EXPERTISE AND BASKETBALL OFFICIATING

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Dissertation

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ABSTRACT

This study examined the knowledge, skills, experience, and abilities of amateur (grade school-high school) basketball officials in the State of Ohio. It investigated novice/expert skill and age differences in officiating. Another issue explored was the identification of a core skill used by expert officials. Variables of interest were knowledge, procedural performance, age effects, mediation of age effects, and anticipation (as the identified core skill). Forty high school basketball officials participated in the study 25 were experts and 15 were novices. Experts had 10 or more years officiating high school basketball and novices three or less years officiating high school basketball. Age was defined as older officials being ≥ 37 years of age and young officials were ≤ 36 years. The study required participants to view DVD scenarios of actual varsity state championship basketball games and make the correct basketball call. After viewing DVD scenarios they had to answer questions in relation to the call made. Using different DVD scenarios a participant would view a portion of the game scenario and it would be stopped part way in the action. Then the participant would have to tell the researcher what he/she thought would happen next (anticipation). The DVD scenario would be started again and how well the participant anticipated what happened was determined. Participants answered questions from written basketball vignettes situations, a test of the rules, and a test of the mechanics of
basketball. Participants had to recall and physically demonstrate the hand signals used
to officiate basketball. Test of fluid (Cultural Fair test of “g”) and crystallized abilities
(Mill-Hill Vocabulary Test) were administered. Results from the all tests indicated
that expert officials recalled significantly more information than novice officials about
other plays, specific game situations, and refereeing the defense/ offense. Experts were
significantly more aware than novices of their own position on the court and their area
of responsibility. When the amount of information given to experts decreased, their
performance in making correct calls significantly increased. Experts were better able
to anticipate players’ movements than novices. Experts made significantly more
predictions about anticipation of players’ movements as complexity level increased.
Experts recalled and demonstrated more hand signals than novices. Older officials had
significantly more correct calls on the DVD scenarios of game situations, recalled and
demonstrated more hand signals, and significantly reported watching a court area than
young officials. Experience was found to mediate age effects on performance, age was
found to predict crystallized abilities above any expertise effects, and anticipation was
found to be a core skill for expert basketball officials in this study.
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CHAPTER I
INTRODUCTION

This dissertation examined the knowledge, skills, experience, and abilities of licensed amateur expert and novice (grade school-high school) basketball officials in the State of Ohio. It also looked for age effects between the older and younger licensed basketball officials. The dissertation attempted to scientifically answer three research questions.

The first question asked if experience mediates age effects in possible performance differences between older and younger officials. A second question investigated the identification of a core skill (anticipation) in relation to the development of expertise. The third question examined the effects of expertise on different types of knowledge. Further exposition on these research questions is done later in the dissertation.

Examination of these research questions required testing for expert novice differences and age effects between older and younger officials. To understand the reasoning