in the following example: Mr. Blue (unlike Ms. Red) believes that he should prepare for the essay portion of the exam (as contrasted to the multiple choice section) by trying to relate his class notes to the material in the text book (rather than simply re-reading the class notes).

Brown's contribution, as described by Yussen (1985), to defining the concept of metacognition has been to fine-tune what we mean by metacognitive knowledge. Brown (1978) and Brown and DeLoache (1978), while discussing the complexity of the metacognitive abilities demanded of the mature problem solver, indicated that there are six basic skills of metacognition that are critical for the functioning of an effective problem solving system. Brown and DeLoache (1978) stated that:

The basic skills of metacognition include *predicting* the consequences of an action or event, *checking* the results of one's own actions (did it work?), *monitoring* one's ongoing activity (how am I doing?), *reality testing* (does this make sense?), and a variety of other behaviors for *coordinating* and *controlling* deliberate attempts to learn to solve problems. (p. 15)

These skills are said to be the basic characteristics of efficient thought, able to be applied to the whole range of problem solving activities (Brown & DeLoache, 1978). As stated by Yussen (1985), these concepts represent some of the major ideas that have structured the definition of metacognition as a domain of inquiry and, as a result, have greatly influenced the investigation reported here.

There appears to be considerable support for the representational concept of metacognition. It has been shown as being conceptually distinct from cognition (Nelson,

Dunlosky, White, Steinberg, Townes, & Anderson, 1990) as well as positively influencing problem solving performance (Swanson, 1990). As was demonstrated for both declarative and procedural representations of knowledge, expert-novice differences have also been observed with respect to metacognitive knowledge. Chi and Glaser (1985) state that when attempting to solve problems experts are more aware than novices when they make errors, why they fail to comprehend, and when they need to check their solutions; illustrating an enhanced functioning of at least three of the six basic skills of metacognition as outlined by Brown (1978) and Brown and DeLoache (1978). The metacognitive knowledge possessed by experts is also said to be manifested in their being more accurate than novices in judging the difficulty of problems to be solved (e.g., Chi, Glaser, & Rees, 1982). While expert-novice differences have been observed with respect to metacognitive functioning, this paradigm has not been used as extensively by researchers examining metacognition as it has by researchers exploring declarative and procedural representations of knowledge. Rather, metacognitive knowledge is often studied using children as subjects, frequently attempting to identify the developing relation between children's metacognition and the range of problem solving activities.

In an early investigation of one aspect of metamemorial development Flavell, Friedrichs, and Hoyt (1970) found that as children aged their knowledge about their own short-term span of memory increased. These researchers presented children, aged four to nine years, with simple sequences of pictures and asked if they would be able to recall the pictures in each list in order. Children at each age were seen to predict a higher level of recall than was actually observed. However, the degree of over prediction was seen to

drop with increasing age. In an attempt to replicate and extend these results, Yussen and Levy (1975) attempted to examine the developmental changes in the accuracy in predicting one's own recall with preschool, third grade, and college subjects. Subjects were asked to predict their span of memory for picture names and then given a recall task to assess their actual span of memory. Prediction accuracy was seen to increase from the preschool to the college years, supporting the earlier work of Flavell et al. (1970). However, the adults (i.e., college students) were seen to be negatively affected by the presentation of 'false' norm information suggesting that even they have uncertainty about their exact recall capabilities (Yussen & Levy, 1975).

One may safely assume that lacking such metamemorial abilities as being able to predict one's short-term memory span and recall may negatively impact upon one's ability to function well in problem solving situations, or any other cognitively demanding tasks for that matter. Remembering a series of pictures or words, solving problems, or comprehending written prose are deliberate actions that require an individual to be knowledgeable of the plans and cognitive skills, of which recall is one, within his/her possession as well as being able to select and apply them appropriately to the problem at hand. While adults and older children have been shown to be sensitive to such metacognitive variables, children younger than eight years of age are said to be less sensitive (Myers & Paris, 1978). Myers and Paris (1978) believe that since the development of children's metacognitive knowledge is associated with efficient learning, remembering, and communicating, it may provide a link in explaining the transition from a less sophisticated to a more sophisticated problem solver.

One domain that has been subject to an increasing amount of empirical research specific to identifying its relationship to a child's developing metacognitive knowledge, awareness, and understanding is that of reading and reading comprehension (e.g., Cross & Paris, 1988; Myers & Paris, 1978; Paris & Myers, 1981). Most studies of children's knowledge about reading have used interview techniques to assess their metacognitive abilities (Jacobs & Paris, 1987). Myers and Paris (1978) assessed the metacognitive awareness of variables that influence reading in 40 eight and 12 year old children through the analysis of their responses to 18 interview items. The variables selected and assessed during the interview process were Flavell's (1979) categories of person, task, and strategy. While the eight year olds were found to be aware of the influence of some reading dimensions such as interest, length, and familiarity, they were less sensitive to the semantic structure of paragraphs, goals of reading, and strategies for resolving comprehension failures than the 12 year olds. As a result it was suggested that age-related differences in metacognitive knowledge may be correlated with the acquisition of reading skills (Myers & Paris, 1978). In a subsequent study, Paris and Myers (1981) compared the metacognitive abilities of good and poor fourth grade readers. It was found that good readers knew more about reading strategies, had better memory for text, and detected more errors while reading than did their poor reading counterparts.

In a study designed to increase children's understanding and use of comprehension strategies, Paris and Jacobs (1984) observed a modest yet significant correlation between metacognition and various measures of reading comprehension. Within their study children were instructed about the existence and use of reading strategies in an attempt to stimulate

greater awareness of declarative, procedural, and conditional knowledge, while at the same time teaching children how to evaluate, plan, and regulate their own comprehension in strategic ways. This experimental curriculum was thus labelled Informed Strategies for Learning (ISL) (Paris & Jacobs, 1984). As stated previously, significant correlations were observed between comprehension and reading awareness. Furthermore, children within the ISL condition gained significantly more from pretest to posttest on measures of reading awareness and strategic reading than did those students within the control condition. Hence, by explaining thinking skills that can be used before, during, and after reading, children can benefit through an increased reading awareness, skill, and comprehension (Jacobs and Paris, 1987). Cross and Paris (1988) were able to replicate these findings, again making use of the ISL when attempting to examine the relationship between children's metacognition and reading comprehension. Informed strategies for learning served to prompt children to connect cognitive strategies with reading goals and helped to shift responsibility for recruiting and applying strategies from the teacher to the learner (Cross & Paris, 1988).

While evidence has been provided for the positive influence that metacognition has on both reading and reading comprehension these are not the only areas believed to benefit from enhanced metacognitive functioning. Recall that Myers and Paris (1978) also believed that metacognitive knowledge may provide a link in explaining the transition from a less sophisticated to a more sophisticated problem solver. There is, in fact, considerable evidence that metacognitive knowledge influences problem solving (e.g., Artzt & Armour-Thomas, 1992; Flavell, 1976; Swanson, 1990), and that the use of metacognitive

strategies may be a result of learning ability (e.g., Swanson, 1990). Some studies have also suggested that the influence of metacognition is independent of the overall level of aptitude possessed by the problem solver (e.g., Swanson, 1990).

It was believed that establishing the independence of metacognition from cognition was important for a number of reasons, the most important of which Swanson (1990) stated was related to determining whether subjects of relatively low aptitude can compensate their performance with high levels of metacognition. In an attempt to determine the independence of metacognition and general aptitude on various problem-solving measures Swanson (1990) analysed the think aloud protocols of four groups (high aptitude/high metacognition, high aptitude/low metacognition, low aptitude/high metacognition, low aptitude/low metacognition) of subjects engaged in problem solving activities. Those individuals classified as high metacognitive individuals were seen to outperform the lower metacognitive individuals in problem solving regardless of the overall aptitude level possessed by the problem solvers. Therefore, these results indicated that high metacognitive ability positively influenced problem solving performance. In an attempt to explain his findings, Swanson (1990) speculated that high metacognitive skills can compensate for overall ability by providing a certain knowledge about cognition. He argued that measures of metacognition and general aptitude are tapping different forms of knowledge, and that high performance on the problem solving tasks within his investigation was more closely associated to higher performance on the metacognitive measures than on the aptitude measures. Swanson's results are very similar to those of Walker (1987) and Schneider et al., (1989) who, you will recall, found that one's level of

domain specific knowledge, not one's general aptitude, had the greatest influence upon one's problem solving behaviour. A study performed by Slife, Weiss, and Bell (1985) provides further support for Swanson's (1990) argument. In their study, it was found that high metacognitive students were more likely to correctly monitor right and wrong answers to mathematics problems than were low metacognitive students (Slife et al., 1985).

Some investigations of the relationship between metacognition and problem solving have implicated metacognition as a possible source of learning disabled children's deficient performance on problem solving tasks (e.g., Borkowski, Estrada, Milstead, & Hale, 1989; Slife et al., 1985; Swanson, 1993). It has been suggested that learning disabled children suffer high-order processing inefficiencies related to problem solving, with metacognition possibly representing one such inefficiency. Slife et al. (1985) demonstrated that learning disabled students, when matched to regular students on the basis of achievement test scores, IQ scores, and performance scores on 10 math problems, were less skilled in two forms of metacognition. The learning disabled group was found to be less accurate in their knowledge about problem solving skills as well as less accurate in monitoring their problem solving performance (Slife et al., 1985). To compensate for these suggested higher-order processing inefficiencies, learning disabled children are believed to rely on a different set of mental operations than their non-disabled peers.

To test the hypothesis that learning disabled children, when compared to non-disabled children, rely on different mental processes to arrive at a solution during problem solving because of a weakness in metacognitive functioning Swanson (1993) had 63

children (32 learning disabled, 17 gifted, 14 normal achievers) perform a battery of three problem solving tests. The three groups of children were compared on their problem solutions, “think-aloud” protocols during problem solving, and their responses to a metacognitive questionnaire. While the learning disabled children were comparable to the other ability groups with respect to problem solution, their metacognitive and “think-aloud” responses were found to be distinct. The interrelationships between problem solution, “think-aloud” protocols, and measures of metacognition varied among the three ability groups. The observed correlation coefficients were low for the learning disabled children, moderate for the normal achievers, and high for the gifted children. As a result, Swanson (1993) concluded that learning disabled children’s problem solving performance reflects a weak integration of metacognitive skills with both processing and problem solution.

Swanson (1993) claimed that the results of his study did not support the notion that learning disabled children are strategically inactive learners. Rather, he suggested that the learning disabled children in his study were ‘actively inefficient’ when compared to their peers. That is to say, the learning disabled children actively developed strategic thought patterns when solving the problems presented to them, however, they were developed differently than their peers. The differences were said to be related to their metacognitive ability to use other strategy subroutines in a flexible manner (Swanson, 1993).

### **REPRESENTATION OF KNOWLEDGE ABOUT ACTION**

As was evidenced in the discussion of the representation of knowledge within the

first section of this review, an individual's knowledge base can significantly influence one's performance in a great number of domains. High levels of domain specific knowledge (i.e., declarative and procedural knowledge) have been shown to be related to high levels of task performance. Likewise, an increased awareness of, and instruction in, strategy usage (i.e., metacognitive knowledge) has been shown to result in enhanced task performance. To this point in the review these representational advantages have only been discussed with respect to performance in the semantically rich domains of mathematics, reading, physics, and chess, to name but a few. Of interest to researchers within the movement oriented domain of sport is whether individuals of varying levels of skill, related to task performance, represent, access, and operationalize their knowledge in ways similar to individuals within the more purely cognitive problem solving domains discussed previously.

Performance within the domain of sport would appear to require similar problem solving skills to those used in chess and bridge for example. To illustrate, prior to the execution of an 'action' one may consider the opponent's strengths in response to any possible selections made. Based upon the conditions evaluated, one then decides upon the appropriate action and attempts to execute it. As a result, it becomes obvious that a player's representation of the situation (e.g., problem representation and cognitive strategies) may affect the quality of the action selected as well as the speed of response (McPherson, 1993a). However, before we may understand how a player represents a performance situation we must first understand how knowledge about action is represented within memory. Once we have gained an understanding as to how knowledge

about action is represented, we may then begin to understand one's behaviour within the context of the sporting environment.

Traditional definitions have stated that an individual's acquired knowledge is representative of the product stored in memory of one's interactions with the environment (Newell & Barclay, 1982). Gains in one's acquired knowledge are said to occur as a result of one's cumulative interactions, or experiences, and development (Wall, 1986). Newell and Barclay (1982) believed that action, as well as knowledge, could be viewed in this manner. They suggested that knowledge was acquired about the usefulness of various actions for meeting different task demands. The usefulness of the actions was based upon whether or not they resulted in the successful completion of the task, or in the failure to meet the imposed task demands (Newell & Barclay, 1982). This section of the review is not specifically concerned with the acquisition of action per se, rather it is concerned with the types of knowledge one may develop about action. Of specific interest to this section are the metacognitive aspects of knowledge about action that may develop. However, before focussing attention on the metacognitive aspects of knowledge about action a brief overview of the other types of knowledge about action that are said to exist is first presented.

### **Declarative and Procedural Knowledge about Action**

Wall (1986) and Wall et al. (1985) categorised acquired knowledge about action into three major types: procedural, declarative, and affective. Much as general procedural knowledge underlies the performance of skills within a given domain, procedural knowledge about action is said to underlie all aspects of action including perception,

stimulus identification, cognition, response initiation, response execution, and the evaluation of feedback (Wall, 1986; Wall et al., 1985). In fact, Wall et al. (1985) stated that, "An action sequence may be viewed as the instantiation of procedural knowledge about action" (p. 29). Declarative knowledge about action, on the other hand, is said to refer to factual information stored in memory which may influence the development and execution of skilled action (Wall et al., 1985). Affective knowledge, as described by Wall et al. (1985), refers to the attachment of subjective feelings (e.g., feelings of competence or failure) to an action by an individual. When viewed in this manner, affective knowledge about action appears to be the motoric equivalent of Flavell's metacognitive experiences. Combining Flavell's (1979) description of metacognitive experiences and Wall et al.'s (1985) definition of affective knowledge about action one may define metacognitive experiences, as they relate to the performance of motor skills, as any conscious or affective experiences that accompany and pertain to any movement experience.

### **Metacognitive Knowledge about Action**

Newell and Barclay (1982) believed that one way to approach the issue of knowledge about action was to answer the following question: "What can a person know or come to know about his/her own actions" (p. 187)? As previously discussed, this 'knowing about knowing' is central to the concept of metacognition. Within Wall's (1986) and Wall et al.'s (1985) taxonomy of types of acquired knowledge about action metacognitive knowledge about action and metacognitive skills were also differentiated.

Metacognitive knowledge about action is said to represent one's knowing about knowing how to move (Wall et al., 1985) or, as stated by Newell and Barclay (1982),

represents an individual's awareness of the association between movement and its consequences. One may, in fact, think of metacognitive knowledge about action as a higher type of factual (i.e., declarative) knowledge about action that develops as individuals become consciously aware of what they can or cannot do in a number of movement situations. Wall et al. (1985) suggest that metacognitive knowledge about action refers to an individual's awareness of their procedural, declarative, and affective knowledge about action. It has been suggested that this knowledge develops with experience (Thomas & Thomas, 1994). To illustrate this last point, Wall et al. (1985) stated that as children learn to swim their awareness of the swimming skills within their possession grows. Children begin to realize how well they can float, bob up and down, or swim a specific stroke. They state that children next begin to realize that they can selectively focus their attention on certain parts of a skill, model the behaviour of others, and use verbal instructions to help guide their actions. As the children mature they then use such metacognitive knowledge about action to improve their ability to learn in other problem-solving situations (Wall et al., 1985).

The ideas expressed by Wall (1986), Wall et al. (1985), and Newell and Barclay (1982), with respect to metacognitive knowledge about action, have been greatly influenced by the earlier work of those cognitive psychologists (e.g., Brown, Flavell, and Wellman) that first explored the concept of metacognition. Newell and Barclay (1982) were among the first to apply what had previously been learned through the study of verbal learning and memory to the area of motor development. They suggested that developing an awareness about one's own actions involves two types of knowledge;

sensitivity to situations requiring skilled action, and the knowledge of variables that affect the outcome of action. Sensitivity to different situations refers to knowledge of the fact that action is required, as well as an understanding of the movements required to successfully complete the act. The latter component of sensitivity, an understanding of the movements required to successfully complete the act, can itself be broken down into two related elements. The first of these being an understanding of the nature of the problem to be solved, with the second referring to an individual's awareness of the specific situational cues which define the parameters of the task demands (Newell & Barclay, 1982).

The second type of metacognitive knowledge presented by Newell and Barclay (1982), the knowledge of variables that affect the outcome of actions, is said to include three related variables; person, task, and strategy variables (Newell & Barclay, 1982). These variables are, quite obviously, an extension of the metacognitive knowledge categories first described by Flavell (1979). However, rather than only influencing cognitive functioning, these variables are also said to influence motor functioning.

The person variable, as described by Newell and Barclay (1982), reflects an individual's knowledge of him/herself, or others, as being skilled in certain actions and exists in two dimensions. The first dimension, entitled traits, consists of an individual's knowledge of his/hers or others enduring physical structures, whereas the second dimension, entitled states, refers to an individual's understanding of his/her present ongoing action (Newell & Barclay, 1982). This understanding will allow the individual to determine if the action should be terminated or continued depending on whether or not the perceived goal of the action was reached.

The task variable, as described by Newell and Barclay (1982), refers directly to an individual's knowledge of the task constraints which affect the difficulty of the action to be performed. This knowledge is believed to be acquired through two sources: (a) actual experience at the task, and/or (b) generalized knowledge on a class of tasks with similar constraints (Newell & Barclay, 1982).

The last variable considered by Newell and Barclay (1982) was the strategy variable, which makes reference to the way that an individual approaches a task. The type of strategies employed during problem solving are believed to be representative of an individual's level of knowledge concerning that particular task. Newell and Barclay (1982) conclude that the understanding of skilled action requires an analysis of the interrelationship of the sensitivity and variable categories of metacognition.

Within Wall's (1986) discussion of metacognitive knowledge about action frequent reference was made to the five general classes of metacognitive knowledge that Wellman (1984) suggested children become aware of as they mature and gain experience. Within Wellman's (1984) first class of metacognitive knowledge, he stated that as children age they become aware of the fact that mental processes exist. Wall (1986) then suggested that an important aspect of this awareness will be related to their physical body and its control. As children continue to gain experience, Wellman (1984) believed that they will begin to distinguish between different types of cognitive processes such as remembering and reasoning. Application of this class of knowledge to the motor domain would suggest that children learn that they can mentally plan and rehearse actions (Wall, 1986). The third class of metacognitive knowledge believed to develop in children as they continue to grow

and gain experience is an awareness of the types of variables that affect their cognitive processing (Wellman, 1984). Wall (1986) suggests that, in a similar way, they also become aware of the factors that affect their memory performance and skill execution in the motor domain. Within Wellman's (1984) fourth class of metacognitive knowledge children are believed to develop an understanding of how different cognitive processes affect each other as well as how they can be combined to influence different types of tasks. When applied to the motor domain, Wall (1986) suggests that this understanding is very important as skilled action often requires the use of different types of knowledge about action. Finally, within Wellman's (1984) fifth class of metacognitive knowledge, children learn to appreciate their own mental states. They now know when they know and when they understand, as well as when they don't know and don't understand. Wall (1986) suggests that this final class of metacognitive knowledge is of crucial importance in the monitoring and control of cognitive-motor activities. As such, he states that it becomes procedural in nature and may be better classified as a metacognitive skill.

Metacognitive skill is said to refer to the operationalization of metacognitive knowledge about action (Wall et al., 1985). As a result, metacognitive skill is often thought of as a higher type of procedural knowledge about action. As individuals develop and/or refine their declarative, procedural, and metacognitive knowledge about action, higher level metacognitive skills will emerge and will be used to procedurally control cognition and action within skill learning situations (Wall et al., 1985).

Within the motor domain, most voluntary actions are initiated to meet specific goals and situational demands (Wall, 1986). Whether one is opening a jar, crossing a

street, or attempting to catch a fly ball, the actions are characterised by their goal-directed nature. If one fails to achieve the goal the action can not be considered a success.

Therefore, higher-level executive processes are considered essential for the control and execution of skilled action. Wall (1986) states that, "effective metacognitive control of cognitive processes underlying stimulus identification, response selection, and response programming can ensure that voluntary actions optimally meet the demands of a situation" (p. 42).

Recall that Brown and DeLoache (1978) emphasized the importance of six basic skills of metacognition for the effective functioning of a problem solving system. Wall (1986) states that the development of such generic metacognitive skills as predicting, checking, monitoring, reality testing, coordinating, and controlling allow people to control and enhance their own learning within the motor domain. These metacognitive skills are believed to develop slowly with age and experience, similarly to how Thomas and Thomas (1994) stated that metacognitive knowledge develops.

As they have been described within the literature (Wall, 1986; Wall et al., 1985), both metacognitive knowledge about action and metacognitive skills assume an almost superordinate role in relation to the other types of knowledge about action as they respectively represent one's awareness of and control over his/her declarative, procedural, and affective knowledge about action. As was indicated in the first section of the review, both metacognitive skills and metacognitive knowledge are believed to increase with age and experience. However, this developmental relationship has yet to be as strongly illustrated within the cognitive-motor domain (Newell & Barclay, 1982). Research

examining the development of knowledge about action, as well as differences in the knowledge possessed by individuals of varying levels of motor skill, will be examined next.

### **Representation, Decision Making, and Task Performance: Motor Skills**

While Thomas (1994) has suggested that a working relationship exists between declarative, procedural, and strategic (i.e., metacognitive) knowledge, decision making, skill, and game performance, the exact nature of this relationship is not yet clearly understood. As was evidenced in the previous discussion of the relationship between knowledge representation, decision making, and task performance for verbal skills, much of the research examining these same relationships for motor skills has also focussed upon identifying differences in individuals labelled as either expert or novice performers. The contemporary study of motor expertise, as described by Abernethy (1994) and Abernethy, Burgess-Limerick, and Parks (1994) has been dominated by the same two research paradigms that were used extensively to study expertise within the domain of verbal skills; namely the perceptually based pattern-recognition and recall paradigms of deGroot (1965) and the knowledge-based paradigm of Anderson (1982).

**Pattern-Recognition and Recall.** First let us briefly consider those investigations that borrowed the pattern-recognition and recall paradigms first used by cognitive psychologists. When applied to the motor domain these research paradigms become concerned with identifying the perceptual skills used by players in simulated sport situations (McPherson, 1993a). Allard, Graham, and Paarsalu (1980), using a four second recall paradigm, were able to show that expert basketball players recall game-structured information more accurately than non-expert players. Starkes (1987) and Starkes and

Deakin (1984) obtained similar findings using an 8 second recall paradigm. Experts within the Canadian women's field hockey team performed better than both varsity players and physical education students in the recall of structured field hockey situations.

These results are consistent with the earlier investigations of chess (Chase & Simon, 1973; deGroot, 1965) and bridge (Charness, 1979).

While the studies performed by Allard et al. (1980), Starkes (1987), and Starkes and Deakin (1984) provide evidence of the expert's sensitivity to structure within their sport, they do little to enlighten us with respect to the characteristics of these perceptual structures. In an attempt to obtain this information, Allard and Burnett (1985), borrowing an experimental procedure from Chase and Simon (1973), had basketball experts and novices study, for five seconds, 10 diagrams of basketball plays. All subjects were then asked to reproduce the diagrams as fully as possible. The recall for each subject was scored by counting the number of elements correctly recalled. The experts were found to take significantly fewer looks than the novices to complete the plays. It was, as a result, concluded that the basketball knowledge possessed by experts may be organized in a manner similar to that proposed for experts within skill domains requiring obvious cognitive involvement (e.g., chess and bridge) (Allard & Burnett, 1985). Keep in mind that the superior recognition and recall abilities displayed by experts in both motor and verbal domains is not due to their having greater memory capacities per se, but rather is due to their more efficient encoding strategies for familiar materials. While valuable information has been gained using perceptually based pattern-recognition and recall paradigms, McPherson (1993a) would argue that little understanding has been gained of

the knowledge underlying players' decisions using such paradigms. To achieve an understanding of the knowledge underlying players' decisions one must first come to understand how this knowledge is represented within memory and this is best accomplished using the knowledge base paradigms discussed within the first section of this review.

Knowledge Base. Two of the first investigations into the representation of sport knowledge were conducted by cognitive psychologists interested in examining how knowledge of one domain influenced the acquisition and processing of new domain related information (Chiesi, Spilich, & Voss, 1979; Spilich, Vesender, Chiesi, & Voss, 1979). The knowledge domain studied was baseball. High and low baseball knowledge individuals were presented with passages of domain-related information and examined with respect to their ability to process this information. The high baseball knowledge individuals were found to perform better on tasks requiring the recall and recognition of baseball text. These performance differences were attributed to the fact that the high knowledge individuals displayed (a) a greater understanding as to how the actions of the game related to the game's goal structure, and (b) a superior ability to relate game actions and changes in game state to the game's goal structure. The investigators indicated that the more sophisticated knowledge structure of the high knowledge individuals guided the interpretation of input information as well as the retrieval of that information.

Since these early investigations much has been learned regarding the representation of sport knowledge. Allard and Burnett (1985) have suggested that skilled athletes develop the same advanced forms of declarative and procedural knowledge as have been

demonstrated for experts in other domains. Williams and Davids (1995) and Allard, Deakin, Parker, and Rodgers (1993) were able to demonstrate that sport experts possess a larger and more elaborate declarative knowledge base that is a constituent of their skill as opposed to simply being the product of task familiarity and experience. In other words, these studies were able to demonstrate that knowing and doing are related, specifically that knowing facilitates doing. While declarative knowledge levels may differ between experts and novices, a high level of declarative knowledge alone will not guarantee expertise (Thomas, 1994). Rather, one must also be aware of the nature of the declarative-procedural relationship (Allard et al., 1993). Williams and Davids (1995) attempted to account for this relationship when they examined whether training and playing promoted the acquisition and retention of specific declarative knowledge. They found that even limited amounts of playing experience could facilitate the development of task-specific declarative knowledge.

In an attempt to relate their results to the work of Anderson (1983), Williams and Davids (1995) explained that information is initially represented in a declarative manner and as one gains experience through practice a production system develops that is able to generate skilled performance. As suggested by their results, the transition to control by procedural knowledge from control by declarative knowledge within the domain of sport is facilitated through training and playing. They believe that the action produced informs the performer of the appropriateness of the procedural knowledge which, in turn, enhances the performer's declarative knowledge. Williams and Davids (1995) summarized the declarative-procedural relationship by stating that "declarative knowledge is

proceduralized through training and playing, and procedural knowledge promotes the acquisition and retention of specific declarative knowledge” (p. 272). Therefore, the observed relationship between knowing and doing was circular in nature in that knowing was found to facilitate doing while doing was found to facilitate knowing.

A number of other investigations have also explored the declarative-procedural relationship within the domain of sport. French and Thomas (1987) examined the relationship of sport-specific knowledge to the development of children’s skills in the sport of basketball. Two experiments were conducted that used coding of actual game play to assess procedural knowledge and a paper and pencil test to evaluate declarative and procedural knowledge, both as they relate to basketball performance. The first experiment compared child expert and novice basketball players on individual components of basketball performance as well as on measures of basketball knowledge dribbling skill, and shooting skill. The second examined developmental changes in the individual components of basketball performance, basketball knowledge, dribbling skill, and shooting skill across one season of play.

Within experiment one the child experts exhibited superior ability in all components of performance measured suggesting that skilled performance in basketball requires a basic foundation in motor skills and specific sport knowledge. No developmental trend was observed in the comparison of child experts and novices of two different age levels. The scores for the components of basketball performance, the knowledge test, and the dribbling and shooting skill revealed that the older child experts performed best on all measures, followed by the younger child experts, older child

novices, and younger child novices. French and Thomas (1987) suggest that the lack of a developmental trend indicates that greater opportunity to practice and learn the cognitive and motor skills necessary for skilled performance in basketball is more important than an individual's age.

Within both experiments a significant relationship between the sport specific knowledge and the decision component of performance was observed. Therefore, French and Thomas (1987) speculated that the acquisition of domain related knowledge may, in part, be responsible for the facilitation of performance on certain tasks. Support for this speculation is offered by the research that has previously demonstrated a relationship between knowledge and performance (e.g., Adelson, 1984; Chi et al., 1981; Chiesi et al., 1979; Spilich et al., 1979). The results of both experiments one and two also suggested that the development of declarative basketball knowledge, as measured by the knowledge test, was related to the procedural knowledge observed with respect to decision making during the game. French and Thomas (1987) interpreted this as support for the contention made by previous researchers (i.e., Anderson, 1982; Chi and Rees, 1983) that the acquisition of declarative knowledge provides the foundation for the development of procedural knowledge, such as how to respond or react in a given game situation. While their results indicated that declarative knowledge may influence the development of procedural knowledge, French and Thomas (1987) suggested that further research needs to be performed to better understand this relationship.

McPherson and Thomas (1989), using a protocol similar to that used by French and Thomas (1987), examined the relationship between knowledge representation,

decision making, and performance in the sport of tennis. Again, procedural and declarative knowledge were assessed using the coding of actual game play and a pencil and paper test. Interviews during and after game play were also used to assess both declarative and procedural knowledge. In the first phase of their study the relationship between the quality of the subjects decision making ability to their skilled performance was examined. As assessed through performance on the knowledge test, serve test, and ground stroke test, the experts exhibited more tennis skill and more tennis knowledge. During actual game play, the decision making ability (i.e., procedural knowledge) was found to be greater for the experts than for the novices. McPherson and Thomas (1989) suggested that these results indicated that declarative and procedural knowledge, as well as motor skill, develop with expertise.

The second phase of McPherson and Thomas' (1989) study was concerned with identifying how tennis knowledge facilitated the expert tennis players' decision making ability (i.e., procedural knowledge) during game play. A situation interview was used to assess the current status of tennis knowledge and a point interview was used to assess how this knowledge was used during game play. Overall, the results of both interviews suggested that the experts had available more conditions and more alternative actions that were important to the goal structure of the game situation. McPherson and Thomas (1989) suggested that the results of both the situation and point interviews mirror the predictions of how knowledge develops made by Chiesi et al. (1979). Specifically, they stated that "individuals first develop a general hierarchical goal structure of the game and with practice and instruction increase their knowledge of the relations of conditions and

actions to the games goal structure" (McPherson & Thomas, 1989, p.206).

Overall, the results of the study performed by McPherson and Thomas (1989) indicated that experts' skilled performance was influenced by their knowledge structure which allowed them more effective use of their knowledge during game play. When combined with the earlier results of French and Thomas (1987) these findings begin to reveal the development of the declarative-procedural knowledge interaction and its influence on skilled motor performance. In both studies (French & Thomas, 1987; McPherson & Thomas, 1989) the development of sport declarative knowledge was related to the development of productions (i.e., procedural knowledge) that allowed the players to make better decisions, hence better movements, during game play.

While these studies have clearly illustrated expert-novice differences with respect to the knowledge and skill possessed they have done little to examine the transition process from expert to novice. French and Thomas (1987) did address the transition issue when they attempted to describe changes in the components of basketball performance across one season of play. While the young subjects within French and Thomas' (1987) study demonstrated improvements in their decision making skills little improvement in the execution of their motor skills was observed. In an attempt to more overtly examine the changes in both the cognitive and motor skill aspects of sport performance that may occur as one acquires expertise, McPherson and French (1991) conducted two studies that followed beginning tennis players across a semester of instruction.

Within experiment one the instructional focus consisted of a traditional fundamental skill approach where motor skill development preceded strategy instruction.

The subjects received instruction in motor skills and declarative knowledge followed by the introduction and integration of tennis strategies. In experiment two, the primary focus of instruction was on singles strategy rather than on motor skill development. The instructional environment within experiment two promoted the integration of knowledge (i.e., declarative and procedural) and skill (i.e., response selection) in the context of a sport situation. For all subjects, a knowledge test, skills test, and actual game play were analysed at the beginning, middle, and end of the semester.

Decision making ability, knowledge, and ground stroke skill were all seen to improve across the semester of instruction for those students in experiment one. That is, cognitive components were seen to increase concurrently with skill improvement when the instruction was skill oriented. Instruction within experiment two resulted in significant increases in declarative knowledge, as assessed by the knowledge test, while motor skill ability denoted little improvement over time. The results of the study performed by McPherson and French (1991) suggest that changes in cognitive components occur concurrently with skill improvement when instruction is skill oriented. These results support those of French and Thomas (1987) and McPherson and Thomas (1989) who suggested that developing a declarative knowledge base is related to the development of procedural knowledge, or decision making. McPherson and Thomas (1989) further suggested that items from one's declarative knowledge base are used to develop the condition and action sides of productions that are activated to make decisions in sport.

In a more recent investigation McPherson (1993b) sought to examine how conceptual knowledge concerning batting preparation develops with playing experience

and how this knowledge influences decision making during a simulated game situation. Twelve expert and 12 novice baseball players were required to simulate being the fourth batter while viewing a half-inning in a videotaped collegiate baseball game. The video recording consisted of a setting similar to an actual game in which a number of environmental variables (e.g., pitcher, prior batters, other players) and situational variables (e.g., pitch selections, status of the game) were available.

The video recording consisted of one pitcher throwing a total of 15 pitches to three batters prior to the subjects attempt at bat and four pitches to a player the subjects were required to imagine as themselves. The subjects were instructed to think aloud while viewing the video and were asked to respond to the question, "What are you thinking about?" at different intervals while viewing the tape. Analysis of the think aloud protocols indicated that the experts' conceptual representation of batting preparation enabled them to search through a highly restricted problem space, which facilitated the development of sophisticated condition-action rules used to solve the problem. The experts were also seen to differ from the novices in that their rules were more refined (e.g., concepts were analyzed at a deeper level) and associated (e.g., concepts emerged as patterns) than novices, the attributes considered important for solving problems were different from those of novices, and they generated self-regulatory strategies to update, check, and modify their predictions of pitcher characteristics whereas novices did not. McPherson (1993b) believed that the results of her study provided evidence of the nature of adult expert sport performers' conceptual knowledge underlying the decision making process in sport.

The results of McPhersons' (1993b) study served to both support and extend the findings of the previous research examining the relationship between knowledge and skilled performance. As was noted in the previous sport studies, players declarative representations of content knowledge developed with increasing levels of expertise, a result also supported by Chi et al. (1981) in their examination of the representation of physics problems by expert and novice problems solvers. With respect to procedural representations of knowledge, McPhersons' (1993b) results support the consensus findings of the research within the sporting domain as they indicated that experts generated and possessed more sophisticated "condition sides" and "action sides" of procedures (McPherson, 1993a). Thus, as the skill level was refined and developed (i.e., expertise was developed) so too were the declarative and procedural representations of knowledge.

### **PROBLEM ARTICULATION**

As presented, most of the investigations examining the relationship between the representation of knowledge and skilled sport performance have identified expert-novice differences with respect to the acquisition, development, and use of both declarative and procedural representations (e.g., Allard, Deakin, Parker, & Rodgers, 1993; French & Thomas, 1987; McPherson & French, 1991; McPherson & Thomas, 1989; Williams & Davids, 1995). However, little has been done in the way of directly examining the relationship between skilled sport performance and metacognitive knowledge and metacognitive skill. McPhersons' (1993b) study did, however, hint at the presence of this relationship. When compared to novices, the sport experts within her investigation were

better able to monitor and modify the procedures within their possession through the use of self regulatory strategies. This suggests, though not explicitly stated by McPherson (1993b), that experts within the domain of sport may also possess certain metacognitive skills not possessed by novices. For the ability to monitor, check, and modify one's performance is clearly evident of enhanced metacognitive skill functioning as described by Brown and DeLoache (1978), Wall (1986), and Wall et al. (1985).

As evidenced by McPherson's (1993b) results, though rarely overtly stated as an objective, some studies have begun to highlight the importance of one's metacognitive functioning (i.e., metacognitive knowledge and metacognitive skill) in relation to skilled sport performance. Indeed, if we are to fully appreciate the process of skill acquisition within the domain of sport we must begin to examine the development of metacognitive knowledge and metacognitive skill as well as determine their relationship to both declarative and procedural knowledge (Thomas & Thomas, 1994; Wall, 1986). The importance of this relationship as a topic for research is further highlighted when one considers that metacognitive knowledge about action is said to refer to one's awareness of the declarative and procedural knowledge about action within one's possession.

Preliminary work by Toward (1995) sought to investigate the association between metacognitive knowledge and skilled sport performance. The skill selected for examination was the basketball foul shot. An experimental protocol similar to the one utilised in the current investigation was used in this smaller pilot project. Four female university students participated in the collection of both verbal and visual protocol data in three experimental tasks. Two of the subjects (Group one) were varsity basketball players

and were classified as experts as each was found to have a seasonal foul shot completion percentage approaching 75% (Expert one = 72%, Expert two = 75%) which has been defined as being the level of proficiency associated with U.S. male collegiate basketball players (Krause, 1983). The other two subjects (Group two) were graduate students with physical education backgrounds. These subjects were classified as novices as neither had played organized basketball at any level, yet both had received instruction in basic basketball skills at some point in their past. Hence, the novice subjects had some knowledge of the game and its technique and were able to understand the task instructions presented to them throughout the investigation.

The three tasks utilised within the pilot study (Toward, 1995), and replicated with modifications in the larger study reported within this document, required the subjects to verbally instruct a novice basketball player in the proper execution of the basketball foul shot (Task one), to talk aloud while performing 10 foul shots (Task two), and to predict the success of each attempted shot immediately upon the release of the ball on a further 10 foul shots (Task three). As previously stated, both verbal and visual protocol data was collected during the performance of each task allowing for comparisons between groups with respect to the frequency and quality of the verbalizations and physical movements produced.

Both Tasks one and two were designed to provide an indication of each subjects level of metacognitive knowledge about action specific to the basketball foul shot. Task one provided an indication of each subjects' awareness of her skill specific declarative knowledge about action as it necessitated that she recall and verbally express the various

performance components that constitute a basketball foul shot. Task two provided an indication of each subjects' awareness of her skill specific procedural knowledge about action as it necessitated that she translate her physical actions into verbal descriptions. Task three was designed to illustrate the level of functioning of the basic skills of metacognition outlined by Brown (1978), Brown and DeLoache (1978), Wall (1986), and Wall et al. (1985) as each subject was required to monitor her shot execution, predict her shot success, and elaborate upon her perceived misses.

An observational instrument was designed to assess the quality of both the verbalizations and physical movements recorded during performance of all three tasks. Three categories of foul shot skill specific behaviour were coded: spatial skill components (SSC's), technical skill components (TSC's), and mental skill components (MSC's) . Verbalizations and actions that emphasized or illustrated the segment positioning necessary to perform the skill were coded as spatial skill components. Verbalizations and actions that emphasized or illustrated the technique necessary to perform the skill were coded as technical skill components. Verbalizations that emphasized the mental aspects of skill performance were coded as mental skill components. The coding system that was used in this investigation was based on an adaptation of those proposed by Rowe (1985) and Schoenfeld (1985) (Refer to Tables 1, 2, and 3 in Chapter 3 for a modified version of the coding grid used). When coding the protocols, both verbal and visual, each instance of a skill component was assigned either a positive or negative sign indicating that this skill component was either stated or performed correctly (+), or was stated or performed incorrectly (-). The frequency of occurrence for each coded skill component, whether

positive or negative, was recorded and this data was combined within groups and analysed in a descriptive fashion.

Observation of the coded verbal protocols indicated that at both Tasks one and two the experts verbalized the SSC's and the TSC's with greater frequency than the novices and were also more accurate, or correct, in the verbalizations made. These results suggested that the experts were in possession of superior levels of declarative knowledge about action with respect to both the spatial and technical skill components of the basketball foul shot. Experts were seen to possess a complete understanding of both the spatial and technical skill components of the foul shot while the novices displayed a lack of understanding or, at best, an inconsistent understanding of both.

Observation of the visual protocol data indicated that similar trends existed for the performance of both the spatial and technical skill components examined. Task two and three visual protocol data indicated that the experts performed almost all of the coded spatial skill components and technical skill components correctly. The novices, on the other hand, were seen to perform some skill components correctly, however, most were either performed incorrectly or inconsistently. The results of the visual protocol analysis indicated that the experts possessed more procedural knowledge and skill than did the novices with respect to both the spatial skill components and technical skill components of the basketball foul shot.

The most interesting results were found when the verbal protocol data was compared to the visual protocol data. The expert performers described almost all spatial and technical skill components correctly as well as performed them correctly. Therefore,

these individuals were said to possess superior levels of metacognitive knowledge about action as evidenced through their heightened awareness of both their declarative and procedural representations of knowledge about action. The experts descriptions of their physical performance were congruent with their actual physical movements leading one to conclude that the experts were cognizant of their ability to correctly perform the basketball foul shot. The expert performers "knew they knew" how to perform the skill and were able to perform it very effectively, representative of a high level of metacognitive knowledge and metacognitive skill.

The novice performers, on the other hand, were unable to completely and accurately describe how to perform the skill. They were, at best, inconsistent in their attempts to physically perform the skill correctly. The descriptions of their physical performance were incongruent with their actual physical movements. This incongruence indicated that the novice performers "did not know they did not know" how to perform the skill and lacked the ability to perform it correctly, representative of a low level of metacognitive knowledge and metacognitive skill.

Observation of the verbal protocol data for the MSC's at both Tasks one and two indicated that the experts differed most from the novices in terms of their verbalizations emphasizing the MSC of focussing. However, since both groups of subjects did mention this component a number of times it appeared that they were aware of the benefits to be gained by focussing on the various aspects of the skills performed.

Observation of the results obtained for the predictive portion of Task three indicated that the experts were able to correctly predict 80% of their foul shots while the

novices were able to correctly predict only 65% of their foul shots, regardless of whether or not the shot itself was successful. The reasons given by the experts and novices for predicted missed shots were seen to vary in their content. The novices had a tendency to rely on the success of the previous shot when predicting the success of the current shot. The reasons given by the novice performers when explaining a predicted missed shot were vague and imprecise. For example, novice subject number two gave the following reason when attempting to explain a predicted missed shot that was actually successful,

*“That one I was not sure, really because I thought it felt like it was going off, but I was closer than I guess I had thought I was”.*

The reasons given by the experts when explaining a predicted missed shot were clear, logical, and precise. For example, expert subject number two gave the following reason when attempting to explain a predicted missed shot,

*“No, off to the side. I didn't follow through properly and I could tell it was going to miss left”.*

Therefore, not only were the experts better able to predict the outcome of their actions, the reasons provided for missed shots indicated that these subjects were better able to monitor their skilled performance and were more cognizant of the influence that any perceived performance errors would have on final skill execution and performance.

Although the data obtained in this pilot study was not analysed using inferential statistics and, therefore, no statements of significant differences were made, the frequency measures which were obtained were consistent with the contention that the expert performers were in possession of superior levels of metacognitive knowledge and

metacognitive skill specific to the performance of the basketball foul shot. The expert performers, when compared to the novices, possessed more knowledge with respect to skill performance, were better able to physically perform the skill, were more cognizant/aware of their performance abilities, and were better able to monitor and predict their performance outcomes. This may, as a result, suggest that a relationship exists between one's level of skill specific metacognitive knowledge and his/her corresponding ability to properly execute a skill.

The study reported within this text is concerned with further examining expert-novice differences in metacognitive functioning within the domain of sport. If differences in metacognitive functioning are observed across levels of expertise within the domain of sport it could have possible implications for those involved in the education and generation of skilled movers. As has become evident within this review, the development of one's metacognitive knowledge base and corresponding metacognitive skills allows individuals to control and enhance their own learning and performance. Thus, instruction in the use of such metacognitive skills as monitoring, planning, and predicting may allow one to increase their own rate of learning and as a result enhance their performance. Likewise, assisting an individual in becoming cognizant of, and comfortable with, the skills in his/her possession may help ensure that the correct decisions are made within the movement environment.

## **CHAPTER III**

### **METHODOLOGY**

This chapter serves three main purposes: (a) to discuss the origin of the tasks and coding instruments used in this investigation, specifying how they assess metacognitive knowledge as operationally defined in relation to the specific motor skill examined; (b) to present the experimental protocol followed during performance of this investigation; and (c) to discuss how the data was collected and prepared for analysis and interpretation. To serve these purposes this chapter is divided into three sections, Task Development, Experimental Protocol, and Data Collection.

#### **Task Development**

##### **Theoretical/Empirical Support**

Prior to discussing the tasks developed for use within this investigation it is necessary to first operationally define the constructs that were examined, these of course being metacognitive knowledge about action and metacognitive skill. The definitions offered in this investigation represent the consolidation of the many definitions presented by researchers and theorists across various performance domains. Recall that Dillon (1986) stated that metacognitive knowledge pertains to the state of one's declarative knowledge as well as one's procedural knowledge. Similarly, in a discussion of the development of motor skills from a knowledge-based perspective, Wall et al. (1985) referred to metacognitive knowledge about action as an awareness of the procedural and declarative knowledge about action within one's possession. Jacobs and Paris (1987), in their discussion of children's metacognition about reading, described metacognitive

knowledge as a "reportable, conscious awareness about cognitive aspects of thinking" (p.258). Of great import to their description, as well as to the operational definitions presented within this chapter, was that metacognitive knowledge be reportable. Application of these definitions to the movement oriented domain of sport suggested that metacognitive knowledge about action be operationally defined, within this investigation, as a reportable conscious awareness about the cognitive aspects of moving. The cognitive aspects of moving, in turn, consisting substantively of propositionally based declarative knowledge about action and performance oriented procedural knowledge about action.

As stated previously, a defining feature of this operational definition of metacognitive knowledge about action, as well as the description presented by Jacobs and Paris (1987), was that it can be made public. To illustrate their point, Jacobs and Paris (1987) stated that an individual who understands how the characteristics of a passage may impede or facilitate comprehension is providing evidence of metacognition about reading. On the other hand, if while reading an individual pauses at an unfamiliar word and rereads it in an attempt to understand it, yet is unaware of having done so, Jacobs and Paris suggest that it would be superfluous to attribute metacognition to that behaviour. When applied to the domain of sport this illustration may suggest that a person who understands how the individual components of skilled movement may impede or facilitate performance is providing evidence of metacognition about action. However, if when performing an action an individual is forced to alter his/her movement pattern as a result of an unanticipated environmental obstacle, yet is unaware of having done so, it would be superfluous to attribute metacognition to that behaviour as well. By restricting the

operational definition of metacognitive knowledge about action to reportable knowledge, as suggested by Jacobs and Paris (1987), the term is constrained considerably. However, false inferences about the presence of metacognition are avoided, thus making the tasks that utilize demonstration, communication, examination, or discussion more conservative.

As it was presented in chapter two, metacognitive skill was said to refer to the operationalization of metacognitive knowledge about action (Wall et al., 1985). Therefore, for the purpose of this investigation, metacognitive skill was operationally defined as the dynamic process of translating metacognitive knowledge about action into action. It is believed that metacognitive skills are used to procedurally control cognition and action through the functioning of such higher level executive strategies as predicting, checking, monitoring, reality testing, coordinating, and controlling. Applying Brown and DeLoaches' (1978) descriptions of these six basic metacognitive skills to the domain of sport suggested that each, in turn, be operationally defined as follows; predicting the consequences of an action or movement, checking the results of an action or movement, monitoring one's ongoing actions or movements, testing the logic of selected actions or movements, and both coordinating and controlling one's actions or movements in relation to the intended goal.

Having operationally defined both metacognitive knowledge about action and metacognitive skill, the issue then became one of trying to develop tasks that would accurately represent and assess both constructs as they are possessed by individuals with varying levels of skill specific to the performance of the basketball foul shot . While both definitions are somewhat restrictive in that they emphasize reportable knowledge about

motor activities, they also facilitate measurement as will become evident in the discussion of the tasks developed for use in this investigation. Specifically, three tasks were developed, each designed to assess a different aspect of an individual's metacognitive knowledge about action and metacognitive skill specific to the basketball foul shot. It was believed that through combining several tasks and their resultant dependent measures, additional insight into the metacognitive knowledge possessed by the individuals in this investigation would be gained. The incorporation of a multitask approach, though seldom used (Helsen & Pauwels, 1993), has recently come into favour when examining the development of knowledge within the domain of sport (Williams & Davids, 1995; Abernethy, Thomas, & Thomas, 1993; McPherson, 1993a). Williams and Davids (1995) believed that a multitask approach allowed for a more comprehensive analysis of the cognitive characteristics underlying skilled performance. A discussion of the three tasks used in this investigation, including a description as to how each differentially assesses metacognition follows.

Task One - Verbal Instruction. Task one was designed to assess each subject's awareness of the declarative knowledge about action, relative to the performance of the basketball foul shot, within her possession. This task required that each subject verbally instruct a novice basketball player in the proper execution of a basketball foul shot. Doing so necessitated the self-appraisal of one's cognition as it specifically relates to performance of the foul shot. This, in turn, required the conscious effortful recall of propositionally based information from long-term memory (i.e., a search through declarative memory). Recall that two of the defining characteristics of declarative

knowledge are (a) that one has conscious access to this knowledge, and (b) that it may be verbally communicated (Anderson, 1976, 1993; Mandler, 1989). Jacobs and Paris (1987) believe that declarative knowledge represents one of the classifications into which self-appraisals of cognition fall, with self-appraisals of cognition representing one of their two identified categories of metacognition. As their description specifically related to Task one within the current investigation, self-appraisals were thought of as demonstrating the declarative component of metacognitive knowledge about action. Therefore, the verbalizations produced at Task one were believed to be reflective of the level of the declarative component of metacognitive knowledge about action, relative to the performance of the foul shot, within each subject's possession. All verbalizations (i.e., verbal protocols) produced during the performance of Task one were recorded for later analysis.

Task Two - Talk Aloud While Performing. Task two was designed to assess each subject's awareness of the procedural knowledge about action, relative to the performance of the basketball foul shot, within her possession. Much like the tasks used by Swanson (1990, 1993), Task two allowed for concurrent motor activity and verbalization as each subject was required to perform 20 foul shots, "talking aloud" during the performance of alternate shots. Talking aloud meant that each subject attempted to describe all actions as they were performed and all thoughts as they occurred. As in Task one, performance here also necessitated the self-appraisal of one's cognition as it specifically relates to performance of the basketball foul shot. However, the self-appraisals differed at Task two in that subjects were attempting to describe their procedural knowledge as it was

operationalized. Procedural knowledge, like declarative knowledge, was believed to represent one of the classifications into which self-appraisals of cognition fall, with self-appraisal again representing one of Jacobs and Paris' (1987) two identified categories of metacognition. Just as Jacobs and Paris (1987) stated that an awareness of the cognitive processes involved in thinking is a fundamental aspect of metacognition, one may claim that an awareness of the cognitive processes involved in moving is also a fundamental aspect of metacognition.

The subjects were asked to talk aloud during the performance of alternate shot attempts at Task two because information within procedural memory can only be inspected when represented in working memory and to be represented there the procedures must be active (Ohlsson, 1987). Performing the skill of foul shooting would, therefore, have resulted in the activation of those procedures specific to skill performance. The "talk aloud" protocols then would have reflected subsets of the information that were brought forward into working memory (Swanson, 1993). Essentially, what the subjects were asked to do was to declaratively represent and express the procedures used to produce an overt behavioural response. In this instance, the overt behavioural response (i.e., the foul shot) was itself an expression of those same procedures.

Although it may seem awkward having asked the subjects to represent procedural information in a declarative fashion, O'Neil, Slawson, and Baker (1991) have stated that declarative knowledge is useful as an aid for encoding and retrieving procedural information. Likewise, McPherson and French (1991) have suggested that verbal report data may be useful to interpret game play. When one considers the fact that procedural

memory is said to have a "limited inspectability" (Ohlsson, 1987), the utility of the declarative representation is further highlighted.

To conclude, performance at Task two represented an attempt by each subject to do two things, (a) consciously access and appraise the internal processing (i.e., procedures) which occurred during skilled motor performance, and (b) translate this processing activity into words. Application of Jacobs and Paris' (1987) description of the self-appraisal process to Task two would suggest that the appraisals performed were demonstrative of the procedural component of metacognitive knowledge about action. Therefore, the verbalizations produced at Task two were believed to be reflective of the level of the procedural component of metacognitive knowledge about action, relative to the performance of the foul shot, within each subject's possession. All verbalizations (i.e., verbal protocols) and actions (i.e., visual protocols) produced during the performance of Task two were recorded for later analysis.

Task Three - Predicted Performance. Task three was designed to provide an indication of each subject's level of metacognitive skill functioning relative to the performance of the basketball foul shot. This task required that each subject physically perform 10 foul shots, monitor her skilled performance, and predict her success immediately upon the release of each ball. Following each prediction the subject was then asked to elaborate upon her perceived success or failure in an attempt to illustrate the level of functioning of the basic skills of metacognition as they were operationally defined for this investigation. The performance prediction paradigm is not new to the study of metacognition. Traditionally this paradigm has been used to investigate the metamemory-

memory behaviour relationship (Schneider, 1985). As it was used within this investigation, the performance prediction paradigm was expanded to include such strategies (i.e., metacognitive skills) as monitoring, checking, reality testing, coordinating, and controlling. These basic metacognitive skills may be regarded as each subjects attempt to self-manage or self-regulate the process of translating knowledge into action. Therefore, the verbalizations produced by each subject during the self-management process at Task three were believed to be reflective of the level of functioning of each of the basic metacognitive skills. As with the previous two tasks, the verbalizations (i.e. verbal protocols) produced during the performance of Task three were recorded for later analysis.

All subjects had previously encountered the physical performance components (i.e., foul shot performance) of the three tasks utilized within this investigation, whether in skill classes or coaching environments. Hence, all subjects had a basic understanding regarding how to proceed. It should be noted that for Tasks one and two a subject could make a correct verbal statement without having a complete understanding of that statement. For example, it was possible that a subject may have repeated a correct instructional statement previously presented to her in an educational environment while, at the same time, she may lack a full understanding of what was actually involved in the production and coordination of the instructed movement. This lack of understanding would then become evident in the production of physical actions that were not congruent with the verbalizations made. Choices were involved with respect to both skill instruction and performance, for example, where and how to position the feet. In both tasks the

probability existed that subjects who more fully understood the skill would present stronger, more richly detailed, and more accurate verbal statements than those who may only have been repeating past instructional statements. Thus, the tasks utilized within this investigation allowed for the concurrent assessment of an individual's skill specific knowledge base and their subjective (i.e., metacognitive) awareness of the knowledge and skill within their possession. The collection of verbal and visual protocol data across tasks allowed for comparisons both between and within groups with respect to the frequency and quality of the verbalizations and physical movements produced. Both types of protocol collection are addressed in the following text.

Protocol Collection. The use of verbal protocols to assess knowledge and mental functioning during the performance of a specific task is not unique. The technique of verbal protocol collection and analysis was first formalized by Ericsson and Simon (1984). The usefulness of protocol data to evaluate the on-line mental processing of individuals has since been repeatedly demonstrated in such cognitively rich performance domains as genetics (Hackling & Lawrence, 1988), biology (Lavoie, 1993), map reading (Gilhooly, Wood, Kinnear, & Gree, 1988), and physics (Ferguson-Hessler & de Jong, 1990).

Verbal protocols have also been used, to a lesser degree however, to assess the representations of knowledge held by expert and novice performers within the domain of sport (e.g., McPherson, 1993b, baseball; McPherson & Thomas, 1989, tennis). Verbal protocols can be collected in any number of ways. Individuals may be asked to talk aloud or think aloud during task performance (e.g., McPherson, 1993b; McPherson & Thomas, 1989), may be interviewed at specific points during performance (e.g., McPherson,

1993b), or may be asked to retrospectively describe their thought processes and/or skilled performance (e.g., Toward & Kerr, 1994a). Thomas and Thomas (1994) have stated that self-report and probe techniques are critical methods when studying expertise and that the verbal protocol data collected as a result of their use can provide measures of declarative, procedural, and metacognitive knowledge. McPherson and Thomas (1989) required expert and novice tennis players, in two age groups, to think aloud when presented with diagrams of court situations, as well as between points during actual game play in an attempt to assess both their declarative and procedural knowledge. McPherson (1993b) required subjects to think aloud during the performance of a simulated batting task in an attempt to examine how conceptual knowledge concerning batting preparation develops with playing experience as well as how this knowledge influences decision making during game performance. The use of “think aloud” protocols in both of these investigations is similar to what was asked of subjects at Task two in the investigation reported within this document. Recall that subjects at Task two were required to talk aloud during the performance of alternate foul shot attempts. As Ericsson and Simon (1984) have suggested that the use of “think aloud” protocols does not interfere with or change performance as participants are simply stating what is currently in their working memory, it was assumed that the protocols collected here would not interfere with performance of the skill of foul shooting.

The observation and analysis of physical movements or actions (i.e., visual protocols), while used less frequently as an experimental protocol, has also been used to assess procedural representations of knowledge. Again, recall that at Task two measures

of procedural knowledge were obtained using both talk aloud verbal protocols as well as direct observation of game play, or more specifically, skill execution. As suggested by Gentner (1988) the observation of motor skills provides a unique psychological insight into one's thought processes, hence knowledge base, as they are the direct concrete product of the large amount of mental processing required for the planning, coordination, and control of actions. Gentner states that, from a practical standpoint, motor skills offer an advantage to the researcher studying expertise as the normal performance of a motor skill produces an externally observable sequence of events that are directly related to the task. French and Thomas (1987) and McPherson and Thomas (1989) utilized this advantage when they coded actual game play in an attempt to assess procedural knowledge. Therefore, the tasks used in the current investigation, while perhaps novel in their application and combination, have been proven useful for assessing declarative, procedural, and metacognitive knowledge within a variety of performance domains.

#### **Instrumentation: Coding Grids**

A number of observational instruments (i.e., coding grids) were designed to assess both the frequency and quality of the recorded verbal and visual protocols produced at all three tasks. To assist in the development of coding categories specific to the skill of foul shooting various coaching and instructional manuals (Fox, 1988; Krause, 1983) for the sport of basketball were consulted. Examination of the instructional literature led to the partitioning of the skill of foul shooting into three distinct skill component classifications; spatial skill components (SSC's), technical skill components (TSC's), and mental skill components (MSC's). Spatial skill components were operationally defined as those

verbalizations and actions that emphasized or illustrated the segment (i.e., body part) positioning necessary to perform the skill of foul shooting. Included within the SSC's were those verbalizations and actions that emphasized or illustrated positioning at the feet (SSC1), knees (SSC2), waist (SSC3), back (SSC4), shoulders (SSC5), head (SSC6), elbow/arm (SSC7), wrist (SSC8), fingers (SSC9), and hand (SSC10).

Technical skill components were operationally defined as those verbalizations and actions that emphasized or illustrated the technique necessary for performance of the skill of foul shooting. Included within the TSC's were those verbalizations and actions that emphasized weight (TSC1), alignment (TSC2), release (TSC3), follow-through (TSC4), flight of the ball (TSC5) ritual (TSC6), extension (TSC7), aim (TSC8), technical information (TSC9), ball position (TSC10), and approach/setup (TSC11).

Mental skill components were operationally defined as those verbalizations that emphasized the mental aspects of skill performance. Included within the MSC's were those verbalizations that emphasized focus/concentration (MSC1), visualization (MSC2), and feel/relaxation (MSC3). Tables 1, 2, and 3 present task specific operational definitions and examples for each of the coded spatial, technical, and mental skill sub-components presented in the preceding paragraphs.

The partitioned skill components, and their respective sub-components, were then presented to two University level basketball coaches in an attempt to determine the relevance and accuracy of the partitions. It was agreed that the partitioned skill sub-components, as determined through observation of the instructional literature, were relevant to the skill of foul shooting and that the components accurately represented the

**Table 1: Coding Grid for Task One - Verbal Instruction**

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
Reading	Read Instructions	Read Instructions in their Entirety	RIE	The episode begins when the subject reads the instructions out loud and continues until they are completed	(NA)
		Read Instructions Partially	RIP	The subject begins to read the instructions aloud, stops to perform another task or correct herself, then returns to reading the instructions	(NA)
		Re-Reads the Instructions	RRI	The subject rereads the instructions aloud. This may occur at any stage during performance of the task	(NA)
		Segmentation of Task Instructions	STI	Includes summarizing or paraphrasing the important points in the task instructions	(Ok, so I just have to show you how to shoot a basketball)
		Statement of Understanding	SU	The subject makes a statement indicating that she understands the instructions read or comments made	(Fine, I understand, OK)
		Experimenter Comments	EC	The experimenter asks questions or makes statements to clarify apparent misunderstandings, determine task completion, or initiate task performance	(Do you understand that instruction?) (Do you have anything you would like to add?)
Comprehension	Task	Response to Experimenter Comment	RIEC	Responses made to the experimenter by the subject in response to a comment/question posed	(That's what I thought)
		Questions to the Experimenter	QE	The subject asks questions to the experimenter in order to clarify task demands. May be asked at any time	(When am I supposed to talk?)
		Experimenter Response	ER	The experimenter responds to a question posed.	(You may begin now)
		Questioning the Learner	QL	Asking questions of the individual being taught the skill to assist in instruction planning	(What hand do you shoot with?)
		Learner Response	LR	Learner responds to the question posed	(I shoot with my right hand)
		Skill			

**Table 1 (cont.)**

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
Task Performance	Discussion of the Skill Components	Elimination	E	Identification of unsuitable or faulty paths to the generation of ideal instructive behavior	(Ok, wait, I need to show you something else first.)
		Learner Clarification of A Component	LCC	The learner asks a question to obtain additional information about a component or attempts to extrapolate/interpret	(How am I supposed to hold my elbow?)
		Spatial Skill sub-Component	SSC	Instructions which emphasize the segment (i.e., body part) positioning necessary to perform the skill:	
			SSC1	feet	(Put one foot in front of the other, shoulder width apart)
			SSC2	knees	(Bend your knees)
			SSC3	waist	(Bend slightly forward at the waist)
			SSC4	back	(Keep your back straight)
			SSC5	shoulders	(Keep your shoulders square to the basket)
			SSC6	head	(Keep your head up, looking at the basket)
			SSC7	elbow/arm	(Bend your shooting elbow to 90 degrees and keep it by your side)
	SSC8	wrist	(Bend your wrist back)		
	SSC9	fingers	(Your fingers should be fanned out, spread apart)		
	SSC10	hand	(Keep one hand beside the ball and one, the shooting hand, behind)		
		Mental Skill sub-Component	MSC	Instructions which emphasize the mental aspects of skill performance:	
			MSC1	focus/concentration	(Focus your attention while shooting, concentrate)
			MSC2	visualization	(Try to picture the ball traveling in a high arc into the basket)
			MSC3	feel/relaxation	(Try to feel comfortable and relaxed, get a feel for the ball)
		Technical Skill sub-Component	TSC	Instructions which emphasize the technique necessary to perform the skill:	
			TSC1	weight	(Your weight should be over the front foot)
			TSC2	alignment	(Stand close to the middle of the net)
			TSC3	release	(Try to release the ball at its highest point)
			TSC4	follow through	(Follow through after release of the ball, flick your wrist)
			TSC5	flight of the ball	(You want to try to get a nice arch on the ball)
			TSC6	ritual/routine	(Some people like to dribble the ball a few times before shooting)
			TSC7	extension	(When you go up you unbend everything at the same time)
			TSC8	aim	(You want to aim for the back of the rim)
			TSC9	technical information	(The net is 15 feet from the foul line, the foul shot is an important part of the game)
			TSC10	ball position	(Hold the ball at waist height)
			TSC11	approach/setup	(You should stand just behind the foul line)

Table 1 (cont.)

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
		Comments Unrelated to Instruction	CUI	The subject talks during the task but it does not aid instruction	(I guess I'm done, I'll take a shot now, OK)
	Pause	Complete Silence	CS	A pause with complete silence	(NA)
		Examiner Prodding	EP	After a period of silence the examiner requests the subject to think aloud	(Remember to talk out loud)
		Activity Filled Pauses	AFP	Used to classify comments/actions which can not be interpreted as bearing a direct relationship to the task at hand	(i.e., dribbling the basketball before setting for the shot)
	Memory Related Activity	Attempts To Recall	ATR	Attempts to recall previous experiences	(Uhm, Ok; so...; then...)
		Illumination/Insight	II	Sudden recognition of how to instruct the learner in an aspect of the skill	(Oh, I just remembered something)
Evaluation/Judgement	Affective Reaction	Positive Reaction	PR	Expression of a feeling of accomplishment, pleasure, excitement, relief, or ease. May be made in relation to task performance or the knowledge/skill possessed. These may be made prior to, or during performance (i.e., positive comments regarding task performance and/or the knowledge/skill possessed)	(This should be simple, that was fun: I think I did OK on this, Laughter, I made it)
		Negative Reaction	NR	Expression of a feeling of failure, dread, anxiety, or difficulty. May be made in relation to task performance or the knowledge/skill possessed. These may be made prior to, or during performance (i.e., negative comments regarding task performance and/or the knowledge/skill possessed)	(This sounds hard, I wish I didn't have to talk out loud; I don't think I did that very well, this is hard to do, I know I need help with the stance, sigh)

**Table 2: Coding Grid for Task Two-Talk Aloud While Performing**

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
Reading	Read Instructions	Read Instructions in their Entirety	RIE	The episode begins when the subject reads the instructions out loud and continues until they are completed	(NA)
		Read Instructions Partially	RIP	The subject begins to read the instructions aloud, stops to perform another task, or correct herself, then returns to reading the instructions	(NA)
		Re-Reads the Instructions	RRI	The subject rereads the instructions aloud. This may occur at any stage during the performance of the task	(NA)
		Segmentation of Task Instructions	STI	Includes summarizing or paraphrasing the important points in the task instructions	(Ok, so I shoot and try to describe everything as I do it)
		Statement of Understanding	SU	The subject makes a statement indicating that she understands the instructions read/comments made	(Fine, I understand, OK)
		Experimenter Comments	EC	The experimenter asks questions or makes statements to clarify apparent misunderstandings, determine task completion, or initiate task performance	(Do you understand that instruction?) (Do you have anything you would like to add?)
Comprehension	Task	Response to Experimenter Comments	REC	Responses made to the experimenter by the subject in response to a comment/question posed	(That's what I thought!)
		Questions to the Experimenter	QE	The subject asks questions to the experimenter in order to clarify task demands. May be asked at any time	(I don't talk on each shot?)
		Experimenter Response	ER	The experimenter responds to a question posed	(You talk only during alternate shots)

Table 2 (cont.)

Episode	Component	Skill-Component	Code	Definition	Example (where appropriate)
Task Performance	Performance of the Skill Components	Spatial Skill sub-Components	SSC	Verbalizations and actions which emphasize/illustrate the segment (i.e. body part) positioning necessary to perform the skill:	
			SSC1	feet	(Feet shoulder width apart)
			SSC2	knees	(Knees bent)
			SSC3	waist	(Bent slightly forward at waist)
			SSC4	back	(Back straight)
			SSC5	shoulders	(Square to the basket)
			SSC6	head	(Head up)
			SSC7	elbow/arm	(Bent at 90 degree angle)
			SSC8	wrist	(Wrist cocked back)
			SSC9	fingers	(Fingers spread)
			SSC10	hand	(One hand is beside the ball the other behind)
		Mental Skill sub-Component	MSC	Verbalizations which emphasize the mental aspects of skill performance:	
			MSC1	focus/concentration	(Concentrate on the shot)
			MSC2	visualization	(Picture the ball going in)
			MSC3	feel/relaxation	(Get a feel for the ball, relax, take a deep breath)
		Technical Skill sub-Component	TSC	Verbalizations and actions which emphasize/illustrate the technique necessary to performance of the skill:	
			TSC1	weight	(Weight is over the front foot)
			TSC2	alignment	(Stand in the middle of the basket)
			TSC3	release	(Release the ball at the top)
			TSC4	follow through	(Flick your wrist)
			TSC5	flight of the ball	(The ball should arc towards the basket)
			TSC6	ritual	(Dribble twice before shooting)
			TSC7	extension	(Straighten the legs, extend, jump if you need to)
			TSC8	aim	(Aim at the back rim)
			TSC9	technical information	(Keep the motion continuous)
			TSC10	ball position	(Hold the ball at waist level)
			TSC11	approach/setup	(Stand just behind the line)
	Comments Unrelated to Physical Performance		CUP	Verbalizations which do not represent translated actions	(The microphone feels loose, it takes me time to warm up)

Table 1 (cont.)

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
Pause	Complete Silence	Complete Silence	CS	A pause with complete silence	(NA)
		Examiner Prodding	EP	After a period of silence the examiner requests the subject to think aloud	(Remember to talk out loud)
		Activity Filled Pauses	AFP	Used to classify comments/actions which can not be interpreted as bearing a direct relationship to the task at hand	(i.e., dribbling the basketball before setting for the shot)
	Memory Related Activity	Attempts To Recall	ATR	Attempts to recall previous experiences	(Uhm....., Ok....., so....., then.....)
		Illumination/Insight	II	Sudden recognition of how to instruct the learner in a aspect of the skill	(Oh, I just remembered)
		Positive Reaction	PR	Expression of a feeling of accomplishment, pleasure, excitement, relief, or ease. May be made in relation to task performance or the knowledge/skill possessed. These may be made prior to, or during performance (i.e., positive comments regarding task performance and/or the knowledge/skill possessed)	(This should be simple, that was fun, I think I did OK, finally I made one, laughter, I made it)
Evaluation/Judgement	Negative Reaction	NR	Expression of a feeling of failure, dread, anxiety, or difficulty. May be made in relation to task performance or the knowledge/skill possessed. These may be made prior to, or during performance (i.e., negative comments regarding task performance and/or the knowledge/skill possessed)	(I wish I didn't have to actually shoot the ball, I need to work on my stance, I don't think I did that very well, it's hard to talk, I missed, sigh)	

**Table 3: Coding Grid for Task Three-Predicted Performance**

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
Reading	Read Instructions	Read Instructions in their Entirety	RIE	The episode begins when the subject reads the instructions out loud and continues until they are completed	(NA)
		Read Instructions Partially	RIP	The subject begins to read the instructions aloud, stops to perform another task, or correct herself, then returns to reading the instructions	(NA)
		Re-Reads the Instructions	RRI	The subject rereads the instructions aloud. This may occur at any stage during the performance of the task	(NA)
		Segmentation of Task Instructions	STI	Includes summarizing or paraphrasing the important points in the task instructions	(Ok, so I shoot and try to describe everything as I do it)
		Statement of Understanding	SU	The subject makes a statement indicating that she understands the instructions read/comments made	(Fine, I understand, OK)
Comprehension	Task	Experimenter Comments	EC	The experimenter asks questions or makes statements to clarify apparent misunderstandings, determine task completion, or initiate task performance	(Do you understand that instruction?) (Do you have anything you would like to add?)
		Response to Experimenter Comments	REC	Responses made to the experimenter by the subject in response to a comment/question posed	(That's what I thought)
		Questions to the Experimenter	QE	The subject asks questions to the experimenter in order to clarify task demands. May be asked at any time	(I don't talk on each shot?)
		Experimenter Response	ER	The experimenter responds to a question posed	(You talk only during alternate shots)

**Table 3 (cont.)**

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
Task Performance	Explanation of the Predicted Outcome *	Spatial Skill sub-Component Reasoning	SSC	Any explanation which emphasized segment (i.e., body part) positioning (whether correct or incorrect) when performing the skill. If any of the sub-components listed below were discussed then the explanation was coded SSC feet knees waist back shoulders head elbow/arm wrist fingers hand	(My feet were not shoulder width apart) (My knees were not bent enough) (I was bent over too much) (My back was not straight) (I was not positioned square to the basket) (My head was down) (My elbow was bent too much) (I did not cock my wrist back) (My fingers were too close together) (I did not position my hands correctly)
		Technical Skill sub-Component Reasoning	TSC	Any explanation which emphasized the technique used (whether correct or incorrect) when performing the skill. If any of the sub-components listed below were discussed then the explanation was coded TSC weight alignment release follow through flight of the ball ritual extension aim technical information ball position approach/setup	(My weight was not over the front foot) (I was not standing in the middle of the basket) (I released the ball too soon) (I did not flick my wrist) only appropriate if not "sight" dependent (e.g., did not put enough force into the arc) (I forgot to dribble first before shooting) (I did not straighten my legs properly) (I felt like I didn't extend) (I pushed too hard) (Not enough force) (I aimed at the wrong spot) (I did not keep the motion continuous) (I held the ball in front of my eyes) (I was too far from the line)
		Kinaesthetic Reasoning	KR	Any explanation which emphasized the "feel" (whether correct or incorrect) when performing the skill was coded KR	(I didn't feel right) (It felt good) (The ball felt like it rolled off to the side) (I did not have a good feel for the ball) (I felt more comfortable) (I felt like I didn't extend)

Table 3 (cont.)

Episode	Component	Sub-Component	Code	Definition	Example (where appropriate)
		Other Reasoning	OR	Any explanation that could not be coded using one of the above sub-components was coded OR, as was no explanation	(The light was in my eyes) (I did the same as last time) (it just happened) (I was distracted by a noise) (I concentrated more) (I rushed it) (I lost my focus) (I don't know) (It had the height) (I was not really ready) (It looked like ...) (I liked the arc) (I shot it to the side) (I was off balance)
		Comments Unrelated to Task Performance	CUP	Any verbalizations which do not serve as an explanation for the predictions offered are coded CUP	(The microphone feels loose, that was terrible, I forgot to predict...)
Evaluation/Judgement	Affective Reaction	Positive Reaction	PR	Expression of a feeling of accomplishment, pleasure, excitement, relief, or ease. May be made in relation to task performance or the knowledge/skill possessed. These may be made prior to, or during performance (i.e., positive comments regarding task performance and/or the knowledge/skill possessed)	(This should be simple, that was fun, I think I did OK, finally I made one, laughter, I made it)
		Negative Reaction	NR	Expression of a feeling of failure, dread, anxiety, or difficulty. May be made in relation to task performance or the knowledge/skill possessed. These may be made prior to, or during performance (i.e., negative comments regarding task performance and/or the knowledge/skill possessed)	(I wish I didn't have to actually shoot the ball, I need to work on my stance, I don't think I did that very well, it's hard to talk, I missed, sigh)

\*NOTE: When coding performance at Task Three the raters had to, at times, extrapolate to code some explanations as SSC, TSC, and KR. If the explanation was connected to segment positioning in any way it was coded SSC. If the explanation was connected to shot technique in any way it was coded TSC. If the explanation contained the words "feel" or "felt" it was coded as KR. However, an explanation could be coded both KR and SSC/TSC. For example, if the subject said "it felt like I did not extend enough" this would be coded KR and TSC.

individual skills necessary for successful foul shot performance.

The coding systems developed for use in this investigation were based partially upon the models proposed by Schoenfeld (1985) and Rowe (1985). These models assisted in the construction of the coding grids used here by lending their structure and organization. Schoenfeld (1985) suggested that protocols be parsed into large chunks called "Episodes" which represent periods of time in which the problem solver is engaged in a single set of actions of the same type and character. This analysis of protocols at a macroscopic level provides a way of identifying the large-scale consequences of individual decisions made during problem solving sessions (Schoenfeld, 1985).

The episodes developed for use in Tasks one, two, and three were; reading, comprehension, task performance, and evaluation/judgement. The reading episode began when a subject started to read the task instructions presented to her and finished when she had completed reading them in their entirety. The comprehension episode represented periods of time when the subject was engaged in activities designed to improve her understanding of, and performance within the task. The task performance episode involved the actual completion of the task demands whether they were providing verbal instruction, or talking aloud during shot performance. The evaluation/judgement episode involved such activities as expressing feelings of accomplishment, failure, pleasure, or anxiety as they all relate to task performance.

Rowe's (1985) modelling system served to move the analysis to a microscopic level helping to identify "components" and "sub-components" that may be subsumed within the larger episodes. A large number of the components and sub-components used in

this investigation were developed after the protocols had been collected. The observation of a particular verbalization or movement led to its inclusion in the coding grid. A small pilot study performed by Toward (1995) also assisted in the identification of relevant components and sub-components. In the pilot study two expert and two novice basketball players performed the same three tasks used in the current investigation. The components and sub-components developed for use within the pilot study were appropriate for inclusion in this study. However, as previously stated, this did not preclude the creation of new categories if warranted by the protocols collected.

Unlike the episodes developed for use in this investigation, the components and sub-components varied, though at times only slightly, for each task. Each of the three tasks used in this investigation required that a separate grid be developed for the purpose of coding the collected protocols. Tables 1 and 2 contain the coding information which was used to code both the verbal and visual protocols obtained from Tasks one and two respectively. These tables contain operational definitions and examples for each of the sub-components that were used in the coding process.

The verbal protocols obtained at Task three were coded differently than Tasks one and two. The main responsibility of each subject at Task three was to predict the performance outcome at each shot attempt. The verbal protocol information that followed served to supplement the original prediction. That is, it represented each subjects attempt to explain their prediction. Essentially, the task performance episode differed from those used in Tasks one and two in that it was used to code verbal protocols that were collected retrospectively, after each shot attempt, rather than concurrently during motor

performance. The task performance episode within Table 3 contains the information which was used to code the post-prediction verbal protocols collected at Task three.

### **Experimental Protocol**

#### **Subjects**

Twenty-four female undergraduate students from McGill University volunteered to participate in this study. Twelve of the 24 subjects were classified as basketball experts while the remaining twelve were classified as basketball novices. Classification as either an expert or novice was dependent upon the total number of seasons spent playing competitive basketball and the level of competition. For use within this investigation, competitive basketball was operationally defined as participation in a league, whether it be high school, C.E.G.E.P., university, or club, with full-time coaching and organized seasonal practices.

Analysis of the number of competitive seasons played by the subjects within both groups yielded significant ( $F(1,22) = 64.55, p < .01$ ) group differences, thereby lending support to the relative classification of 'expert' and 'novice' for Group one and Group two subjects respectively. The 12 subjects within the expert group (Group one) had, on average, 10.58 seasons ( $SD = 3.36$ ) of competitive experience while the 12 subjects within the novice group (Group two) had, on average, 1.42 seasons ( $SD = 2.06$ ) of competitive experience. Refer to Table 4 for a listing of the mean number of competitive seasons played by both groups of subjects at various levels of competition.

Table 4

Mean Number of Competitive seasons of Basketball Experience for Group One and Group Two

Group <sup>a</sup>	Level of Competition				Total
	High School	C.E.G.E.P. <sup>b</sup>	University	Club	
One	3.83	1.08	1.42	4.25	10.58
Two	1.25	0.17	0.00	0.00	1.42

<sup>a</sup>Group One N = 12, Group Two N = 12

<sup>b</sup> C.E.G.E.P. = Collège D'enseignement Général et Professionnel

**Procedure**

The performance of all three tasks and the resultant verbal and visual protocol collection took approximately 50-60 minutes per subject. Each testing session began with the subject entering the gymnasium and having the experimental setting shown to her. The subject was then presented with the letter of informed consent (see Appendix A) and was told that this study focussed on the skill of foul shooting. Each subject was then informed that she would be asked to perform the following three tasks: (a) instruct a novice learner in the proper execution of a foul shot, (b) "talk aloud" while performing ten foul shots, and (c) assess performance and predict the outcome of ten attempted foul shots.

The concept of "talking aloud" while performing was further explained to each subject emphasizing that she was to attempt to verbalize all thoughts as she had them and all actions as she performed them. To assist in the understanding of this concept each subject was asked to perform a simple motor task (putting on one's shoes and tying the laces) and to talk aloud while doing so. The task itself was simple but the act of describing each movement proved more difficult. Each subject was encouraged and prodded by the experimenter to ensure that all thoughts and actions were verbalized. Each subject continued to practice "talking aloud" until they felt comfortable with the concept.

Prior to initiating actual task performance each subject was next provided with a period of time to physically warm up and prepare for the skill of foul shooting. When the subject felt she was ready to begin she was presented with the instructions (see Appendix B) for Task one, asked to read them aloud, and then to execute them. When Task one was completed the subject then performed the same steps for the next two tasks, reading the

instructions aloud, followed by their execution. The verbal and visual protocols were recorded at each task using a wireless microphone worn by the subject, a JVC colour video camera, and a JVC VHS video cassette recorder. The text that follows presents a detailed explanation of the performance requirements at each task.

Task One - Verbal Instruction. Each subject was required to verbally instruct a novice basketball player in the proper execution of a basketball foul shot. The investigator served as the novice in this task. Each subject was told that the novice learner had never before received any direct instruction in the proper execution of basketball skills and had never before played the game at an organized level. The responsibility of each subject was to tell the novice learner everything she felt he needed to know in order to successfully perform the skill. There was no time restriction placed upon the completion of the task and each subject was allowed to supplement her verbal instruction with physical demonstrations, if deemed necessary. The subjects were instructed to think aloud at all times during the performance of the task to ensure that all information was verbalized. Before Task one was concluded a general probe was asked to ensure that each subject had addressed the components of foul shot performance that she perceived as being relevant to skill instruction (e.g., "Before finishing, I would like to ask if there is anything else that you would like to add?").

Task Two - Talk Aloud While Performing. Each subject performed 20 foul shots, talking aloud during the performance of alternate shots. Each subject was told that starting with the first shot attempt, and on alternate shot attempts following, she must verbalize all of her thoughts and actions. If the subject remained silent for any length of time she was

reminded to talk aloud. In an attempt to stimulate thinking and enhance verbal output each subject was required to collect her own rebounds. Doing so required that each subject step off the foul line after each shot attempt, collect the ball, and then reposition herself for the next attempt, necessitating the re-statement of the previously performed skill components.

Task Three - Predicted Performance. Each subject performed 10 foul shots, assessing and predicting her performance outcome at specific times throughout task performance. Immediately upon the release of the ball, at each shot attempt, the subject was asked to verbally indicate (i.e., predict) whether she believed the shot was going to be successful by saying either "YES" or "NO". This task required that each subject monitor and assess her performance prior to predicting the success of each shot attempt. After predicting the success of the shot each subject was then asked to explain her prediction, or justify her response, regardless of whether or not their prediction was accurate. As in the previous task the subjects were asked to collect their own rebounds.

### **Data Collection**

#### **Coding**

Once collected the verbal protocols were transcribed verbatim and were assigned the appropriate codes from either Table 1, 2, or 3. When coding the verbal protocols for Tasks one and two each coded task performance skill sub-component was assigned a quality assessment value (QAV) of either 3, 2, or 1. These assigned values were representative of the quality of the verbalizations produced. That is, each verbalized sub-component was assessed to determine if the information provided was correct (3), incorrect (1), or incomplete (2). An assigned value of 2 indicated that the sub-component

was discussed in such a way that a judgement could not be made with respect to the quality (i.e., correct or incorrect) of the statement. If a sub-component was not addressed it was assigned a value of 0 which meant that it was omitted.

A somewhat different method of value assignment was used when coding the visual protocol data for Task two. As the visual protocol data was collected through the direct observation of movement it was possible to limit QAV assignment to only correct and incorrect movements. No movement was coded as incomplete since direct observation allowed for the collection of sufficient information to fully assess the quality of the movements or actions produced. Likewise, direct observation of the movements or actions produced also meant that the skill sub-components of interest were all present and that none were assigned a QAV of 0. Therefore, each coded skill sub-component was assigned a QAV of either 3 or 1, dependent upon whether or not the coded sub-component was performed correctly or incorrectly.

The verbalizations coded at Task three did not have a QAV assigned to them, as the intent was simply to code and document the occurrence of the explanations presented. Appendix C provides an explanation of the coding and scoring system utilized within this investigation, including definitions and examples of correct, incorrect, and incomplete verbalizations and/or actions for each skill sub-component. The information within Appendix C supplements that already presented in Tables 1, 2, and 3.

### **Reliability**

Due to the relatively subjective nature of the coding process, it was crucial that the extent to which meaning was assigned (i.e., coded) to the protocols could also be inferred

by external observers. Therefore, in an attempt to determine the reliability of both the coding procedures and the resultant protocol data three independent raters were trained and assessed with respect to their ability to reproduce the codes previously assigned by the investigator. This reliability check was performed for both the verbal protocol data and visual protocol data using the same three individuals. The procedures used to determine the reliability of the coding procedures for this investigation were based upon those used by Blais (1989) and Côté (1993).

Verbal Protocols. When coding the verbal protocols the primary concern for Tasks one and two was to determine whether or not a specific skill sub-component (SSC, TSC, MSC) was represented, while the primary concern for Task three was to determine whether or not a specific reasoning sub-component (SSC, TSC, KR, OR) was represented. Therefore, identifying group differences in reading, comprehension, and evaluation/judgement was of secondary importance when compared to identifying group differences in task performance. However, all four of the identified episodes were included within the coding process. That is, equal time and attention was devoted to coding all verbalizations not just those associated with task performance.

The reliability check performed on the procedures used and data obtained when coding the verbal protocols followed five distinct steps. First, because of the complexity of the coding process, the three raters selected to assist in coding the verbal protocols were provided with an explanation as to the purpose of the investigation. The raters next participated in a discussion of the various episodes, components, and sub-components contained within the coding grids for Tasks one, two, and three. Examples of correct,

incorrect, and incomplete verbalizations, as they relate to instruction in foul shooting, were also discussed at this point. The document entitled "Foul Shot Skill Components" (see Appendix C) and Tables 1, 2, and 3 were presented to each rater in an attempt to enrich their understanding of the coding process. The raters were then trained on the coding process at each task using the protocols collected from one of the subjects who participated in this investigation. The training session concluded when the raters and the investigator were able to reach a consensus opinion (i.e., 3 of 4) on each coded verbalization within the training protocols. This four step training process took approximately two hours to complete.

The fifth step in the performance of the reliability check involved providing each rater with the transcribed protocols of six randomly selected subjects (three experts and three novices). Working independently, the raters first coded the six transcribed protocols for Task one. When the coding was completed both the raters and the investigator then reviewed each coded protocol and attempted to resolve any observed differences. The review process continued until a consensus opinion was reached with respect to the code assigned to each verbalization. The raters next coded the six transcribed protocols for Task two. When the coding was completed the raters and the investigator again reviewed the coded protocols attempting to resolve any observed differences. The process was again repeated for Task three. When coding the protocols the code for each identified sub-component was placed directly above its corresponding transcribed verbalization. An example of a coded verbal protocol for each of Tasks one, two, and three is provided within Appendix D. The 18 protocols, representative of the performance of six subjects on

each of the three tasks, used to determine the reliability of the coding process represented approximately 26% (i.e., 18 of 69) of the remaining verbal protocols not used during the training process. It took approximately 12 hours to code the verbal protocols and reach consensus with respect to the assigned codes.

The investigator had originally assigned 184 sub-component codes to the six transcribed Task one verbal protocols that were randomly selected for the purpose of reliability testing. Rater one assigned 180 sub-component codes to these same transcribed protocols, however 15 of these codes did not match those assigned by the investigator; yielding an inter-rater reliability of 90%. Of the 15 non-matching codes, 10 were representative of performance within the same episode but differed with respect to either the sub-component code or the QAV assigned; yielding an inter-episode reliability coefficient of 95%. Raters two and three were seen to respectively assign 177 and 174 sub-component codes to the same Task one verbal protocols. Rater two assigned 21 codes that did not match those assigned by the investigator while rater three assigned 15 non-matching codes; yielding respective inter-rater reliability coefficients of 85% and 86%. Examination of those codes that were representative of performance within the same episode but differed with respect to the sub-component code or QAV assigned yielded inter-episode reliability coefficients of 93% and 92% for raters two and three respectively.

Specific to Task two, the investigator assigned 467 sub-component codes to the six transcribed verbal protocols randomly selected for the purpose of reliability testing. Rater one assigned 459 sub-component codes to these same transcribed protocols, however 35 of these codes did not match those assigned by the investigator; resulting in

an inter-rater reliability coefficient of 91%. Of the 35 non-matching codes, 25 were representative of performance within the same episode but differed with respect to either the sub-component code or the QAV assigned; yielding an inter-episode reliability coefficient of 96%. Raters two and three both assigned 464 sub-component codes to the same Task two verbal protocols. Rater two assigned 47 codes that did not match those assigned by the investigator while rater three assigned 44 non-matching codes; yielding respective inter-rater reliability coefficients of 89% and 90%. Examination of those codes that were representative of performance within the same episode but differed with respect to the sub-component code or QAV assigned yielded inter-episode reliability coefficients of 97% for both raters two and three.

At Task three only those codes assigned to the explanations offered in response to the predictions made were of interest. The investigator assigned 110 sub-component codes to the six transcribed verbal protocols randomly selected for the purpose of reliability testing. Rater one assigned 114 sub-component codes to these same transcribed protocols, however 7 of these codes did not match those assigned by the investigator; resulting in an inter-rater reliability coefficient of 97%. Raters two and three respectively assigned 114 and 110 sub-component codes to the same Task two verbal protocols. Rater two assigned 8 codes that did not match those assigned by the investigator while rater three assigned 4 non-matching codes; yielding inter-rater reliability coefficients of 96% for both raters two and three when compared to the investigator.

Visual Protocols. When coding the visual protocols collected at Task two the primary concern was to determine whether or not a particular skill sub-component (SSC,

TSC, MSC) was performed, and whether it was done so correctly or incorrectly. The reliability check performed on the procedures used and data collected when coding the visual protocols at Task two followed five distinct steps. To begin, the raters were again reminded about the purpose of this investigation and the importance of accurately coding the visual protocols. The raters next participated in a discussion of the various skill sub-components that were to be coded. Examples of correct and incorrect actions, as they relate to the performance of the foul shot, were also discussed at this point. The document entitled "Foul Shot Skill Components", found within Appendix C, was again discussed to ensure that each rater had a complete understanding of the coding process. The raters then participated in a training exercise designed to perfect their coding skills. This exercise involved coding all of the actions of one of the subjects who participated in this investigation. The training exercise concluded when the raters and the investigator were able to reach a consensus opinion (i.e., 3 of 4) on each coded action within the training tape. This four step training process took approximately 45 minutes to complete.

The fifth step in the performance of the reliability check involved having the raters, together with the investigator, view the recorded performance of the same six subjects whose verbal protocols were coded earlier. The raters were provided with checklists (See Table E1 in Appendix E) for recording the occurrence of the skill sub-components at each shot attempt. The coding took place within a video lab where the raters and the investigator simultaneously viewed the performance of each of the six selected subjects. Alternate shot attempts were coded, starting with the first shot.

The coding process itself occurred at two distinct points within each shot attempt.

First, the performance of each subject was observed, in real time, up to the point at which she had just set herself, prepared to shoot. At this point, just prior to shot initiation, the tape was stopped and the following skill sub-components were coded; SSC1 (feet), SSC2 (knees), SSC7 (elbow), SSC10 (hand), TSC6 (ritual), TSC10 (ball position), and TSC11 (approach). Each sub-component was coded with respect to the quality of its performance. When this first phase of the coding process was completed the tape was again started and performance was observed, in real time, up to the point at which the ball was just about to be released. At this point, just prior to completion of shot, the tape was observed one frame at a time while the following skill sub-components were coded; TSC3 (release), TSC4 (follow through), and TSC7 (extension). Again each sub-component was coded with respect to the quality of its performance.

After each shot attempt was coded the raters and the investigator then reviewed their selections and attempted to resolve any apparent coding differences. This review process continued until a consensus opinion (i.e., 3 of 4) was reached. If, during either phase of the coding process, the raters again needed to observe the performance of any of the coded sub-components the tape was rewound and that specific sub-component was displayed. This process was repeated for all 10 shot attempts within each of the six selected visual protocols. The 6 protocols, representative of the performance of six subjects at Task two, used to determine the reliability of the coding process represented approximately 26% of the remaining visual protocols not used during the training process. It took approximately 4 hours to code the visual protocols and reach consensus with respect to the assigned codes.

The investigator assigned 720 sub-component codes to the six recorded Task two visual protocols that were randomly selected for the purpose of reliability testing. Raters one, two, and three also assigned 720 sub-component codes as 12 actions had to be coded for each of 10 foul shots taken by the six subjects. Raters one, two, and three matched the codes assigned by the investigator 687, 698, and 686 times respectively; producing respective inter-rater reliability coefficients of 95%, 97%, and 95%.

None of the mental skill sub-components (MSC1, MSC2, MSC3) were coded during this phase of data collection as it was impossible to infer the presence of any such activity simply through the observation of physical skill performance. For a similar reason a number of the spatial skill sub-components (SSC3-waist, SSC4-back, SSC5-shoulders, SSC6-head, SSC8-wrist, SSC9-fingers) and technical skill sub-components (TSC1-weight, TSC2-alignment, TSC5-flight of the ball, TSC8-aim, TSC9-technical information) were not coded. Limitations in the number of cameras available, hence viewing angles, reduced the number of skill sub-components that could be clearly recorded and assessed. However, those sub-components that were recorded represented the most essential and fundamental elements of skilled foul shot performance.

### **Data Preparation and Analysis**

The method of data preparation and analysis varied for each task. The following text is a description of the preparation and analysis procedures used at Tasks one, two, and three.

Task One - Verbal Instruction. The initial step in the preparation of the data was to record the coded verbal protocols for each subject. A count was recorded regarding the

number of times each sub-component, and its corresponding quality assessment value, was coded within each group during Task one performance. It is important to note that only the first occurrence of each verbalized skill sub-component was recorded (i.e., repeated verbalizations were not counted) for each subject at Task one. This was done to prevent biasing the results through recording the repeated verbalization of information already presented. If repetitions were recorded it may have resulted in one individual appearing to possess more knowledge than another simply because a specific skill sub-component was discussed with greater frequency. However, we could not assume that an individual who correctly instructed the novice learner in the proper positioning of the knees four times during task performance knew more than an individual who did it only once. The content of the information presented would have been similar and the fact that it was repeated would not necessarily indicate a greater understanding. Repetitions were noted, however, when a subject discussed a specific skill sub-component more than once and each occurrence was assigned a different QAV. For example, if a subject discussed the placement of the knees twice and the first occurrence was judged to be "correct" while the second was judged to be "incomplete" the subject was recorded as having discussed the skill correctly as it was demonstrated that she possessed the correct knowledge of that particular skill sub-component. Similarly, if an "incorrect" assessment was made along with an "incomplete" assessment the subject was recorded as having discussed the skill incorrectly as it was demonstrated that she possessed incorrect knowledge of that particular skill sub-component. Therefore, any combination of a correct and incomplete assessment was recorded as correct, and any combination of an incorrect and incomplete

assessment was recorded as incorrect. If a subject was seen to have discussed a specific skill sub-component repeatedly and was assessed as having discussed it both correctly and incorrectly the subject was recorded as having discussed that sub-component incorrectly, as the conflicting verbalizations demonstrated an incorrect understanding of that particular skill sub-component. Coding the conflicting verbalizations in this manner resulted in our obtaining more conservative results.

The data, as originally recorded, was then collapsed within groups indicating the number of "correct", "incorrect", "incomplete", and "omitted" verbalizations. Initial observation of this data indicated that group differences may have been present with respect to both the quality and quantity of the instructional information presented. However, there were a relatively large number of empty cells, meaning that a number of subjects failed to discuss all of the skill sub-components when providing their verbal instruction. Therefore, in an attempt to enrich the analyses the data was collapsed further within each of the three skill sub-components. With respect to the spatial skill sub-components, the coded verbalizations that addressed similar areas of the body were collapsed into three segments. These three segments were: (a) the legs, including the feet (SSC1) and knees (SSC2); (b) the upper body, including the waist (SSC3), back (SSC4), shoulders (SSC5), and head (SSC6); and (c) the arm, including the elbow (SSC7), wrist (SSC8), fingers (SSC9), and hand (SSC10).

With respect to the technical skill sub-components, the coded verbalizations that addressed the necessary technique for performance were collapsed into three temporal segments, each representative of a different stage in the execution of the foul shot. These

three segments were: (a) the setup, including weight (TSC1), alignment (TSC2), ritual (TSC6), ball position (TSC10), approach (TSC11), and aim (TSC8); (b) the execution, including extension (TSC7), release (TSC3), follow-through (TSC4), and flight of the ball (TSC5); and (c) information, including technical information (TSC9).

The categories within the mental skill sub-components were collapsed into one segment. This segment was labelled mental and included focus/concentration (MSC1), visualization (MSC2), and feel/relaxation (MSC3).

To further refine the analyses, the counts obtained for the verbalizations assessed as being incorrect and incomplete were combined. It was reasoned that the sub-components originally assessed as being incomplete closely approximated those sub-components assessed as being incorrect, and in fact were representative of incorrect responses. This reasoning was derived from what is commonly practised in the field of cognitive test construction where multiple choice tests are used to assess an individuals knowledge base. The responses provided within multiple choice tests are often representative of varying degrees of "correctness". That is, the respondent is asked to select the response that is most correct, with all other responses being judged incorrect. The application of this reasoning to Task one performance resulted in an incomplete, or neutral response, being coded as an incorrect response. The raw data, representative of the collapsed SSC, TSC, and MSC verbal protocol data, for each subject within Groups one and two can be found in Appendix F in Tables F1, F2, and F3 respectively.

The data obtained at Task one were ultimately represented as the observed frequencies of the coded verbalizations at each of the three collapsed skill sub-component

segments. With respect to the collapsed spatial skill sub-component data the observed frequencies were arranged within a three dimensional 3 X 3 X 2 (SSC X QAV X GP) contingency table. The observed frequencies representative of the collapsed technical skill sub-component data were also arranged in a three dimensional 3 X 3 X 2 (TSC X QAV X GP) contingency table.

The data contained within both contingency tables were next analysed using logit-linear analyses. This method of analysis is appropriate for use when one wishes to determine if there are group differences in the pattern of responding to two or more qualitative variables (Kennedy, 1983).

In brief, the logit linear method of analysis is an extension of the 2 X 2 traditional chi-square for more complex contingency tables. This method of analysis allows the researcher to set one variable as the dependent measure. The dependent variable measured within Task one was the Quality Assessment Value (QAV) frequency count, representative of the number of times the various skill sub-components were verbalized correctly, incorrectly, or were omitted. The independent variables were group, collapsed technical skill sub-components, and collapsed spatial skill subcomponents. Within a logit-linear analysis the main effect of any independent variable actually represents an interaction with the dependent variable (Baker, 1981). Bock's approach (Bock, 1975, chap. 8) was used to obtain the most parsimonious logit-linear model. This approach used a nested hierarchical model, meaning that all lower associations nested within the model were included. Parsimony under Bock's approach was also obtained by building the model in a forward stepwise manner. Forward model-building started with simple main effects

and more complex associations were added until a hierarchical model was found to be significant. The overall evaluation of the model was made using the likelihood-ratio chi-square ( $L^2$ ) statistic. This first use of the likelihood-ratio was referred to as a "goodness of fit" or "residual" chi-square test (Kennedy, 1983). These residual chi-square tests assessed the extent of agreement between cell frequencies that were observed and those issued by a model. Within the logit-linear analysis this statistic functioned as a stop rule, which indicated when there was enough information to sufficiently explain the observed frequencies. A model with a  $p$ -value greater than or equal to .15 was considered adequate. In this case a  $p$ -value greater than or equal to .15 indicated that the residuals (i.e., parts not explained by the model) were not significant, or in other words, that the suggested model fit the data very well. The strategy behind this kind of modelling was to find the simplest model that explained the observed frequencies. This ultimately provided an idea as to how the observed frequencies could be summarized.

The likelihood-ratio  $L^2$  statistic was next used to make comparisons of the models in pairs. Because the likelihood-ratio  $L^2$  possesses additive properties, the arithmetic difference between the residual  $L^2$  statistics of two models was tested for statistical significance to determine if the more parsimonious member of the pair fit the data significantly better than the less parsimonious member of the pair (Kennedy, 1983). This approach was used in this study to yield simple models that did not overfit the data. In summary, the logit linear analysis was performed in the following three steps. First, lower associations were added into the model until the model fit (i.e.,  $p \geq .15$ ). This process consisted of adding main effects first, two-way interactions second, and the three-way

interactions last. Second, the independent effect of the new component added to the model was assessed using a chi-square test of difference. Third, the model was simplified by keeping only lower nested associations for the effect that was deemed to make the model fit at a  $p$ -value  $\geq .15$ . For example, if a two-way interaction (GP X SSC) was deemed adequate to make the model fit (i.e., a  $p$ -value  $\geq .15$ ) the complete model would need to include all lower associations (i.e., GP and SSC). In this situation it would be inappropriate to include the QAV main effect in the model as this is not nested within the interaction, unless the main effect significantly contributed to making the model fit (i.e.,  $p$ -value  $\geq .15$ ).

The observed frequencies representative of the collapsed Mental Skill sub-Component data were arranged within a 1X2 (MSC X GP) contingency table. As log-linear methods are not appropriate for use in the analysis of two dimensional contingency tables the collapsed Mental Skill sub-Component data was analysed using more traditional ANOVA procedures.

Task Two -Talk Aloud While Performing. The initial step in the preparation of the data at Task two consisted of recording the coded verbal and visual protocols for each subject. A count was recorded regarding the number of times each sub-component, and its corresponding QAV was coded during Task two performance. Coding the visual protocols on the same shot attempt where the verbal protocol data was collected allowed for the later comparison between what was said to what was actually done.

Recall that none of the mental skill sub-components could be coded during the data collection phase at Task two as their presence was impossible to infer simply through

the observation of physical skill performance. As a result, the coded verbal protocols that addressed the mental skill sub-components at Task two were not recorded during the data preparation phase as comparisons could not be made with their visual protocol counterparts. Similarly, those coded verbal protocols (SSC3, SSC4, SSC5, SSC6, SSC8, SSC9, TSC1, TSC2, TSC5, TSC8, and TSC9) whose visual protocol counterparts could not be recorded and coded as a result of equipment limitations were also not recorded during the data collection phase at Task two. The verbal and visual protocol data that was collected was collapsed across the 10 shots for each subject, respectively indicating the number of correct and incorrect verbalizations and actions produced.

The next step in the preparation of the data for analysis consisted of collapsing the recorded skill sub-component data within each of the spatial and technical skill sub-components. With respect to the spatial skill sub-components, the coded verbalizations and actions that addressed similar areas of the body were collapsed into two segments. These two segments were: (a) the legs, including the feet (SSC1) and the knees (SSC2); and (b) the arm, including the elbow (SSC7), and the hand (SSC10). With respect to the technical skill sub-components, the coded verbalizations and actions that addressed the technique necessary for performance were collapsed into two temporal segments, each representative of a different stage in the execution of the foul shot. These two segments were: (a) the set-up, including the ritual (TSC6), the approach (TSC11), and ball position (TSC10); and (b) the shot, including the release (TSC3), the follow-through (TSC4), and the extension (TSC7). Tables F4 and F5, in Appendix F, present the collapsed spatial skill sub-component and technical skill sub-component verbal and visual protocol data for

Group one and Group two respectively.

The data obtained at Task two were ultimately represented as the observed frequency of the coded verbal and visual protocols at the collapsed spatial and technical skill sub-component segments legs, arm, shot, and set-up. These data were analysed in two distinct ways. First, a series of ANOVA's were performed in an attempt to identify possible group differences with respect to the coded correct and incorrect verbalizations and actions at each of the collapsed spatial and technical skill sub-component segments for both the verbal and visual protocol data respectively. Second, Pearson Product Moment correlations were computed to identify possible relationships between (a) the verbal and visual protocol data for groups One and Two combined, (b) the verbal and visual protocol data for Group One subjects, and (c) the verbal and visual protocol data for Group Two subjects.

Task Three - Predicted Performance. The preparation of the data at Task three involved recording the following information for each subject; (a) the number of successful shots, (b) the number of shots predicted as successful, (c) the number of shots correctly predicted as successful, (d) the number of shots predicted as unsuccessful, (e) the number of shots correctly predicted as unsuccessful, (f) the total number of shots correctly predicted, and (g) a count of the number of times each reasoning sub-component (SSC, TSC, KR, OR) was coded during each subject's attempt to explain their predictions (See Tables F6 and F7 in Appendix F).

The data were then collapsed across subjects, within group, so that between group comparisons could be easily made. The data were analysed using a series of ANOVA's in

an attempt to identify any group differences with respect to the predictions made and the corresponding explanations.

## CHAPTER IV

### RESULTS

This chapter presents the results of the analyses performed on the protocol data collected within this investigation. The results are presented in such a way that they relate to both the primary research objective and the specific research hypothesis tested at each task. The primary objective of this investigation was to examine expert-novice differences in metacognitive knowledge about action and metacognitive skill functioning, both as they relate to performance of the basketball foul shot.

The research hypothesis tested within this investigation was stated as follows:

The level of metacognitive knowledge about action and metacognitive skill possessed by an individual is a function of the level of expertise, relative to the performance of that action, of that individual.

Each of the three tasks developed for use in this investigation tested this hypothesis in a different way. Task one sought to identify group differences in the declarative component of metacognitive knowledge about action through the collection and comparison of instructional verbal protocols. Task two sought to identify both between group differences and the within group relationship between one's actions and the corresponding verbal description of those actions through the collection and comparison of verbal and visual protocols. It was believed that such a comparison would serve to identify group differences in the procedural component of metacognitive knowledge about action. Finally, Task three sought to identify group differences in metacognitive skill functioning as determined through each subject's ability to monitor her performance, predict performance outcomes, and justify or explain the predictions made. The results obtained

during the performance of each task are presented in turn.

### **Task One - Verbal Instruction**

Recall that the effects of the independent variables (group, collapsed technical skill sub-components, and collapsed spatial skill sub-components) within Task one were analysed using logit-linear analyses. A logit-linear analysis is a log-linear analysis with one variable specified as the dependent variable. As stated previously, the dependent variable measured within Task one was the QAV (Quality Assessment Value) frequency count, representative of the number of times the various skill sub-components were verbalized correctly, incorrectly, or were omitted. As they relate to the collapsed spatial skill sub-component segments, the QAV frequency measures collected during Task one performance are presented in Table 5.

The results of the logit-linear analysis for the collapsed spatial skill sub-component data (see Table 6) indicated that model six provided the best fit for the observed data ( $L^2(0) = 0.0$ ,  $p = 1.00$ ). Although the chi-square test of difference at model five indicated that adding the SSC X QAV interaction significantly improved the model ( $L^2(4) = 66.3$ ,  $p < .05$ ) it was not enough to explain all of the observed frequencies as indicated by the residual  $L^2$  test. Rather, the residual  $L^2$  test indicated that the addition of the three-way (SSC X QAV X GP) interaction, within model six, was needed to explain the observed frequencies. This, despite the fact that the chi-square test of difference at model six indicated that this three-way interaction was not significant ( $L^2(4) = 7.89$ ,  $p > .05$ ), meaning that it did not significantly improve the model. However, the chi-square test of difference at model six was deemed borderline indicating that, although not found to

Table 5

Observed QAV Frequencies by Collapsed Spatial Skill sub-Component Segment and Group at Task One

Spatial Skill sub-Components	Collapsed Spatial Skill sub-Component Segments (SSC) <sup>a</sup>		Quality Assessment Value (QAV)	Group (GP)	
				One B <sub>1</sub> <sup>b</sup>	Two B <sub>2</sub>
SSC1	A <sub>1</sub>	Legs	C <sub>1</sub> Correct (3)	25	24
SSC2			C <sub>2</sub> Incorrect (1)	8	2
			C <sub>3</sub> Omitted (0)	15	22
SSC3	A <sub>2</sub>	Upper-Body	C <sub>1</sub> Correct (3)	4	5
SSC4			C <sub>2</sub> Incorrect (1)	0	0
SSC5			C <sub>3</sub> Omitted (0)	44	43
SSC6					
SSC7	A <sub>3</sub>	Arm	C <sub>1</sub> Correct (3)	24	19
SSC8			C <sub>2</sub> Incorrect (1)	1	5
SSC9			C <sub>3</sub> Omitted (0)	23	24
SSC10					

<sup>a</sup>(SSC, QAV, GP) represent the variable names used in analysis

<sup>b</sup>(A<sub>1-3</sub>, B<sub>1-2</sub>, C<sub>1-3</sub>) represent the different levels at each variable

Table 6

Summary of the Logit-Linear Analysis for the Data Presented in Table 6 (Collapsed Spatial Skill sub-Component Data)

Model and Design	Residual Chi-Square test			Chi-Square Test of Differences		
	L <sup>2</sup>	df	p <sup>a</sup>	L <sup>2</sup>	df	p <sup>b</sup>
(1) SSC & QAV	74.96	13	<.05			
						model 1 - model 2
(2) SSC & QAV & GP	74.96	13	<.05	0.00	1	>.05
						model 2 - model 3
(3) SSC & QAV & GP & SSC X GP	74.95	10	<.05	0.01	2	>.05
						model 3 - model 4
(4) SSC & QAV & GP & SSC X GP & QAV X GP	74.19	8	<.05	0.76	2	>.05
						model 4 - model 5
(5) SSC & QAV & GP & SSC X GP & QAV X GP & SSC X QAV	7.89	4	.096	66.33	4	<.05*
						model 5 - model 6
(6) SSC & QAV & GP & SSC X GP & QAV X GP & SSC X QAV & SSC X QAV X GP	0.00	0	1.00**	7.89	4	>.05

a (critical value  $\alpha = .15$ )b (critical value  $\alpha = .05$ )\*\* significant at p-value  $\geq .15$ \* significant at p-value  $\leq .05$

significantly improve the model, this three-way interaction was needed to adequately explain the observed frequencies. In fact, all of the main effects and interactions contained within model six were needed to explain the observed frequencies. Hence, model six is termed a saturated model as it included all possible combinations of the explanatory variables. Within the saturated model all expected frequencies were completely determined by the observed frequencies. The restricted models (models one through five) were unable to fit the observed data adequately, therefore, all attempts to advance a parsimonious explanation had to be abandoned and the saturated model (model six) interpreted.

Because the analysis at Task one was an asymmetrical inquiry, the selection of the saturated model meant that effects existed for all levels of the explanatory variables - Group one subjects and Group two subjects did not respond similarly on the response variable across the three collapsed spatial skill sub-component segments. The data presented within Table 5 indicated that Group one subjects expressed more incorrect verbalizations at the collapsed spatial skill sub-component segment labelled legs, while Group two subjects were seen to omit this segment with greater frequency. With respect to the observed frequencies at the collapsed spatial skill sub-component segment labelled arm, Group one subjects were seen to have produced both correct verbalizations with a greater frequency and incorrect verbalizations with a lesser frequency when compared to those produced by Group two subjects. The frequency of the correct, incorrect, and omitted verbalizations produced at the collapsed spatial skill sub-component segment labelled upper body were seen to differ very little between groups. However, the distribution of the QAV's at this segment was seen to differ from those at both the 'arm'

and 'legs' segments. Both groups of subjects were seen to omit instruction related to the segment labeled upper body with far greater frequency than at the other two collapsed segments. The distribution of the QAV's at both the 'legs' and 'arm' segments were seen to be more equally divided between the correct and omitted response categories for both groups of subjects.

With respect to the collapsed technical skill sub-component segments, the QAV frequency measures obtained during Task one performance are presented in Table 7. The results of the logit-linear analysis performed on the data contained within Table 7 indicated that model five (see Table 8) fit the observed data best. The residual  $L^2$  test, which functioned as the STOP rule, indicated that model five explained the observed frequencies significantly better ( $L^2(4) = 1.02, p = .91$ ) than did the more restricted models that came before it. The chi-square test of difference at model five indicated that adding the TSC X QAV interaction significantly improved the model ( $L^2(4) = 18.66, p < .05$ ) and therefore, was the only important interaction. This result suggested that a simpler model would best explain the frequencies observed for the collapsed technical skill sub-component data. This simpler model is presented as model seven in Table 8. The result of the residual  $L^2$  test on model seven confirmed that the TSC and QAV main effects, and the TSC X QAV interaction best explained the observed frequencies for the collapsed technical skill sub-component data ( $L^2(4) = 2.62, p = .911$ ). Likewise, the chi-square test of difference confirmed that the TSC X QAV interaction significantly improved upon model one ( $L^2(4) = 18.59, p < .05$ ). The prediction from model seven was not perfect but the amount of errors made were negligible. Therefore, there was no need to include more

Table 7

Observed QAV Frequencies by Collapsed Technical Skill sub-Component Segment and Group at Task One

Technical Skill sub-Components	Collapsed Technical Skill sub-Component Segments (TSC) <sup>a</sup>		Quality Assessment Value (QAV)	Group (GP)	
				One B <sub>1</sub> <sup>b</sup>	Two B <sub>2</sub>
TSC1	A <sub>1</sub>	Set-up			
TSC2			C <sub>1</sub> Correct (3)	20	16
TSC6			C <sub>2</sub> Incorrect (1)	14	14
TSC10			C <sub>3</sub> Omitted (0)	38	42
TSC11					
TSC8					
TSC7	A <sub>2</sub>	Execution	C <sub>1</sub> Correct (3)	24	20
TSC3			C <sub>2</sub> Incorrect (1)	4	8
TSC4			C <sub>3</sub> Omitted (0)	20	20
TSC5					
TSC9	A <sub>3</sub>	Technical Information	C <sub>1</sub> Correct (3)	2	3
			C <sub>2</sub> Incorrect (1)	0	0
			C <sub>3</sub> Omitted (0)	10	9

<sup>a</sup>(TSC, QAV, GP) represent the variable names used in analysis

<sup>b</sup>(A<sub>1-3</sub>, B<sub>1-2</sub>, C<sub>1-3</sub>) represent the different levels at each variable

Table 8

Summary of the Logit-Linear Analysis for the Data Presented in Table 8 (Collapsed  
Technical Skill sub-Component Data)

Model and Design	Residual Chi-Square test			Chi-Square Test of Differences		
	L <sup>2</sup>	df	p <sup>a</sup>	L <sup>2</sup>	df	p <sup>b</sup>
(1) TSC & QAV	21.21	13	.069			
						model 1 - model 2
(2) TSC & QAV & GP	21.21	12	.047	0.00	1	>.05
						model 2 - model 3
(3) TSC & QAV & GP & TSC X GP	21.21	10	.020	0.00	2	>.05
						model 3 - model 4
(4) TSC & QAV & GP & TSC X GP & QAV X GP	19.68	8	.012	1.53	2	>.05
						model 4 - model 5
(5) TSC & QAV & GP & TSC X GP & QAV X GP & TSC X QAV	1.02	4	.906**	18.66	4	<.05*
						model 5 - model 6
(6) TSC & QAV & GP & TSC X GP & QAV X GP & TSC X QAV & TSC X QAV X GP	0.00	0	1.00**	1.02	4	>.05
						model 6 - model 7
(7) TSC & QAV & TSC X QAV (simplified for parsimony)	2.62	9	.911**	18.59	4	<.05*

a (critical value  $\alpha = .15$ )b (critical value  $\alpha = .05$ )\*\* significant at p-value  $\geq .15$ \* significant at p-value  $\leq .05$

complicated interactions, such as those in model six, as a model was found that fit the data well enough.

As a result of the information obtained at this analysis it was concluded that the patterns observed in the original three dimensional contingency table (Table 7) can, in fact, be summarized in two dimensions. As no group difference was observed the expert (Group one) and novice (Group two) data were collapsed resulting in the creation of a two dimensional (TSC and QAV) contingency table (see Table 9). This would result in the loss of some information, however, that loss would not be significant. Observation of the data presented within Table 9 indicated that correct verbalizations were produced with greater frequency than incorrect verbalizations at each of the three collapsed technical skill sub-component segments. However, the frequency with which the segments labelled set-up and technical information were omitted during instruction was greater than the combined frequencies for the number of times that either segment was verbalized correctly or incorrectly.

Considering next the collapsed mental skill sub-component data, recall that those verbalizations coded as being representative of the mental aspects of skill performance were not assigned a QAV. Rather, the presence and frequency of MSC coded verbalizations was the measure of interest here. Observation of the data presented within Table 10 would seem to indicate that there were no group differences with respect to the frequency with which the mental skill sub-components were verbalized during Task one performance. The results of the analysis of variance performed on the raw data supported this observation. Although Group one subjects (Mean = 0.50, SD = 0.80) were seen to

Table 9

Observed QAV Frequencies by Collapsed Technical Skill sub-Component Segment atTask One

Collapsed Technical Skill sub-Component Segments (TSC)	Quality Assessment Value (QAV)		
	Correct (3)	Incorrect (1)	Omitted (0)
Set-up	36	28	80
Execution	44	12	40
Technical Information	5	0	19

Table 10

Observed Frequencies by Collapsed Mental Skill sub-Component Segment and Group atTask One

Mental Skill sub-Components	Collapsed Mental Skill sub-Component Segments (TSC) <sup>a</sup>		Group (GP)	
			One B <sub>1</sub> <sup>b</sup>	Two B <sub>2</sub>
MSC1				
MSC2	A <sub>1</sub>	Mental	6	4
MSC3				

Note. The scores for each group simply represent a summed total of the number of times the three Mental Skill sub-Components were verbalized during instruction.

<sup>a</sup>(MSC, GP) represent the variable names used in analysis

<sup>b</sup>(A<sub>1</sub>, B<sub>1,2</sub>) represent the different levels at each variable

make reference to the mental skill sub-components with slightly greater frequency than Group two subjects (Mean = 0.33, SD = 0.65), this difference was not found to be significant ( $F(1,22) = 0.314, p > .05$ ).

### **Task Two - Talk Aloud While Performing**

The results of the analyses of variance performed on the coded correct and incorrect verbal protocol data at each of the collapsed spatial and technical skill sub-component segments indicated that no significant differences existed between Group one and Group two at any segment (see Table 11). However, observation of the data indicated that, on average, both groups of subjects were correct (Mean = 4.60) more often than incorrect (Mean = 0.37) with respect to their description of the various skill sub-components.

The results of the analyses of variance performed on the coded correct and incorrect visual protocol data at each of the collapsed spatial and technical skill sub-component segments for Group one and Group two (see Table 12) indicated that a number of significant group differences were present. Group one subjects were seen to perform significantly better than Group two subjects with respect to the correct performance of those actions associated with the collapsed skill sub-component segments labelled legs ( $F(1,22) = 14.68, p < .05$ ), shot ( $F(1,22) = 19.70, p < .05$ ), and set-up ( $F(1,22) = 11.93, p < .05$ ). This meant that those individuals labelled as expert (Group one) performed the constituent skill sub-components of foul shooting significantly better than their novice (Group two) counterparts. Although not a significant difference ( $F(1,22) = 3.05, p = .09$ ), Group one subjects were also seen to correctly perform those actions

Table 11

Descriptive Statistics and the Summary of the ANOVA's Performed on the Coded Correct and Incorrect Verbal Protocol Data at each of the Collapsed Spatial and Technical Skill sub-Component Segments for Group One and Group Two

QAV	Segment	ANOVA Results <sup>a</sup>	Group One		Group Two	
			Mean	SD	Mean	SD
Correct	Legs	$F(1, 22) = 0.77, p > .05$	5.83	±5.47	8.25	±7.85
	Arm	$F(1, 22) = 0.58, p > .05$	2.33	±5.68	4.17	±6.10
	Shot	$F(1, 22) = 0.31, p > .05$	2.83	±3.66	3.58	±2.87
	Set-up	$F(1, 22) = 0.41, p > .05$	5.50	±4.19	4.33	±4.74
Incorrect	Legs	$F(1, 22) = 0.01, p > .05$	0.67	±2.02	0.58	±2.02
	Arm	$F(1, 22) = 1.00, p > .05$	0.00	±0.00	0.08	±0.29
	Shot	$F(1, 22) = 1.54, p > .05$	0.00	±0.00	0.42	±1.16
	Set-up	$F(1, 22) = 1.24, p > .05$	0.17	±0.39	1.00	±2.56

<sup>a</sup> critical value  $\alpha = .05$

Table 12

Descriptive Statistics and the Summary of the ANOVA's Performed on the Coded Correct and Incorrect Visual Protocol Data at each of the Collapsed Spatial and Technical Skill sub-Component Segments for Group One and Group Two

QAV	Segment	ANOVA Results <sup>a</sup>	Group One		Group Two	
			Mean	SD	Mean	SD
Correct	Legs	F(1, 22) = 14.68, p < .05*	35.33	±7.00	23.08	±8.59
	Arm	F(1, 22) = 3.05, p = .09	20.00	±0.00	16.92	±6.11
	Shot	F(1, 22) = 19.70, p < .05*	29.58	±0.90	15.67	±10.82
	Set-up	F(1, 22) = 11.93, p < .05*	28.75	±2.99	22.75	±5.22
Incorrect	Legs	F(1, 22) = 14.68, p < .05*	4.67	±7.00	16.92	±8.59
	Arm	F(1, 22) = 3.05, p = .09	0.00	±0.00	3.08	±6.11
	Shot	F(1, 22) = 19.70, p < .05*	0.42	±0.90	14.33	±10.82
	Set-up	F(1, 22) = 11.93, p < .05*	1.25	±2.99	7.25	±5.22

<sup>a</sup> critical value  $\alpha = .05$

\* significant at the .05 level

associated with the collapsed spatial skill sub-component segment arm more frequently than Group two subjects.

The results of the analyses of variance examining the coded incorrect visual protocol data for Groups one and two mirrored the results of the previous series of analyses. As one would expect, since Group one subjects were seen to perform the coded actions correctly to a significantly greater extent than Group two subjects, Group two subjects performed the coded actions incorrectly to a significantly greater extent than Group one subjects. The actions associated with the collapsed skill sub-component segments labelled legs ( $F(1,22) = 14.68, p < .05$ ), shot ( $F(1,22) = 19.70, p < .05$ ), and set-up ( $F(1,22) = 11.93, p < .05$ ) were performed incorrectly by Group two subjects significantly more often than they were by Group one subjects. Again mirroring the earlier result, Group two subjects were seen to incorrectly perform those actions associated with the collapsed spatial skill sub-component segment arm more frequently, though not significantly so, than Group one subjects. These results served to further reinforce the earlier relative classification of the Group one subjects as experts and Group two subjects as novices.

The results of the Pearson Product Moment correlations performed at each of the collapsed spatial and technical skill sub-component segments indicated that there were few significant associations between the coded verbal and visual protocol data. Examination of the protocol data collapsed across groups indicated that no significant correlations existed between any of the coded verbal and visual protocols. All of the correlation coefficients obtained within this first analysis were less than 0.25. When examining only those scores

representative of Group two subject's performance, similar results were found. There were no significant correlations between any of the coded verbal and visual protocols for Group two subjects. Again, all but one of the correlation coefficients were less than 0.25. Analysis of those scores representative of Group one subject's performance yielded a significant relationship ( $r = .58, p < .05$ ) between those verbal and visual protocols coded as correct at the collapsed technical skill sub-component segment set-up. This was the only significant correlation observed for Group one subjects.

### **Task Three - Predicted Performance**

The results of the analyses of variance performed on the data obtained at Task three indicated that a number of significant group differences were present (see Table 13). As one may have expected, Group one subjects (Mean = 7.5, SD = 1.78) were seen to have made significantly ( $F(1,22) = 61.73, p < .01$ ) more baskets than Group two subjects (Mean = 1.83, SD = 1.75). The analyses performed on the shot prediction data resulted in the identification of similar group differences. Analysis of the total number of correct predictions made, combining correct predictions regarding the successful and unsuccessful completion of shot attempts, indicated that Group one subjects were significantly ( $F(1,22) = 23.20, p < .01$ ) more accurate than Group two subjects with respect to their ability to predict the outcome of the attempted shots. On average, Group one subjects were seen to correctly predict the results of the attempted foul shots 7.8 times (SD = 1.3) out of 10 while Group two subjects were seen to correctly predict the results of the attempted foul shots only 5.0 times (SD = 1.5) out of 10, representative of performance at a chance level.

Table 13

Descriptive Statistics and the Summary of the ANOVA's Performed on the ShotPrediction Data Obtained at Task Three for Group One and Group Two

Variable	ANOVA Results <sup>a</sup>	Group One		Group Two	
		Mean	SD	Mean	SD
Shots Made	F(1, 22) = 61.73, p < .01*	7.50	±1.78	1.83	±1.75
Shots Predicted as Successful	F(1, 22) = 13.05, p < .01*	8.25	±1.42	6.17	±1.40
Shots Correctly Predicted as Successful	F(1, 22) = 57.52, p < .01*	6.75	±1.91	1.50	±1.45
Shots Predicted as Unsuccessful	F(1, 22) = 13.05, p < .01*	1.75	±1.42	3.83	±1.40
Shots Correctly Predicted as Unsuccessful	F(1, 22) = 17.55, p < .01*	1.08	±1.24	3.50	±1.57
Correct %	F(1, 22) = 23.20, p < .01*	78.33	±13.37	50.00	±15.37

<sup>a</sup> critical value  $\alpha = .01$

\* significant at the .01 level

Examination of the frequency with which each group of subjects specifically predicted shot attempts as successful or unsuccessful yielded some interesting results (See Table 13). Group one subjects were seen to predict shots as successful with a significantly ( $F(1,22) = 13.05, p < .01$ ) greater frequency than Group two subjects. On average, Group one subjects predicted that 8.25 (SD = 1.42) of the 10 shots attempted would be successful while Group two subjects predicted that only 6.17 (SD = 1.4) of the 10 shots attempted would be successful. Analysis of only those shots that were correctly predicted as successful indicated that significant ( $F(1,22) = 57.52, p < .01$ ) group differences were again present. On average, Group one subjects correctly predicted 6.75 (SD = 1.91) shot attempts as successful while Group two subjects correctly predicted 1.5 (SD = 1.45) shot attempts as successful. This data clearly indicates that significant prediction differences existed between groups with respect to those shots predicted as successful and those correctly predicted as successful. However, these differences provided no indication as to which group was most accurate in making predictions with respect to the success of the shots attempted. To obtain this information the ratio of "shots correctly predicted as successful" to "shots predicted as successful" had to be calculated for each group (see Table 14). Group one subjects were found to correctly predict shots as successful 81.8% ( $81/99 \cdot 100 = 81.8\%$ ) of the time while Group two subjects were only able to correctly predict shots as successful 24.3% ( $18/74 \cdot 100 = 24.3\%$ ) of the time.

Analysis of those shots predicted as unsuccessful yielded results that countered those for the shots predicted as successful (See Table 13). Group two subjects were seen to predict shots as unsuccessful with a significantly ( $F(1,22) = 13.05, p < .01$ ) greater

Table 14

Summarized Performance Data for Groups One and Two at Task Three

Variable	Group One			Group Two		
	Total (%)	Mean	SD	Total (%)	Mean	SD
Shots Made (/120)	90 (75.0%)	7.50	1.78	22 (18.3%)	1.83	1.75
Shots Predicted as Successful	99 (82.5%)	8.25	1.42	74 (61.7%)	6.17	1.40
Shots Correctly Predicted as Successful	81 (81.8%)	6.75	1.91	18 (24.3%)	1.50	1.45
Shots Predicted as Unsuccessful	21 (17.5%)	1.75	1.42	46 (38.3%)	3.83	1.40
Shots Correctly Predicted as Unsuccessful	13 (61.9%)	1.08	1.24	42 (91.3%)	3.50	1.57
Correct Predictions	94 (78.3%)	7.83	1.34	60 (50.0%)	5.0	1.54
Coded Explanations						
SSC	11 (6.8% <sup>a</sup> )	0.92	1.88	2 (1.3% <sup>b</sup> )	0.17	0.39
TSC	78 (47.8%)	6.50	2.65	73 (48.0%)	5.58	3.15
KR	53 (32.5%)	4.42	2.54	53 (34.9%)	4.25	2.93
OR	21 (12.9%)	1.75	2.22	24 (15.8%)	2.58	2.71

<sup>a</sup> For Group One: /163 total explanations

<sup>b</sup> For Group Two: /152 total explanations

frequency than Group one subjects. On average, Group two subjects predicted that 3.83 (SD = 1.40) of the 10 shots attempted would be unsuccessful while Group one subjects predicted that only 1.75 (SD = 1.42) of the 10 shots attempted would be unsuccessful. Analysis of only those shots that were correctly predicted as unsuccessful indicated that significant ( $F(1,22) = 17.55, p < .01$ ) group differences were again present. On average, Group two subjects correctly predicted 3.50 (SD = 1.57) shot attempts as unsuccessful while Group one subjects correctly predicted 1.08 (SD = 1.24) shot attempts as unsuccessful. Much like the data representative of those shots predicted as successful, this data clearly indicated that significant prediction differences existed between groups with respect to those shots predicted as unsuccessful and those correctly predicted as unsuccessful. However, these differences again provided no indication as to which group was most accurate in making predictions with respect to the lack of success of the shots attempted. To obtain this information the ratio of "shots correctly predicted as unsuccessful" to "shots predicted as unsuccessful" had to be calculated for each group (see Table 14). Group two subjects were found to correctly predict shots as unsuccessful 91.3% ( $42/46 \cdot 100 = 91.3\%$ ) of the time while Group one subjects correctly predict shots as unsuccessful 61.9% ( $13/21 \cdot 100 = 61.9\%$ ) of the time.

Having noted between group differences with respect to the predictions presented at Task three, as well as the accuracy of those predictions, the explanations presented in support of the predictions were analyzed next. Recall that the verbalizations offered in explanation of each prediction were coded as either SSC, TSC, KR, or OR. The results of the analyses of variance performed on the coded explanations indicated that no significant

Table 15

Descriptive Statistics and the Summary of the ANOVA's Performed on the Coded  
Explanation Data Obtained at Task Three for Group One and Group Two

Variable	ANOVA Results <sup>a</sup>	Group One		Group Two	
		Mean	SD	Mean	SD
Spatial Skill Component	F(1, 22) = 1.83, p > .05	0.92	±1.88	0.17	±0.39
Technical Skill Component	F(1, 22) = 0.60, p > .05	6.50	±2.65	5.58	±3.15
Kinaesthetic Reasoning	F(1, 22) = 0.02, p > .05	4.42	±2.54	4.25	±2.93
Other Reasoning	F(1, 22) = 0.68, p > .05	1.75	±2.22	2.58	±2.71

<sup>a</sup> critical value  $\alpha = .05$

group differences were present with respect to the explanations offered (see Table 15). On average, Group one and Group two subjects were seen to utilize all four of the coded explanation categories with similar frequencies.

It was believed, however, that some information may have been lost when the coded explanation data for the shots predicted as successful were combined with the data for those shots predicted as unsuccessful. Therefore, a series of analyses of variance were executed in an attempt to determine if group differences did indeed exist with respect to the explanations offered when a shot was predicted as successful versus when it was predicted to be unsuccessful. The results of the analyses of variance performed on the coded explanations for those shots predicted as successful indicated that no significant group differences were present (See Table 16). The subjects with Group one and Group two were seen to utilize all four of the coded explanation categories with similar frequencies when attempting to explain the shots they predicted as being successful.

The results of the analyses of variance performed on the coded explanations for those shots predicted as unsuccessful indicated that Group two subjects differed significantly ( $F(1,22) = 8.29, p < .05$ ) from Group one subjects with respect to the use of the coded explanation category OR (See Table 17). Group two subjects were seen to use the Other Reasoning (OR) category to explain their shots predicted as unsuccessful 23 % of the time, compared to only 4 % for Group one subjects.

Table 16

Descriptive Statistics and Summary of the ANOVA's Performed on the Coded  
Explanation Data Obtained for the Shots Predicted as Successful at Task Three for Group  
One and Group Two

Variable <sup>a</sup>	ANOVA Results <sup>b</sup>	Group One		Group Two	
		Mean	SD	Mean	SD
SUCTSC	F(1, 22) = 0.33, p > .05	0.63	±0.28	0.56	±0.37
SUCSSC	F(1, 22) = 1.75, p > .05	0.09	±0.18	0.01	±0.05
SUCKR	F(1, 22) = 0.43, p > .05	0.46	±0.26	0.54	±0.36
SUCOR	F(1, 22) = 0.003, p > .05	0.19	±0.23	0.18	±0.27

<sup>a</sup>SUCTSC = number of shots predicted as successful and explained using TSC divided by the number of shots predicted as successful

SUCSSC = number of shots predicted as successful and explained using SSC divided by the number of shots predicted as successful

SUCKR = number of shots predicted as successful and explained using KR divided by the number of shots predicted as successful

SUCOR = number of shots predicted as successful and explained using OR divided by the number of shots predicted as successful

<sup>b</sup> critical value  $\alpha = .05$

Table 17

Descriptive Statistics and Summary of the ANOVA's Performed on the Coded  
Explanation Data Obtained for the Shots Predicted as Unsuccessful at Task Three for  
Group One and Group Two

Variable <sup>a</sup>	ANOVA Results <sup>b</sup>	Group One		Group Two	
		Mean	SD	Mean	SD
UNSUUCTSC	F(1, 22) = 1.24, p > .05	0.50	±0.48	0.68	±0.27
UNSUCCSSC	F(1, 22) = 1.39, p > .05	0.10	±0.23	0.02	±0.06
UNSUUCKR	F(1, 22) = 0.22, p > .05	0.33	±0.44	0.26	±0.27
UNSUUCOR	F(1, 22) = 8.29, p < .05*	0.04	±0.14	0.23	±0.17

\* significant at the .05 level

<sup>a</sup>UNSUUCTSC = number of shots predicted as unsuccessful and explained using TSC divided by the number of shots predicted as unsuccessful

UNSUCCSSC = number of shots predicted as unsuccessful and explained using SSC divided by the number of shots predicted as unsuccessful

UNSUUCKR = number of shots predicted as unsuccessful and explained using KR divided by the number of shots predicted as unsuccessful

UNSUUCOR = number of shots predicted as unsuccessful and explained using OR divided by the number of shots predicted as unsuccessful

<sup>b</sup> critical value  $\alpha = .05$

## **Chapter V**

### **Discussion**

The fundamental objective of this investigation was to examine expert-novice differences in metacognitive knowledge about action and metacognitive skill functioning. Specifically, this investigation sought to determine whether a group of individuals identified as being representative of 'expert' level performers within the sport of basketball would exhibit superior levels of metacognitive knowledge about action and superior metacognitive skill functioning, both as they relate to performance of the basketball foul shot, when compared to a group of individuals identified as being representative of 'novice' level performers. The results obtained at each of the three tasks utilized in this investigation provided differing levels of support for the existence of expert-novice differences with respect to both metacognitive knowledge about action and metacognitive skill. The discussion presented within this chapter individually addresses the results obtained at each of the three tasks, illustrating how each provided support for the hypothesis tested within this investigation.

#### **Task One - Verbal Instruction**

Recall that Task one sought to identify group differences in the declarative component of metacognitive knowledge about action through the collection and comparison of instructional verbal protocols.

The results of the logit-linear analyses performed on the verbal protocol data collected at Task one provided varying degrees of support for the research hypothesis and its application to this task. With respect to the collapsed spatial skill sub-component

segments, Group one subjects exhibited a greater awareness of those spatial skill sub-components collapsed within the segment labelled legs. This enhanced awareness was illustrated by the fact that Group one subjects addressed this collapsed segment more frequently than did Group two subjects. Group one subjects omitted instruction at this collapsed segment less frequently than Group two subjects, however, they were also seen to provide incorrect instruction with greater frequency than Group two subjects. While the instruction was coded as incorrect more often for Group one subjects it did indicate that these subjects were aware of the importance of positioning the 'legs' during foul shot performance. It is important to remember that Group one subjects did provide correct instruction at this collapsed segment with far greater frequency than they provided incorrect instruction. The fact remains that, in total, Group one subjects addressed this collapsed segment more frequently than did Group two subjects.

Group one subjects were also found to possess more accurate declarative representations of those spatial skill sub-components collapsed within the segment labelled arm. Recall that Group one subjects correctly described the positioning required at the 'arm' with greater frequency than did Group two subjects and were also seen to have incorrectly described positioning at this segment less frequently than Group two subjects. When combined, these results suggested that specific to the spatial skill sub-components, collapsed within the segments labelled arm and legs, Group one subjects possessed slightly greater levels of declarative knowledge about action as well as a greater awareness of this knowledge. The fact that there were no group differences with respect to the verbal instructions offered in support of the spatial skill sub-components collapsed within the

segment labelled upper-body and that both groups were seen to omit instruction here with great frequency suggested that perhaps movement at the 'legs' and 'arm' were perceived as most important to skill execution.

The results of the logit-linear analysis performed on the collapsed technical skill sub-component segments did not serve to identify any differences with respect to the level of declarative knowledge about action possessed by Group one and Group two subjects. In fact, the analysis performed on the collapsed technical skill data found that the variable Group did not significantly contribute to the observed verbalization frequencies.

The results of the logit-linear analyses performed on both the collapsed spatial and technical skill protocol data, though not having provided overwhelming support for the research hypothesis as it was applied to Task one, were not that surprising when the nature of the sample and the skill selected for study were considered. Again, recall that Task one sought to identify group differences in the declarative component of metacognitive knowledge about action through the collection and comparison of instructional verbal protocols. As foul shooting may be considered a relatively static skill when compared to others within the sport of basketball and operates in a successive to simultaneous manner, this skill may be easily represented as a set of simple declarative facts within an associative network model. When combined with the fact that the subjects selected to participate in this investigation were not reflective of the true novice - true expert dichotomy that is often employed in research of this nature, rather they were more reflective of intermediate levels of expertise, one begins to understand why group differences in the declarative representations of knowledge may not have been that

exaggerated. Recall that within Anderson's (1982) description of his three stage model of learning that the first stage (i.e., the declarative stage) entailed receiving and encoding information as a set of facts about how to perform a skill. When performing a task, an individual at this stage was said to have continually accessed this declaratively represented knowledge. With continued experience performance was believed to become relatively automatic and conscious access to the earlier representations about how to perform the skill was said to be lost.

It is suggested that, within this investigation, Group two subjects may not yet have automatized their skilled performance to the degree that conscious access to their earlier representations of skilled performance would have been restricted. Group one subjects, on the other hand, were believed to have maintained access to the early declarative representations of fowl shot performance as the relatively static nature of this skill, at best, welcomes conscious involvement in its execution and, at worst, does not restrict it. Therefore, the degree to which Group two subjects had not yet automatized their skilled performance and the degree to which the skill itself allowed Group one subjects to maintain conscious access to the declarative representations of its execution may have ensured that the protocols collected at Task one be relatively similar. Any differences that were observed that favoured Group one subjects would then suggest that these individuals possessed greater levels of awareness of declarative knowledge about action specific to that skill sub-component segment.

The analysis performed on the collapsed mental skill sub-component data also indicated that there were no significant group differences with respect to the frequency

with which the mental skill sub-components were verbalized. It was possible to interpret this result in one of two ways. As both groups were found to make reference to the mental skill sub-components with a relatively low frequency this may have suggested that instruction at this specific collapsed skill sub-component segment may not have been deemed appropriate for inclusion when instructing a true novice learner. One may also interpret these results to suggest that both groups simply lacked knowledge of the collapsed mental skill sub-components. However, as both groups of subjects were seen to discuss the mental aspects of performance, though with a relatively low frequency, it was suggested that these individuals chose not to emphasize this aspect of performance when instructing the true novice learner.

The collection and comparison of instructional verbal protocols at Task one suggested that Group one and Group two subjects were similar with respect to the declarative component of metacognitive knowledge about action possessed by each. At only a few skill sub-component segments was evidence presented that supported Group one subjects as possessing greater levels of knowledge and awareness with respect to the declarative component of metacognitive knowledge about action. Therefore, with respect to the research hypothesis and its application at Task one, the level of expertise -- as defined in this investigation -- was seen to contribute only minimally to the assessed levels of metacognitive knowledge about action.

### **Task Two - Talk Aloud While Performing**

Recall that Task two sought to identify the within group relationship between one's actions and the corresponding verbal descriptions of those actions through the

collection and comparison of verbal and visual protocols. As stated within chapter four, it was believed that such a comparison would serve to identify group differences in the procedural component of metacognitive knowledge about action.

Initial observation of the results of the analyses of variance performed on the coded correct and incorrect verbal protocol data at each of the collapsed spatial and technical skill sub-component segments suggested that Group one and Group two subjects were in possession of similar levels of procedural knowledge about action. There were no significant differences with respect to the number of coded correct or incorrect verbalizations made by either group. At the same time, both groups were seen to make more correct verbalizations than incorrect. This latter point suggested that the procedural knowledge about action possessed by both groups was in fact appropriate for, or representative of, the correct execution of the foul shot. In other words, based upon the contents of the collected verbal protocols, both groups of subjects were describing their physical performance as correct in relation to the documented procedures for correctly executing the skill of foul shooting. For example, subject two within Group one correctly described one element of the follow through (i.e., TSC4) during her fourth shot attempt when she stated,

*“...flexion at the wrist...”*

Similarly, subject eight within Group two correctly described the same element of the follow through during her second shot attempt when she stated,

*“...and I'm flicking my wrist...”*

The words used to express the actions may have differed but the content was similar.

As the verbal component of this task necessitated that the subjects attempt to translate both their actions and thoughts into words it was quite possible that the protocols collected may have reflected the subjects intentions with respect to movement rather than the actual movements produced. Therefore, to gain a better understanding of the level of procedural knowledge about action possessed by the subjects within both groups, and to better understand their awareness of this knowledge, it was necessary to also search for differences in the actual movements/actions produced. The coding of actual game play, if you will recall, is also considered an appropriate technique for measuring procedural knowledge within the domain of sport (French & Thomas, 1987; McPherson & Thomas, 1989; Thomas & Thomas, 1994).

The results of the analyses of variance performed on the coded correct and incorrect visual protocol data at each of the collapsed spatial and technical skill sub-components indicated that Group one subjects performed those actions associated with the collapsed skill sub-component segments legs, shot, and set-up, significantly better than Group two subjects. At this point one may ask why differences would be found with respect to physical performance of the various actions that make up each of these collapsed skill sub-component segments when no differences were observed when the subjects attempted to describe those very same actions. As procedural knowledge about action is believed to underlie all aspects of action including both response initiation and execution (Wall, 1986; Wall et al., 1985) it may be that the coded visual protocols provided a more accurate representation of the procedural knowledge about action possessed by each subject. Wall et al's. (1985) contention that an action sequence be

viewed as the instantiation of procedural knowledge about action would appear to support this claim.

If we consider that the verbal protocol data indicated that Group one subjects generally provided correct descriptions of the various skill sub-components that constitute foul shot performance while the visual protocol data indicated that these same skill sub-components were correctly executed, this would suggest that these individuals were more aware of the skills, hence procedures, within their possession. In other words, the descriptions provided by subjects within Group one, with respect to their physical performance, were congruent with their actual skilled performance suggesting that these individuals were cognizant of their ability to perform the skill of foul shooting. It could be said that Group one subjects “knew they knew” how to perform the skill and were able to perform it effectively. Therefore, with respect to the procedural component of metacognitive knowledge about action, these results suggested that subjects within Group one possessed higher levels of this type of knowledge. The same, however, cannot be said of Group two subjects.

Examination of the protocol data collected for Group two subjects indicated that while their verbal descriptions of the movements produced approximated those produced by Group One subjects their actual physical execution of those same movements differed significantly. On average, Group two subjects performed 10.40 of the collapsed spatial and technical skill sub-component segments incorrectly while Group one subjects were only seen to produce 1.59 incorrect movements on average. This data would appear to suggest that Group two subjects lacked an awareness of the skills, hence procedures,

within their possession. The verbal descriptions provided by subjects within Group two, with respect to their physical performance, were incongruent with their actual skilled performance suggesting that these individuals were not fully cognizant of their ability to perform the skill of foul shooting. To illustrate this point, recall the example presented earlier within this discussion. Subject eight within Group two was seen to correctly describe one element of the follow through during her attempt to translate her thoughts and actions into words. However, analysis of the visual protocol data (i.e., her actual performance) did not support her description as she was not seen to “flick her wrist” as described during the shot attempt. Therefore, while Group two subjects appeared to possess the correct knowledge for performing the skill of foul shooting, as evidenced by the collected verbal protocols, they had yet to completely operationalize this knowledge and incorporate it into their performance routine and, in fact, were not aware that they were performing many of the skill sub-components incorrectly. Therefore, these results were seen as having supported those obtained at Task one. It would appear that Group two subjects were functioning within the declarative stage of learning, as it was described by Anderson (1982), as the comparison of their verbalizations to their actual movements suggested that their declarative knowledge about action had not yet been translated into its more efficient procedural form. The subjects within Group two had not yet developed new versions of the productions necessary for skilled performance and, as a result, still required that the domain specific declarative knowledge about action be entered into working memory when attempting to execute the skill of foul shooting. It could be said that Group two subjects “thought they knew” how to perform the skill yet were not able

to perform it effectively. Therefore, with respect to the procedural component of metacognitive knowledge about action, these results suggested that subjects within Group two possessed lower levels of this type of knowledge. When combined, the results obtained for both Group one and Group two subjects suggested that individuals possessing greater levels of expertise (i.e., Group one) within a specific motor performance domain are more likely to possess higher levels of the procedural component of metacognitive knowledge about action

The results of the correlational analyses performed at each of the collapsed spatial and technical skill sub-component segments provided minimal support for the existence of a possible expertise-metacognition relationship. As was stated in the results, the only significant correlation observed was between those verbal and visual protocols coded as correct for Group one subjects at the collapsed technical skill sub-component segment labelled set-up. This meant that there was a significant relationship between the description of the actions performed during 'set-up' and the actions themselves. In other words, at this collapsed skill sub-component, Group one subjects did as they said they were doing, providing partial support for an expertise-metacognition relationship.

The fact that no significant correlations were observed between the verbal and visual protocol data for subjects in Group two also provided partial support for the research hypothesis. If the level of metacognitive knowledge about action possessed by an individual is indeed a function of the level of expertise possessed by that individual one would have expected the novice basketball player to demonstrate a lack of awareness of the skills within her possession. This lack of awareness would have been demonstrated by

the absence of a significant correlation, as was noted here. The lack of any significant relationships between the verbal and visual protocols and the differences observed in the visual protocols when compared to subjects within Group one suggested that Group two subjects possessed relatively low levels of the procedural component of metacognitive knowledge about action. However, the results of the correlational analyses must be interpreted carefully as the sample size studied was relatively modest for this type of analysis.

Observation of the differences between groups, with respect to their ability to translate their thoughts and actions into words, appeared to provide initial support for the stated research hypothesis. The expert subjects within Group one were found to be more cognizant/aware of the skills within their possession when compared to the novice subjects within Group two, suggesting that Group one subjects possessed higher levels of the procedural component of metacognitive knowledge about action. This may, in turn, suggest that the level of metacognitive knowledge about action possessed by an individual is a function of the level of expertise of that individual.

### **Task Three - Predicted Performance**

Recall that Task three sought to identify group differences in metacognitive skill functioning as determined through each subjects' ability to monitor her performance, predict performance outcomes, and justify or explain the predictions made. The first point to be made with respect to performance at Task three is that Group one subjects made significantly more baskets than Group two subjects, lending further support to the expert-novice distinction made at the beginning of the investigation. Tables 13 and 14 clearly

illustrate that differences also existed between Group one and Group two subjects with respect to their ability to predict performance outcomes. On a macroscopic level, Group one subjects were significantly more accurate than Group two subjects with respect to their ability to successfully predict performance outcomes across the 10 attempted foul shots. On its own, this would suggest that Group one subjects demonstrated superior functioning of at least one of the six basic skills of metacognition discussed in chapter two. As previously stated, the ability to predict the consequences of an action or event represents one of the basic skills of metacognition (Brown & DeLoache, 1978).

The more interesting results, however, were found at what may be considered a more microscopic level. Significant differences were found between groups when the actual quality of the prediction (i.e., predicted as successful vs. predicted as unsuccessful) was taken into account. Considering first those shots predicted as successful, it was found that Group one subjects, when compared to Group two subjects, both predicted and correctly predicted significantly more shots as successful. Naturally then, Group two subjects were found to predict significantly more shots as unsuccessful. However, what may surprise some was that Group two subjects, when compared to Group one subjects, were found to correctly predict significantly more shots as unsuccessful. These results may be interpreted in a number of ways. One may claim that we would expect Group one subjects to predict more shots as successful as they were probably more comfortable and confident in this skill (i.e., basketball) environment as a result of their significantly greater levels of experience. Group two subjects, on the other hand, may be perceived as being less confident in this skill environment and, as a result, one may expect this to be reflected

in their predicting more shots as unsuccessful. However, having or lacking confidence in one's performance implies an awareness of one's ability to meet the imposed task demands which, in turn, suggests the possession of a certain level of metacognitive knowledge about action and metacognitive skill. To illustrate, I may predict 70% of my shots to be unsuccessful because experience tells me (i.e., I know) that I lack the skills necessary to perform the foul shots correctly. Likewise, I may predict 70% of my shots to be successful because experience tells me (i.e., I know) that I have the skills necessary to perform the foul shots correctly. In either instance, I may be said to be demonstrating a high level of functioning with respect to one of the basic skills of metacognition, predicting the consequences of an action or movement. Therefore, if one were to accept the prediction ratios without further questioning the differences observed between Groups one and two one may in fact conclude that both groups appeared to possess certain metacognitive skills functioning at similar levels. However, it is argued next that closer examination of the results obtained at Task three indicated that Group one subjects demonstrated superior functioning of the six basic skills of metacognition as defined in this investigation.

Referring back to the data presented in Tables 13 and 14 one sees that Group one subjects predicted 82.5% of the shots taken as successful while Group two subjects predicted 61.7% of the shots taken as successful. With respect to those shots predicted as unsuccessful it follows that 17.5% of the shots taken by Group one subjects were predicted as unsuccessful while 38.3% of the shots taken by Group two subjects were predicted as unsuccessful. When these percentage values are considered in relation to the actual number of shots that were made by both groups of subjects one begins to get a

clearer understanding as to each groups level of functioning with respect to the six basic skills of metacognition. If, as some may suggest, Group two subjects, when compared to Group one subjects, predicted significantly more shots as unsuccessful because they lacked confidence in their skill ability and, hence, were aware of their performance deficiencies one must question why these subjects then predicted that the majority (61.7%) of their attempted shots would be successful. It would stand to reason that if one individual lacked confidence in her ability and was aware of her performance deficiencies that she would, more than likely, predict most shots as being unsuccessful. However, as the opposite was observed, this suggested that Group two subjects demonstrated a low level of functioning with respect to one of the basic skills of metacognition, predicting the consequences of an action or movement. This was further demonstrated by the small percentage of shots (24.3%) that were actually correctly predicted as successful.

The tendency to over predict one's success, as was demonstrated by Group two subjects in this investigation, has been demonstrated previously in studies that examined children's ability to recall from short-term memory (Flavell, Friedrichs, & Hoyt, 1970; Yussen & Levy, 1975). Such research has demonstrated that as children age their tendency to over predict their capability for short-term recall decreases while their memory span increases. With respect to the current investigation, the results obtained suggested that as one gains experience, and possibly expertise, the tendency to over predict the success of one's skilled motor performance decreases while one's skilled performance increases. Yussen and Levy (1975) stated that this phenomenon, as it relates to recall from short-term memory, was rather robust. However, as it relates to predicting

the consequences of one's skilled movement, this phenomenon has yet to be demonstrated as robust.

Applying similar logic to Group one subjects indicated that these individuals demonstrated a high level of functioning with respect to the metacognitive skill concerned with predicting movement consequences. One would expect Group one subjects to be confident in their skill ability and, hence, aware of their performance strengths and that this be reflected in their predicting the majority of the shots attempted to be successful. Recall that Group one subjects in fact predicted 82.5% of the shots taken as successful and that 81.8% of these predictions were correct.

Critical examination of those shots that were predicted as unsuccessful and those that were correctly predicted as such also served to differentiate Group one and two subjects with respect to the functioning of the basic skills of metacognition. Again, referring back to the data presented within Tables 13 and 14 one sees that Group one subjects predicted 17.5% of the shots attempted as unsuccessful and that 61.9% of these predictions were accurate. In other words, a minority of the shots attempted were predicted as unsuccessful while the majority of those predicted as such were correct. On the other hand, Group two subjects predicted 38.3% of the shots taken as unsuccessful with 91.3% of these predictions being correct. While the success rate with respect to those shots correctly predicted as unsuccessful was high for Group two subjects it must be remembered that the majority of the shots attempted were predicted as successful and that most of those predictions were incorrect.

Consideration of the characteristics of those shots that were in fact unsuccessful

may serve to explain why Group two subjects were seen to correctly predict misses at a rate much higher than that demonstrated by Group one subjects. When Group two subjects did miss a basket it was usually as a result of a gross movement error (e.g., not bending at the knees, keeping both hands on the ball at release, pushing the ball out from the chest instead of up away from the forehead) resulting in a shot that had little chance of being successful. The severity of the movement errors produced were usually extreme enough to guarantee an unsuccessful attempt, while obviously providing more than enough information for a novice subject to correctly predict the attempt as unsuccessful. On the other hand, the errors produced by Group one subjects were of a much smaller scale and were, therefore, more difficult to predict accurately. As Group one subjects possessed superior levels of procedural knowledge about action, with respect to foul shot performance, even the smallest perceived discrepancy between the movements intended and those produced may have resulted in the attempted shot being predicted as unsuccessful. This, despite the fact that the perceived movement error may have lacked sufficient strength to negatively impact upon the success of the attempted shot. On a number of occasions Group one subjects had commented that a specific skill sub-component was not performed adequately, but that it apparently did not affect the outcome of the shot. For example, on a shot predicted as unsuccessful that was actually successful, subject one in Group one stated,

*“...I thought I had put too much uh, too much on the, the uh release of the ball. I thought it was gonna hit the back of the rim and come out...”*

When commenting on a shot predicted as unsuccessful that was actually successful subject

five in Group one stated,

*“...felt like it kinda rolled off of the side of my hand a little bit so I thought it would be off line this way, like it was a little bit, it did go in kinda that side, but I thought it was gonna be enough to make it miss entirely...”*

When combined, the prediction data obtained at Task three clearly indicated that Group one subjects exhibited superior functioning of that metacognitive skill related to the prediction of one's movement consequences. However, to imply that this one metacognitive skill functions in isolation of the other five would be naive. In fact, it may be reasoned that the other five metacognitive skills are constituent elements to the skill of prediction. Before one is able to predict the outcome of a movement sequence one must first monitor those ongoing movements that are part of that sequence attempting to both control and coordinate those actions produced in relation to the intended goal. At the same time one must test the logic of the selected movements and check their results in an attempt to identify any discrepancies between the movements produced and those that were intended. Only when this process is complete is one able to accurately predict the consequences of the final movement sequence produced. To simplify the description of this process we may state that when predicting movement consequences an individual is essentially attempting to determine if the procedures operationalized were in fact those necessary for, and representative of, the skills correct execution.

The preceding statement raises an interesting question. If a subject believes that she possess the necessary movement abilities (i.e., procedures) for successful skill execution, when in fact she does not, and predicts that her movement will be successful

because she believed that the procedures within her possession were executed properly, when in fact they were not, is this not representative of a high level of metacognitive skill? In other words, is it possible for an individual to display a high level of metacognitive skill yet lack success with respect to their ability to predict the consequences of any movements produced? It is argued here that this is not possible. The fact remains that one who is consistently in error when predicting her movement consequences is displaying a lack of awareness with respect to the procedures in her possession and the ability of those procedures to satisfy the movement goals. This lack of awareness is representative of both a low level of metacognitive knowledge about action and metacognitive skill.

Therefore, the significant group differences obtained at Task three, specific to the predicted shot outcomes, indicated that the metacognitive skills possessed by Group one subjects functioned better than those possessed by Group two subjects. It was reasoned that the ability to successfully predict shot outcomes was as a result of Group one subjects' enhanced ability to monitor, check, coordinate, test, and control the procedures operationalized for skill execution. This reasoning is supported by Chi and Glaser (1985) who suggested that, when solving problems, experts are more aware than novices when they make errors, why they fail to comprehend, and when they need to check their solutions.

Again, an interesting question arises. If the two groups did indeed differ with respect to their ability to monitor, check, coordinate, test, and control the procedures operationalized for skill execution, was it not reasonable to expect that these differences be highlighted in the explanations offered in support of those predictions made? Recall

that the results clearly indicated that, as they were coded, there was but one significant group difference with respect to the type (e.g., SSC, TSC, KR, or OR) of explanation offered. Group two subjects used the OR category to explain their shots predicted as unsuccessful with a significantly greater frequency than that used by Group one subjects. Generally, however, both groups of subjects were seen to use technical skill components in their explanations most often, followed by kinaesthetic reasoning, spatial skill components, and other reasoning. These results indicated that, when compared to Group one, the subjects within Group two used similar movement cues or focussed upon similar skill components when monitoring, checking, coordinating, testing, and controlling their skilled movement. The fact that such skills were utilized and that these subjects functioned in a manner even remotely similar to Group one subjects, while perhaps a bit surprising, provided indirect support for previous research (Chi, Bassok, Lewis, Reimann, & Glaser, 1987; Hardiman, Dufresne, & Mestre, 1989) that has demonstrated that 'feature similarity' is of minimal importance to good novices. Though not within the domain of sport, Chi et al. (1987) demonstrated that good novice problem solvers attempt to justify their conclusions through the use of principles and concepts contained within the text. In the present investigation, the subjects within Group two attempted to justify their conclusions (i.e., predictions) using movement concepts, similar to those used by Group one subjects, deemed relevant to effective foul shot performance. One may have expected the novice subjects within Group two to have relied more heavily upon the surface features of their performance when predicting outcomes. This would have been evident in a significantly greater number of coded OR explanations. While Group two subjects did

use this coded explanation category more than did Group one subjects when predicting shots as unsuccessful, it was far from being the explanation presented or used most often. Rather, the subjects within Group two attempted to use, what may be described as, deep level reasoning and monitoring abilities similar to those used by the expert subjects within Group one. However, as the referents (i.e., their procedural and perhaps declarative representations of knowledge) possessed by Group two subjects were considerably poorer than those possessed by Group one subjects they were not able to make effective use of the basic metacognitive skills in their possession.

Group two subjects, therefore, appeared to possess similar higher order executive strategies (i.e., metacognitive skills), though perhaps not as well developed when compared to Group one subjects, but lacked the appropriate knowledge base to use them effectively. As a result, it may be suggested that a certain amount of declarative and procedural knowledge about action is necessary before the metacognitive skills within one's possession may function effectively. Support was found for this suggestion in Thomas and Thomas' (1994) belief that a certain amount of declarative knowledge and procedural knowledge is necessary before strategic knowledge can be generalized. Therefore, while the prediction data obtained at this task indicated that the metacognitive skills possessed by Group one subjects functioned better than those possessed by Group two subjects, analysis of the coded explanations offered in support of the predictions made indicated that the observed differences in metacognitive skill functioning may have been the result of differences in the levels of knowledge about action possessed by subjects within both groups.

## CHAPTER VI

### CONCLUSIONS

Recall that the primary objective of this investigation was to examine expert-novice differences in metacognitive knowledge about action and metacognitive skill functioning, as they relate to performance of the basketball foul shot. Previous investigations have shown that expert and novice sport performers differ with respect to the levels of declarative and procedural knowledge within their possession (e.g., Allard et al., 1993; McPherson & Thomas, 1989; Williams & Davids, 1995). However, no studies have directly examined differences in the levels of metacognitive knowledge and metacognitive skill possessed by expert and novice sport performers despite the apparent superordinate relationship to both declarative and procedural knowledge. This investigation collected verbal protocols and visual protocols during the performance of three different tasks and compared these protocols in an attempt to test the following hypothesis:

The level of metacognitive knowledge about action and metacognitive skill possessed by an individual is a function of the level of expertise, relative to the performance of that action, of that individual.

The results of the logit-linear analyses performed on the instructional verbal protocol data collected at Task one provided minimal support for the hypothesis as it was applied to this task. As stated within chapter five, however, the results obtained at Task one were not that surprising when considered in light of the fact that the novice subjects in Group two had had some prior experience in the sport of basketball and, as a result, could not be considered true novices. Also, the very nature of the skill of foul shooting was

believed to allow for both relatively easy representation and verbalization. That is to say, the relatively static nature of the skill and its successive to simultaneous execution meant that the skill could be easily represented within memory as a set of simple declarative facts that, when examined, would perhaps do little to differentiate individuals who had any experience at this skill. Differences would more likely have been observed if the novices studied had had no experience at the skill of foul shooting. However, selecting such subjects would have done little to help us understand what happens between the two extremes of the true expert and the true novice. One may interpret the results obtained at Task one as suggesting that as individuals continue to gain experience at a skill their awareness of the declarative knowledge about action within their possession increases rapidly and can not be easily used to distinguish between intermediate levels of expertise. Therefore, with respect to the research hypothesis and its application at Task one, the level of expertise -- as defined in this investigation -- was seen to contribute only minimally to the assessed levels of metacognitive knowledge about action.

The comparison of the verbal and visual protocol data collected at Task two provided a clearer indication of possible group differences with respect to the procedural component of metacognitive knowledge about action. Both Group one and Group two subjects were seen to describe their physical performance as correct in relation to the documented procedures for correctly executing the skill of foul shooting. There were no significant group differences with respect to the verbal protocols collected. However, significant group differences were observed with respect to the visual protocols collected at this task. Group one subjects performed those actions associated with the collapsed skill

sub-component segments labeled legs, shot, and set-up significantly better than Group two subjects. These results were taken to indicate that Group one subjects were more aware of the skills, hence procedures, within their possession and, as a result, were better able to translate their thoughts and actions into words that accurately reflected both. In turn, this suggested that individuals possessing greater levels of expertise (e.g., Group one subjects) within a specific performance domain are more likely to possess higher levels of the procedural component of metacognitive knowledge about action.

The correlations performed at Task two only minimally supported the above suggestion. The modest sample size used in this investigation meant that interpretation of the correlations had to be done cautiously. However, the fact that a significant correlation was observed between those verbal and visual protocols coded as correct for Group one subjects at the collapsed technical skill sub-component segment labeled set-up and the fact that no significant correlations were observed between any of the verbal and visual protocols for Group two subjects was suggested to support, though only minimally, the possible existence of an expertise-metacognition relationship. The combined results at Task two suggested that, with respect to the research hypothesis and its application here, the level of expertise -- as defined in this investigation -- was seen to contribute to the assessed levels of metacognitive knowledge about action.

The results obtained at Task two also suggested that asking subjects to declaratively represent procedural knowledge about action may not provide an accurate representation of the procedural knowledge within one's possession. Rather, as was suggested by Wall et al. (1985), coding actual game play or skilled performance may be

the best way to assess the procedural knowledge about action within one's possession. However, comparing the verbal description of one's performance to his/her actual physical performance does appear to provide an accurate indication of one's level of awareness specific to the skills, hence procedures, within one's possession.

The comparison of the verbal protocol data at Task three provided the strongest support for the hypothesis tested in this investigation. Not only were Group one subjects seen to make significantly more foul shots than Group two subjects, they were also significantly better than Group two subjects with respect to their ability to monitor and successfully predict their performance outcomes across the 10 attempted foul shots. Based upon performance at Task three it was concluded that the metacognitive skills possessed by Group one subjects functioned better than those possessed by Group two subjects. Group one subjects were believed to possess an enhanced ability to monitor, check, coordinate, test, and control the procedures operationalized for skill execution as a result of their possessing higher levels of knowledge about action.

When combined, the results obtained at the three tasks performed in this investigation would appear to suggest that, specific to performance of the basketball foul shot, the level of metacognitive knowledge about action and metacognitive skill possessed by an individual is a function of the level of expertise of that individual. As one's level of expertise increases so to does her awareness of both the declarative and procedural knowledge about action within her possession. The results of this study would suggest that the process of acquiring awareness of the knowledge about action within one's possession proceeds in much the same way as Anderson (1982) described acquiring

domain specific knowledge does. That is, awareness would first be acquired of the declarative representations of knowledge about action within one's possession, followed by acquiring an awareness of the procedural representations of knowledge about action within one's possession. The results also suggest that as an awareness of both types of knowledge about action within one's possession increases the functioning of the metacognitive skills necessary for self-regulating the process of translating knowledge into action will also increase. Recall that it was suggested in chapter five that a certain amount of declarative and procedural knowledge is necessary before the metacognitive skills within one's possession may function effectively.

From a teaching or coaching perspective, while differences in the metacognitive functioning of experts and novices have been demonstrated there was no indication as to how one may attempt to enhance the acquisition of metacognitive knowledge about action, or improve the functioning of one's metacognitive skills. It is important that future research in this area explore more fully the developmental aspect of the expertise-metacognition relationship. In an effort to enhance the awareness of the declarative and procedural knowledge about action within one's possession perhaps more time and effort should be directed towards helping students and/or athletes achieve a personal understanding of their movement abilities. This would include an understanding or awareness of what one is actually doing and what one should be doing in specific movement situations, as well as an ability to monitor and subsequently correct any perceived discrepancies (i.e., performance errors) as they occur. It is not enough to only drill an individual in proper technique and strategy. Simple continuous physical practice of

a skill or strategy will not ensure its acquisition and effective use. Instead, one must combine physical practice with some type of 'cognitive practice', perhaps in the form of informal debriefings, to ensure the understanding and proper use of the instructed skills and strategies. If an individual is aware of the skills, hence procedures, within his or her possession this person is more likely to make correct movement decisions, ultimately enhancing performance.

In light of the findings of this investigation and to assist in the continuation of research into metacognition and skilled sport performance the following suggestions are offered. First, the utility of the experimental techniques used in this investigation (i.e., the collection and comparison of both verbal and visual protocols) should be determined with respect to their ability to assess metacognitive functioning in other skill domains. Similarly, the inclusion of a skill more dynamic than the one selected for study here may also help to determine the utility of the techniques employed. Third, it may prove interesting, from a developmental perspective, to assess metacognitive functioning across three or more groups, each operating at a different level of skill with respect to the execution of some motor task. Ultimately, more research is needed to understand how one develops expertise within different sporting domains and how the cognitive, metacognitive, and skill execution components of task performance interact.

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**Appendix A**  
**Letter of Informed Consent**

### Letter of Informed Consent

This research project, conducted by Jeffrey Toward, is concerned with examining the relationship which exists between knowledge and skilled sports performance. Participation in this investigation will require the following:

- 1) I will be asked to verbally instruct a novice basketball player in the proper execution of a basketball foul shot. All of my responses at this task will be recorded using a video camera.
- 2) I will be asked to perform 20 basketball foul shots, verbalizing my thoughts and actions on alternate attempts. All of my responses at this task will be recorded using a video camera.
- 3) I will be asked to perform 10 basketball foul shots, predicting the outcome of each attempt immediately upon release of the ball. All of my responses at this task will be recorded using a video camera.

All results will be kept confidential with only the investigator (Jeff Toward) having access to the audio and video information. I may address any questions that I have regarding my participation in this investigation to the investigator at any point before, during, or after my participation. I understand that at no point in the investigation will I be exposed to any risk. I also understand that I may withdraw from the study at any time.

I give my informed voluntary consent to participate.

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Date

---

Participant's Name

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Participant's Signature

**Appendix B**  
**Task Instructions**

## **TASK INSTRUCTIONS - TASK ONE**

### **VERBAL INSTRUCTION**

I am to verbally instruct a novice basketball player (Jeff Toward), who has never received any direct instruction in the proper execution of basketball skill, in the proper execution of the basketball foul shot. I am to **THINK ALOUD** while planning my instructive dialogue. **THINK ALOUD** means that I must verbalize everything that I think about from the start of the task until I feel I have completed it. I am to say everything that I feel must be known in order for the novice learner (Jeff) to successfully learn the skill. If I wish I may perform or demonstrate parts of the skill while instructing the novice learner in its execution. If I remain silent for any length of time I will be reminded to **THINK ALOUD**. The novice learner may question my instructions at any time by asking “why” so that certain points are made clear. Any questions that I have regarding task performance may be raised at any point during performance of the task. During the performance of this task all of my actions and instructions will be recorded using a video camera.

**TASK INSTRUCTIONS - TASK TWO**  
**TALK ALOUD WHILE PERFORMING**

I am to perform 20 fouls shots, **TALKING ALOUD** during performance of alternate shots. **TALKING ALOUD** means that I must verbalize everything that I think of and everything that I do while performing the shots. I will **TALK ALOUD** during performance of the first shot attempt and then every other shot attempt following. I am to step off the foul line after every two shots and then reposition myself, **TALKING ALOUD** while I do so. I can take as much time as I need to perform this task provided that I continue to **TALK ALOUD** while doing so. If I remain silent for any length of time while performing this task I will be reminded to **TALK ALOUD**. Any questions that I may have regarding task performance may be raised at any point during performance of the task. During the performance of this task all of my actions and instructions will be recorded using a video camera.

## **TASK INSTRUCTIONS - TASK THREE**

### **PHYSICAL PERFORMANCE**

I am to perform 10 foul shots, being careful to take my time and concentrate upon the successful completion of each attempt. Immediately upon release of the ball I am to verbally indicate whether or not I believe my shot is going to be successful. If I think my shot is going to go in I am to say **“YES”**. If I think the shot is not going to go in I am to say **“NO”**. After providing my prediction for each shot I am to verbally indicate why I thought my shot was or was not going to go in, regardless of whether or not it actually did. I am to step off the foul line after every two shots and then reposition myself. Any questions that I may have regarding task performance may be raised at any point during performance of the task. During the performance of this task all of my actions and instructions will be recorded using a video camera.

**Appendix C**

**Foul Shot Skill Components:  
Descriptions and Definitions of each  
Skill Sub-Component and the Corresponding  
QAV's for Tasks One, Two, and Three**

### **Foul Shot Skill Components**

This document presents an explanation of the scoring system used at Task one, Task two, and Task three when coding the verbalizations and/or actions produced specific to the spatial skill sub-components (SSC's), technical skill sub-components (TSC's), and mental skill sub-components (MSC's) of the foul shot.

#### **Task One**

If the subject provided correct instructional information about a specific skill sub-component that verbalization was labeled "Correct" and received a score of 3. A description of the correct way to execute each skill sub-component is provided in Table C1.

If the subject discussed a specific skill sub-component yet did not provide adequate detail or quality of instruction that verbalization was labeled "Incomplete" and received a score of 2. An example of an incomplete verbalization is provided for each skill sub-component in Table C1.

If the subject provided incorrect instructional information about a specific skill sub-component that verbalization was labeled "Incorrect" and received a score of 1. An example of an incorrect verbalization is provided for each skill sub-component in Table C1.

If the subject did not provide any instructional information about a specific skill sub-component that sub-component was said to be "Omitted" and received a score of 0.

With respect to the MSC's, they were only coded for Task one as they were impossible to infer from the observation of performance in Task two. Within Task one the

MSC's received only a check mark (✓) if they were discussed rather than a score of 3, 2, or 1 as it proved difficult to determine the quality/accuracy of these skill sub-components when verbalized.

### **Task Two**

If the subject correctly performed a specific skill sub-component that action was labeled "Correct" and received a score of 3. A description of the correct way to execute each skill sub-component that was assessed in Task two is provided in Table C2.

The skill sub-components could not receive a score of 2 as the visual protocols provided sufficient information to fully assess the accuracy/quality of the produced movements.

If the subject performed a specific skill sub-component incorrectly that action was labeled "Incorrect" and received a score of 1. An example of an incorrect way to execute each skill sub-component that was assessed in Task two is provided in Table C2.

### **Task Three**

The reasoning sub-components coded at Task three were not assigned a numeric value to indicate their accuracy, rather we were simply interested in documenting their occurrence.

**Table C1: Sub-Components used in the Coding Process for Task One**

Sub-Component	QAV Score	Description/ Example
SSC1a,b,c (feet)	3	<p>a- The feet should be at least 6 inches apart, no more than shoulder width.</p> <p>b- The right foot (if right handed) should be slightly ahead of the left (i.e., staggered).</p> <p>c- The shooting foot should be about 10 degrees to the left while the balance foot should be 45 degrees to the left (if right handed).</p>
	<b>Note:</b>	<p>A description of either of the above three sub-components (a, b, or c) is needed to assign this code. The subject need not discuss all three in her verbalization/instruction. It is possible that a subject may discuss "a" correctly, "b" incorrectly, and not address "c" at all.</p>
	2	"Position your feet" "Stance"
SSC2 (knees)	1	"Your feet should be next to each other, almost touching" "If right-handed you should have your left foot forward" "Feet parallel to each other pointing straight at the basket"
	2	"Set up your knees"
	1	"Keep your knees straight at all times"
SSC3 (waist)	3	The waist should be bent slightly forward
	2	"Be sure to position your waist properly"
	1	"Do not bend at the waist"

Sub-Component	QAV Score	Description/ Example
SSC4 (back)	3	The shooters back should be straight and relaxed, not arched.
	2	“Make sure your back is in the proper position”
	1	“You want to be relaxed and slightly rounded in the back”
SSC5 (shoulders)	3	The shoulders should be kept square to the basket. It is also acceptable if the subject states that the “body” is square to the basket.
	2	“Position your shoulders”
	1	“Angle your shoulders toward the basket”
SSC6 (head)	3	The head should be held steady looking up at the basket.
	2	“Keep your head in the same position during the shot”
	1	“Your head should start down looking at the ball and then follow it up to the basket when the shot is made”
SSC7 (elbow)	3	a) The elbow should be bent at approximately 90 degrees and be kept by the shooters side or in front of the shooters hip.  b) The elbow should be up at shoulder height, in close to the body, bent, in line with the basket, and in front of the wrist.  <b>Note:</b> Either “a” or “b” is correct.
	2	“Position your elbow properly”

Sub-Component	QAV Score	Description/Example
	1	“Keep your elbow bent and out to the side of your body”
SSC8 (wrist)	3	The wrist should be locked and cocked back prior to the shot
	2	“Get your wrist set to shoot”
	1	“Your wrist should be flexed so your hand can cover the ball”
SSC9 (fingers)	3	The ball should rest on the pads of the fingers between the finger tips and the first joint. The fingers should be spread comfortably with the thumb and forefinger forming a “V” not an “L”. The fingers should be pointing up.
	2	“Let the ball rest in your hand”
	1	“The ball should be in contact with the palm of your hand”
SSC10 (hand)	3	The shooting hand should be behind or slightly under the ball while the balance hand is on the side or slightly under the ball offering support. Shoot only with one hand, the balance hand releases prior to the shot.
	2	“Be sure to position your hands to make the shot”
	1	“Make sure that you hold the ball in both hands firmly”
TSC1 (weight)	3	The weight should be on the balls of the feet, with emphasis on the front foot if the feet are staggered.

Sub-Component	QAV Score	Description/ Example
	2	"Make sure your weight is distributed properly"
	1	"You want your weight to be back, over your heels" "Make sure your weight is spread evenly over both feet"
TSC2 (alignment)	3	The shooting foot, elbow, hand, and ball are aligned in a plane with the basket. The body should be close to being in the middle of the basket/net. It is acceptable if the subject says "I am centered in the middle of the net"
		<b>Note:</b> A description of <u>some</u> aspect of this component is needed to assign this code. The subject need not include all aspects in her verbalization/instruction
	2	"You want to align yourself before taking the shot"
	1	"Make sure that your non shooting foot is aligned with the basket prior to the shot"
TSC3 (release)	3	The ball should be released at the highest point in the extension, above and in front of your head.
	2	"Be sure to release the ball at the proper point"
	1	"You want to release the ball at chest height"
TSC4 ( follow through)	3	There should be continuation of the shot motion after release of the ball with the wrist flexing fully and pointing or hanging in the basket. The upper arm should be 30-35 degrees from vertical on the follow through.

Sub-Component	QAV Score	Description/ Example
		<b>Note:</b> A description of <u>some</u> aspect of this component is needed to assign this code. The subject need not include all aspects in her verbalization/instruction
	2	“Be sure to follow through when shooting” “follow through with the hand”
	1	“After the ball is released you can relax and drop your arms”
TSC5 (flight of the ball)	3	The ball should rotate backwards (backspin) as it arcs toward the basket.
	2	“Make sure the ball has spin on it when you release it”
	1	“The ball should approach the basket on a straight line”
TSC6 (ritual/routine)	3	The shooter should do the same pre-shot routine/ritual the same way, every time. It is much easier to groove a pattern that is always the same. The ritual helps prepare for the shot attempt. Sometimes you will see written “one, two, three” this means they were counting their dribbles = ritual.
	2	“Some people like to dribble a few times before shooting”
	1	“Try not to perform any actions before you shoot as it may distract from your shot attempt”

Sub-Component	QAV Score	Description/ Example
TSC7 (extension)	3	<p><b>Note:</b> For Task One the subject should somehow emphasize that the ritual is something they do for each shot to prepare or relax. For Task Two it is acceptable if the subject simply describes the pre-shot ritual (i.e., I take two dribbles), they do not have to say “do my ritual”.</p> <p>The shot is an extension of the body. Mostly it involves the straightening of the knees, the right elbow (if right handed), and the flexing of the right wrist, with a little coming from the straightening of the waist and ankles. The shooter can come off the floor if needed to get power from the legs. However, in most cases a jump is not needed or wanted.</p>
		<p><b>Note:</b> A description of <u>some</u> aspect of this component is needed to assign this code. The subject need not include all aspects in her verbalization/instruction.</p>
	2	<p>“Be sure to use your legs when shooting” “extend” “jump”</p>
	1	<p>“Try to keep your legs bent throughout the shot, the power comes from your arm” “push out”</p>
TSC8 (aim)	3	<p>The shooter should aim at the center eyelet in the back of the rim.</p>
	2	<p>“Be sure to aim at the basket” “Aim just over the front of the rim” “concentrate on the hoop” “focus on the basket”</p>
	1	<p>“You want to aim at the front rim on the basket when shooting”</p>

Sub-Component	QAV Score	Description/ Example
TSC9 (technical info)	3	This sub-component is for any information that is presented during task performance that is factual rather than instructional in nature. As an example; the basket is 10 feet high, the foul line is 15 feet from the basket, foul shots are an important part of the game, stand behind the foul line when taking a foul shot, do not touch the foul line when shooting as this will result in a foot fault, power can come from the legs when making a foul shot.....
	1	Any incorrect factual information will be scored 1. As an example, the foul line is 10 feet from the basket or, you are always given two foul shots at a time.
TSC10 (ball position)	3	a) The ball should be held at hip height in front of the hip in plane with the basket.  b) The ball should be placed above the eyes in front of the forehead or just to the right of the eye (if right handed).
	<b>Note:</b> Either “a” or “b” is correct	
	2	“You must be sure to hold the ball properly when shooting”
	1	“The ball should be held out in front of your chest prior to shooting”
TSC11 (approach)	3	The shooter should set up just behind the foul line, not touching it, but not too far (> 5 inches) away. They should give an indication of the distance.

Sub-Component	QAV Score	Description/ Example
	2	"I'm setting up", "Approach the line" "stand in front of the line" "stand behind the line" "feet behind the line" "approach"
	1	"Stand on the line" "Stand about 6 inches behind the line" "take a step forward"
MSC1 (focus/concentrate)	✓	The shooter should focus/concentrate on each shot attempt.
MSC2 (visualization)	✓	The shooter should visualize the ball going through the basket during shot preparation
MSC3 (feel/relaxation)	✓	The shooter should try to relax at the foul line, get a feel for the ball.

**Table C2: Sub-Components used in the Coding Process for Task Two**

Sub-Component	QAV Score	Description/ Example
SSC1a,b,c (feet)	3	<p>a- The feet should be at least 6 inches apart, no more than shoulder width.</p> <p>b- The right foot (if right handed) should be slightly ahead of the left (i.e., staggered).</p> <p>c- The shooting foot should be about 10 degrees to the left while the balance foot should be 45 degrees to the left (if right handed).</p> <p><b>Note:</b> A description of either of the above three sub-components (a, b, or c) is needed to assign this code. The subject need not discuss all three in her verbalization/instruction. It is possible that a subject may discuss “a” correctly, “b” incorrectly, and not address “c” at all.</p>
	2	“Position your feet”
	1	“Your feet should be next to each other, almost touching” “If right-handed you should have your left foot forward” “Feet parallel to each other pointing straight at the basket”
SSC2 (knees)	3	The knees should be bent comfortably
	2	“Set up your knees”
	1	“Keep your knees straight at all times”
SSC7 (elbow)	3	<p>a) The elbow should be bent at approximately 90 degrees and be kept by the shooters side or in front of the shooters hip.</p> <p>b) The elbow should be up at shoulder height, in close to the body, bent, in line with the basket, and in front of the wrist.</p>

Sub-Component	QAV Score	Description/ Example
		<b>Note:</b> Either "a" or "b" is correct.
	2	"Position your elbow properly"
	1	"Keep your elbow bent and out to the side of your body"
SSC10 (hand)	3	The shooting hand should be behind or slightly under the ball while the balance hand is on the side or slightly under the ball offering support. Shoot only with one hand, the balance hand releases prior to the shot.
	2	"Be sure to position your hands to make the shot"
	1	"Make sure that you hold the ball in both hands firmly"
TSC3 (release)	3	The ball should be released at the highest point in the extension, above and in front of your head.
	2	"Be sure to release the ball at the proper point"
	1	"You want to release the ball at chest height"
TSC4 ( follow through)	3	There should be continuation of the shot motion after release of the ball with the wrist flexing fully and pointing or hanging in the basket. The upper arm should be 30-35 degrees from vertical on the follow through.
		<b>Note:</b> A description of <u>some</u> aspect of this component is needed to assign this code. The subject need not include all aspects in her verbalization/instruction

Sub-Component	QAV Score	Description/ Example
	2	“Be sure to follow through when shooting” “follow through with the hand”
	1	“After the ball is released you can relax and drop your arms”
TSC6 (ritual/routine)	3	The shooter should do the same pre-shot routine/ritual the same way, every time. It is much easier to groove a pattern that is always the same. The ritual helps prepare for the shot attempt. Sometimes you will see written “one, two, three” this means they were counting their dribbles = ritual.
	2	“Some people like to dribble a few times before shooting”
	1	“Try not to perform any actions before you shoot as it may distract from your shot attempt.
		<b>Note:</b> For Task One the subject should somehow emphasize that the ritual is something they do for each shot to prepare or relax. For Task Two it is acceptable if the subject simply describes the pre-shot ritual (i.e., I take two dribbles), they do not have to say “do my ritual”.
TSC7 (extension)	3	The shot is an extension of the body. Mostly it involves the straightening of the knees, the right elbow (if right handed), and the flexing of the right wrist, with a little coming from the straightening of the waist and ankles. The shooter can come off the floor if needed to get power from the legs. However, in most cases a jump is not needed or wanted.

Sup-Component	QAV Score	Description/ Example
		<b>Note:</b> A description of <u>some</u> aspect of this component is needed to assign this code. The subject need not include all aspects in her verbalization/instruction.
	2	“Be sure to use your legs when shooting” “extend” “jump”
	1	“Try to keep your legs bent throughout the shot, the power comes from your arm” “push out”
TSC10 (ball position)	3	a) The ball should be held at hip height in front of the hip in plane with the basket.  b) The ball should be placed above the eyes in front of the forehead or just to the right of the eye (if right handed).
		<b>Note:</b> Either “a” or “b” is correct
	2	“You must be sure to hold the ball properly when shooting”
	1	“The ball should be held out in front of your chest prior to shooting”
TSC11 (approach)	3	The shooter should set up just behind the foul line, not touching it, but not too far (> 5 inches) away. They should give an indication of the distance.
	2	“I’m setting up”, “Approach the line” “stand in front of the line” “stand behind the line” “feet behind the line”
	1	“Stand on the line” “Stand about 6 inches behind the line” “take a step forward”

**Table C3: Sub-Components used in the Coding Process for Task Three**

Sub-Component	Description/ Example																				
SSC	<p>Any explanation which emphasized correct/incorrect segment (i.e., body part) positioning when performing the skill; concerned with shot preparation. May include explanations involving placement/positioning of the following:</p> <table border="0"> <tr> <td data-bbox="623 764 667 795">feet</td> <td data-bbox="899 764 1317 837">(My feet were not shoulder width apart)</td> </tr> <tr> <td data-bbox="623 837 688 869">knees</td> <td data-bbox="899 837 1317 869">(My knees were not bent enough)</td> </tr> <tr> <td data-bbox="623 869 683 900">waist</td> <td data-bbox="899 869 1235 900">(I was bent over too much)</td> </tr> <tr> <td data-bbox="623 900 675 932">back</td> <td data-bbox="899 900 1230 932">(My back was not straight)</td> </tr> <tr> <td data-bbox="623 932 737 963">shoulders</td> <td data-bbox="899 932 1289 963">(I was not square to the basket)</td> </tr> <tr> <td data-bbox="623 963 675 995">head</td> <td data-bbox="899 963 1159 995">(My head was down)</td> </tr> <tr> <td data-bbox="623 995 748 1026">elbow/arm</td> <td data-bbox="899 995 1284 1026">(My elbow was bent too much)</td> </tr> <tr> <td data-bbox="623 1026 680 1058">wrist</td> <td data-bbox="899 1026 1273 1058">(I did not cock my wrist back)</td> </tr> <tr> <td data-bbox="623 1058 699 1089">fingers</td> <td data-bbox="899 1058 1354 1089">(My fingers were too close together)</td> </tr> <tr> <td data-bbox="623 1089 675 1121">hand</td> <td data-bbox="899 1089 1240 1163">(I did not position my hands correctly)</td> </tr> </table>	feet	(My feet were not shoulder width apart)	knees	(My knees were not bent enough)	waist	(I was bent over too much)	back	(My back was not straight)	shoulders	(I was not square to the basket)	head	(My head was down)	elbow/arm	(My elbow was bent too much)	wrist	(I did not cock my wrist back)	fingers	(My fingers were too close together)	hand	(I did not position my hands correctly)
feet	(My feet were not shoulder width apart)																				
knees	(My knees were not bent enough)																				
waist	(I was bent over too much)																				
back	(My back was not straight)																				
shoulders	(I was not square to the basket)																				
head	(My head was down)																				
elbow/arm	(My elbow was bent too much)																				
wrist	(I did not cock my wrist back)																				
fingers	(My fingers were too close together)																				
hand	(I did not position my hands correctly)																				
TSC	<p>Any explanation which emphasized the use of proper/improper technique when performing the skill; concerned with shot execution. May include explanations involving the following technical concerns:</p> <table border="0"> <tr> <td data-bbox="623 1394 699 1425">weight</td> <td data-bbox="899 1394 1321 1467">(My weight was not over the front foot)</td> </tr> <tr> <td data-bbox="623 1467 737 1499">alignment</td> <td data-bbox="899 1467 1321 1499">(I was not aligned with the basket)</td> </tr> <tr> <td data-bbox="623 1499 699 1530">release</td> <td data-bbox="899 1499 1240 1530">(I released the ball too soon)</td> </tr> <tr> <td data-bbox="623 1530 797 1562">follow through</td> <td data-bbox="899 1530 1192 1562">(I did not flick my wrist)</td> </tr> <tr> <td data-bbox="623 1562 802 1604">flight of the ball</td> <td data-bbox="899 1562 1321 1719">           - only appropriate if not sight dependent            (i.e., did not put enough force into the arc)         </td> </tr> <tr> <td data-bbox="623 1719 675 1751">ritual</td> <td data-bbox="899 1719 1338 1751">(I forgot to dribble before shooting)</td> </tr> <tr> <td data-bbox="623 1751 721 1793">extension</td> <td data-bbox="899 1751 1240 1824">(I did not straighten my legs properly)</td> </tr> <tr> <td data-bbox="623 1824 651 1856">aim</td> <td data-bbox="899 1824 1224 1856">(I aimed at the wrong spot)</td> </tr> <tr> <td data-bbox="623 1856 769 1898">technical info</td> <td data-bbox="899 1856 1208 1929">(I did not keep the motion continuous)</td> </tr> </table>	weight	(My weight was not over the front foot)	alignment	(I was not aligned with the basket)	release	(I released the ball too soon)	follow through	(I did not flick my wrist)	flight of the ball	- only appropriate if not sight dependent (i.e., did not put enough force into the arc)	ritual	(I forgot to dribble before shooting)	extension	(I did not straighten my legs properly)	aim	(I aimed at the wrong spot)	technical info	(I did not keep the motion continuous)		
weight	(My weight was not over the front foot)																				
alignment	(I was not aligned with the basket)																				
release	(I released the ball too soon)																				
follow through	(I did not flick my wrist)																				
flight of the ball	- only appropriate if not sight dependent (i.e., did not put enough force into the arc)																				
ritual	(I forgot to dribble before shooting)																				
extension	(I did not straighten my legs properly)																				
aim	(I aimed at the wrong spot)																				
technical info	(I did not keep the motion continuous)																				

Sub-Component	Description/ Example
	ball position (I held the ball in front of my eyes) approach/setup (I was too far from the line)
KR	Any explanation which emphasized a "proper/improper" or "correct/incorrect" feel when performing the skill. May include explanations such as the following: (It did not feel right) (I did not have a good feel for the ball)
OR	Any explanation that could not be coded using one of the above sub-components. May include explanations such as the following: (The light was in my eyes) (I lost my focus, I was not ready) (I was distracted by a noise)

**Appendix D**  
**Coded Verbatim Protocols**

**Transcribed Protocols****E = experimenter****S = subject****Subject #13****TASK ONE**

S: Ok, I am verbally in.. Uhh, I am to verbally instruct a novice basketball player, Jeff Toward, // who has never received any direct instruction in the proper execution of basketball a skill, // skills in the proper execution of a basketball foul shot. // I am to think aloud while planning my instruction // instructive dialogue. Think aloud means that I will verbalize everything that I think // about from the start of the task until I feel that I have completed it. I am // to say everything that I feel must be known in order to, in order for the novice learner (Jeff) // to successfully learn the skill. If I wish I may perform or demonstrate // parts of the skill while instructing the novice learner in its execution. If I remain // silent for any length of time ah I will be reminded to think aloud. The novice // learner may question my instructions at any time by asking "why" so that certain // points are made clear. Any questions that I have regarding task performance // may be raised at any point during performance of the task. During the performance of this task // all of my actions and instructions will be recorded using a video camera. // Fine

RIE

SU

EC

E: any questions?

REC

S: I don't have any //

EC

E: you can go

QE S: alright, do I // do I put you here or do you just stand there?

EC E: I'm standing here

TSC11(3)  
SSC1(3a)

S: Ok, so what you're gonna do is you're gonna // walk up to the line, the free throw line, your foot can be right in front of it but it can't be touching the free throw line // your legs have to be shoulder width apart or comfortable for you,

LCC E: which foot up to the line?

QL S: Ok, it depends // on what handed you are, are you right or left handed?

LR E: right

SSC1(3b)  
SSC1(1c)  
TSC6(3)  
SSC2(3) SSC10(a)

S: Ok, you're a right handed shooter, so your right hand (means foot) will be little bit // forward, Uh, comparison to the left, both feet are square to the basket, so you just be // comfortable, and uh what I do I do a ritual I toss the ball, but // you can do whatever you want, lets say you're just gonna hold the ball, your knees are bent, your looking at the rim, allot of people // look at different spots, I look just over the front of the rim, your hand, your wrist is gonna be cocked backwards // so that uh, there's uh space in there so if there's like paint you wouldn't get it on the ball // the other hand is used as a guider hand, and uh // let me see here, your elbow is to be at a 90 degree angle //and your looking over the ball, Uhm, as you go to shoot you'll be standing up // and you'll be releasing the ball at a 45 degree angle, and as you shoot you follow through with your // wrist and almost put your hand right through the basket.

QL any questions?

TSC9(3)  
TSC7(3)  
TSC3(1)  
TSC4(3)

LCC E: why a 45 degree angle?

TSC5(3)  
QE  
S: Uh, because // if you shoot up too high then uh, well your gonna loose sight of the ball for one thing // and uh if you shoot too flat your not gonna get enough arc so that if it doesn't go directly into // the basket it's not gonna have that roll, the follow through to, to make the roll go. So do I shoot it now // or no?  
any other questions, any other questions

EC  
E: I have another question // do you have anything you would like to add?

TSC9(3)  
TSC4(a)  
S: Uh, // let me think, don't bounce, make it one continuous motion, // it's like a lot of people sit here and go like this, that kinda messes up your shot, and uh one, once you start the shot // follow all the way through, don't like get to here and then shoot it, so it's // continuous motion

EC  
E: that's it

REC  
S: Yup.

EC  
E: I will ask you once more, but it doesn't mean I // think you forgot anything. Is there anything else you would like to add before I stop it?

REC  
S: Uh, I don't think so.

**TOTAL TIME: 3 Minutes 19 Seconds**

**Transcribed Protocols****E = experimenter****S = subject****Subject #13****TASK TWO**

RIE S: to perform 20 foul shots, talking aloud during performance of alternate shots. //  
 Talking aloud means that I must verbalize everything that I think and // everything  
 I do while performing the foul shot. I will think aloud during the performance of  
 the first // shot attempt, and then every other shot following. I am to step off the //  
 foul line after every two shots and then reposition myself, talking aloud // while I  
 do so. I can take as much time as I need to perform this task // provided that I  
 continue to talk aloud while doing so. If I remain silent for any length of // time  
 while performing this task I will be reminded to talk aloud. Any questions that I //  
 may have regarding this task performance may be raised at any point during  
 performance of this task. During the performance // of this task all of my actions  
 and instructions will be recorded using a video camera. That's fine. //

SU

EC

E: Now you're not going to need to step off after every two shots

REC

S: Ok

EC

E: What I'll do // instead is ask you to collect your own rebounds

QE

S: get my own rebounds

ER

E: yup

QE

S: Ok // after every shot or just after the two?

EC E: pardon me?

QE S: after // every shot I'm getting my own rebound?

ER E: after every shot

REC S: Ok

EC E: I just want to make sure that you step off the line // and come to the middle you have to reset

STI S: Ok, but I only talk // about the first one and the third one and the fifth one, Ok // do I go?

EC E: yup

TSC11(3) S: Ok, first of all I position myself at the line // my foot is uh, just before the line, I  
TSC6(3) toss the ball in front of me, gonna take // two bounces, and my fingers are across  
SSC9(2) the seams of the ball, // and my eyes are on the front of the rim but just going over  
TSC8(2) and when I shoot (**TAKES 1 SHOT**) I release // it and follow through into the  
TSC3(2) basket. Now I just do it right? //  
TSC4(2) QE  
Ok? Ok  
**(TAKES 2 SHOT) // // (microphone fell off) is it Ok with this little thing? // still**

QE Ok? Ok

TSC11(2) Ok, again // I'm approaching the line, toss the ball, two bounces, my knees are bent  
TSC6(3) // (**TAKES 3 SHOT**) follow through, and I miss // uhh // // (**TAKES 4 SHOT**) //  
SSC2(3) Same thing? uh again approach the line, toss the ball, // two bounces, I'm looking  
TSC4(2) over the front of the rim (**TAKES 5 SHOT**) release it, it's off to the side //

TSC11(2) TSC6(3) E: don't be afraid to be redundant in what you're saying  
TSC8(2) EC  
TSC3(2) NR

EC E: don't be afraid to be redundant in what you're saying

REC S: Ok

EC E: If there is something you want // to add as well, that's fine

NR S: I'm a horrible foul shooter

EC E: try to describe everything that you are doing // as you do it

TSC6(3)  
TSC8(1)  
TSC4(2)  
PR S: Ok, toss the ball, I'm bending, as I'm bending I take two bounces // I'm looking at the front of the rim, (**TAKES 6 SHOT**) follow through, finally it's in // // (**TAKES 7 SHOT**) //

QE Are you counting for me?

ER E: pardon me?

QE S: Are you counting // is that 6?

ER E: 8 in total

QE S: Oh, is it? Ok

TSC6(3)  
TSC8(2)  
TSC4(2) and I toss the ball, // bend, take two bounces at the same time, look over the front of the rim (**TAKES 8 SHOT**) shoot // follow through, // (**TAKES 9 SHOT**) // //

TSC6(3)  
TSC8(2) Oh, toss the ball, bounce it twice, bending looking over the front // of the rim (**TAKES 10 SHOT**) and oghh, // // (**TAKES 11 SHOT**) //

TSC6(3)  
TSC8(2)  
NR toss the ball, approach the line // bounce it twice, looking over the front of the rim, (**TAKES 12 SHOT**) // oh my god, // // (**TAKES 13 SHOT**) //

TSC6(3)  
TSC8(2)  
TSC4(2) toss the ball, the line, // twice, looking over the front of the rim (**TAKES 14 SHOT**) and follow through // // (**TAKES 15 SHOT**) //

TSC6(3)TSC8(2)  
TSC11(3) TSC4(2) toss the ball, // my foots at the line, two bounces, looking over the front of the rim, (**TAKES 16 SHOT**) // follow through, // // (**TAKES 17 SHOT**) //

TSC6(3)  
TSC8(2) toss the ball, // take two bounces, looking over the front of the rim (**TAKES 18**

TSC4(2)  
NR

**SHOT** // follow through, but it's off, // // **(TAKES 19 SHOT)** //

EC

E: Alright, you have one more talking one

QE

S: and one more normal?

ER

E: just one more talking //

REC

S: just one more talking? Ok

TSC6(3)

SSC2(3)

TSC8(2)

TSC4(2)

toss the ball, take two bounces // my knees are bent, looking over the front of the rim **(TAKES 20 SHOT)** follow through

**TOTAL TIME: 5 Minutes 53 Seconds**

**Transcribed Protocols****E = experimenter****S = subject****Subject #13****TASK THREE**

S: I am to perform 10 foul shots, being careful to take my time and consider, //  
 considera, concentrate upon the successful completion of each // attempt.  
 Immediately upon release of the ball I am to verbally indicate whether or not I //  
 believe my shot is going to be successful. If I think my shot is going to go in // I  
 am to say "yes". If I think my shot is not going to go in I say "no". // After  
 providing my prediction for each shot I am to verbally indicate why I // thought my  
 shot was or was not going to go in, regardless of whether or not it actually // did. I  
 am to step off the line after every two foul shots // and reposition myself. Any  
 questions that I may have regarding // task performance may be raised at any point  
 during performance of the task. During the // performance of this task all of my  
 actions and instructions will be recorded using a video camera. That's fine //

RIC

SU

E: Ok

EC

S: yup

REC

E: any questions?

REC QE

S: No // // go?

ER

E: whenever your ready

S: **(TAKES 1 SHOT) Yes //**

KR  
TSC

Uh, // I, felt like a, a smooth motion, it felt like my arm was straight and then everything // was in one straight line.

EC

E: Ok, //

KR

S: **(TAKES 2 SHOT)** Yes

same thing, I felt like a smooth // smooth pattern

**(TAKES 3 SHOT)** // No, oops

KR  
TSC

cause I felt like it was off to the uh left a little bit more than // it should of been. I felt like my arm came across my body a little bit more //

**(TAKES 4 SHOT)** Yes

TSC

same as before, // smooth motion, //

**(TAKES 5 SHOT)** Yes

TSC

even though // it was gonna hit the front of the rim I knew that the roll, because I followed through, it was, it was good enough that it would go in //

**(TAKES 6 SHOT)** Yes, oops // //

KR

I thought it was going // in just because it felt the same as the other ones, but I had, again I put it off to the side a little bit too much //

**(TAKES 7 SHOT)** Yes //

smooth motion,

EC

E: pardon me

TSC

S: it was smooth motion with my whole // body continuous //

**(TAKES 8 SHOT)** No, oh

TSC

I thought I had put too much uh, too much // on the, the uh release of the ball, I

thought it was gonna hit the back of the rim and come out //

**(TAKES 9 SHOT)** Yes //

TSC, KR

smooth motion, same as before, felt comfortable //

**(TAKES 10 SHOT)** Yes

KR

same, it felt very comfortable // to shoot //

**(TAKES 11 SHOT)** Yes

very comfortable to shoot that too

E: actually that was number 11 //

S: Oh was it

E: Yes, I didn't want to stop you, you were on a roll

**TOTAL TIME: 3 Minutes 6 Seconds** (to the end of the comments for the 10th shot)

**Appendix E**

**Tables Used in Data Collection and Preparation**





**Appendix F**  
**Data Supplements**

Table F1

Collapsed SSC, Verbal Protocol Data for Group One (Experts) and Group Two (Novices) at Task One

Subject #	LEGS (SSC1, SSC2)						UPPER BODY (SSC3, SSC4, SSC5, SSC6)						ARM (SSC7, SSC8, SSC9, SSC10)					
	Correct		Incorrect		Omitted		Correct		Incorrect		Omitted		Correct		Incorrect		Omitted	
	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov
1	3	3	1	0	0	1	0	0	0	0	0	4	3	1	0	0	1	3
2	2	2	1	0	1	2	0	1	0	0	4	2	2	2	0	0	2	2
3	1	3	2	0	1	1	1	2	0	0	3	2	2	3	0	0	2	1
4	2	3	0	0	2	1	0	0	0	0	4	2	2	0	0	1	2	3
5	2	2	0	0	2	2	0	0	0	0	4	1	1	1	0	1	3	2
6	2	2	1	0	1	2	0	1	0	0	4	2	2	0	0	2	2	2
7	3	1	0	1	1	2	0	0	0	0	4	2	2	2	0	0	2	2
8	3	1	0	0	1	3	0	0	0	0	4	3	3	0	0	1	1	3
9	3	1	1	0	0	3	2	1	0	0	2	3	3	1	0	0	1	3
10	1	2	1	0	2	2	1	0	0	0	3	2	2	1	1	0	1	3
11	3	3	1	0	0	1	0	0	0	0	4	0	0	4	0	0	4	0
12	0	1	0	1	4	2	0	0	0	0	4	2	2	4	0	0	2	0

**Note.** The data presented under the heading "Exp" represents the verbal protocol data collected for each Expert.  
 The data presented under the heading "Nov" represents the verbal protocol data collected for each Novice.

Table F2

Collapsed TSC, Verbal Protocol Data for Group One (Experts) and Group Two (Novices) at Task One

Subject #	SETUP												EXECUTION												INFORMATION											
	(TSC1, TSC2, TSC6, TSC10, TSC1, TSC8)				(TSC7, TSC3, TSC4, TSC5)				(TSC9)				(TSC9)				(TSC9)				(TSC9)															
	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov	Exp	Nov								
1	2	0	1	0	3	6	3	3	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1									
2	1	2	0	0	5	4	2	4	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	1									
3	3	3	1	0	2	3	2	2	0	0	2	2	2	0	2	1	1	0	0	0	0	0	0	0	0	0	1									
4	2	2	2	0	2	4	1	1	1	1	2	2	2	0	2	0	0	0	0	0	0	0	0	0	0	1	1									
5	2	0	1	2	3	4	4	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0									
6	3	0	0	2	3	4	2	2	0	1	2	1	1	0	2	1	0	0	0	0	0	0	0	0	0	1	1									
7	0	1	2	1	4	4	3	2	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1									
8	1	3	0	2	5	1	1	2	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1									
9	0	0	2	4	4	2	2	0	0	0	2	4	0	0	2	4	0	0	0	0	0	0	0	0	0	1	1									
10	1	2	1	0	4	4	1	1	1	2	2	1	0	0	2	1	0	0	0	0	0	0	0	0	0	1	1									
11	2	2	2	2	2	2	2	1	0	2	2	2	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1									
12	3	1	2	1	1	4	1	2	1	1	2	1	0	1	2	1	0	0	0	0	0	0	0	0	0	1	0									

Note. The data presented under the heading "Exp" represents the verbal protocol data collected for each Expert.  
 The data presented under the heading "Nov" represents the verbal protocol data collected for each Novice.

Table F3

Collapsed MSC, Verbal Protocol Data for Group One (Experts) and Group Two  
(Novices) at Task One

Subject #	MENTAL (MSC1, MSC2, MSC3)	
	Group One (Experts)	Group Two (Novices)
1	0	0
2	0	0
3	1	0
4	1	0
5	0	1
6	0	0
7	0	0
8	0	0
9	2	1
10	0	0
11	0	2
12	2	0

Table F4

Collapsed SSC and TSC Verbal and Visual Protocol Data for Group One (Experts) at Task Two

Subject #	LEGS (SSC1, SSC2)				ARM (SSC7, SSC10)				SHOT (TSC3, TSC4, TSC7)				SET-UP (TSC6, TSC11, TSC10)			
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		Correct		Incorrect	
	Audio	Video	Audio	Video	Audio	Video	Audio	Video	Audio	Video	Audio	Video	Audio	Video	Audio	Video
1	30	0	10	0	20	0	0	0	30	0	0	0	12	30	0	0
2	26	7	14	20	20	0	0	12	30	0	0	0	0	20	0	10
3	30	0	10	0	20	0	0	0	29	0	1	6	30	1	0	0
4	40	0	0	3	20	0	0	0	30	0	0	9	30	0	0	0
5	20	0	20	3	20	0	0	4	30	0	0	3	30	0	0	0
6	40	1	0	1	20	0	0	2	27	0	3	10	30	0	0	0
7	40	0	0	0	20	0	0	1	30	0	0	6	30	0	0	0
8	38	0	2	0	20	0	0	0	29	0	1	1	30	0	0	0
9	40	0	0	0	20	0	0	7	30	0	0	0	26	0	4	0
10	40	0	0	1	20	0	0	1	30	0	0	2	29	0	1	0
11	40	0	0	0	20	0	0	2	30	0	0	9	30	0	0	0
12	40	0	0	0	20	0	0	5	30	0	0	8	30	1	0	0

Note. The data presented under the heading "Audio" represents the verbal protocol data at each collapsed skill sub-component. The data presented under the heading "Video" represents the visual protocol data at each collapsed skill sub-component.

Table F5

Collapsed SSC and TSC Verbal and Visual Protocol Data for Group Two (Novices) at Task Two

Subject #	LEGS (SSC1, SSC2)		ARM (SSC7, SSC10)		SHOT (TSC3, TSC4, TSC7)		SET-UP (TSC6, TSC11, TSC10)								
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect							
1	20	0	10	0	9	20	0	7	2	0	28	12	14	0	16
2	1	20	0	20	0	1	0	3	20	0	10	0	24	1	6
3	25	40	0	20	20	0	0	7	30	0	0	1	23	0	7
4	4	20	0	20	0	0	0	3	10	0	20	0	18	0	12
5	11	19	0	21	3	0	20	4	10	0	20	0	19	1	11
6	4	10	0	30	1	20	0	2	30	0	0	7	20	9	10
7	6	20	7	20	1	20	0	0	0	0	30	3	30	0	0
8	0	20	0	20	0	17	0	6	28	4	2	9	30	0	0
9	2	20	0	20	0	10	0	0	20	0	10	3	30	0	0
10	14	20	0	20	10	20	0	8	14	0	16	13	20	0	10
11	4	38	0	2	5	20	0	3	21	0	9	3	20	1	10
12	8	20	0	20	1	16	0	0	3	1	27	1	25	0	5

Note. The data presented under the heading "Audio" represents the verbal protocol data at each collapsed skill sub-component. The data presented under the heading "Video" represents the visual protocol data at each collapsed skill sub-component.

Table F6

Summarized Performance Data for Group One (Experts) at Task Three

Measure	Group One (Experts)											
	1	2	3	4	5	6	7	8	9	10	11	12
Shots Made (/10)	9	7	6	9	9	5	9	8	9	5	5	9
Shots Predicted as Successful	8	7	8	10	9	8	9	6	10	6	8	10
Shots Correctly Predicted as Successful	7	7	4	9	8	5	8	6	9	4	5	9
Shots Predicted as Unsuccessful	2	3	2	0	1	2	1	4	0	4	2	0
Shots Correctly Predicted as Unsuccessful	0	3	1	0	0	2	0	2	0	3	2	0
Correct Predictions (/10)	7	10	5	9	8	7	8	8	9	7	7	9
Coded Explanations: SSC	0	6	0	0	3	2	0	0	0	0	0	0
TSC	7	10	5	7	5	10	7	6	5	10	5	1
KR	6	0	6	4	6	3	5	5	3	8	0	7
OR	0	0	2	4	0	0	1	0	4	1	7	2

Table F7

Summarized Performance Data for Group Two (Novices) at Task Three

Measure	Group Two (Novices)											
	1	2	3	4	5	6	7	8	9	10	11	12
Shots Made (/10)	4	3	5	1	0	1	0	3	3	0	2	0
Shots Predicted as Successful	6	7	7	8	5	6	3	6	7	5	6	8
Shots Correctly Predicted as Successful	3	3	4	1	0	1	0	3	2	0	1	0
Shots Predicted as Unsuccessful	4	3	3	2	5	4	7	4	3	5	4	2
Shots Correctly Predicted as Unsuccessful	3	3	2	2	5	4	7	4	2	5	3	2
Correct Predictions (/10)	6	6	6	3	5	5	7	7	4	5	4	2
Coded Explanations: SSC	1	0	0	0	0	0	0	0	0	1	0	0
TSC	10	4	3	8	9	7	3	10	1	7	4	7
KR	1	9	9	3	4	5	6	0	5	4	2	5
OR	0	2	0	1	0	1	1	1	5	2	5	6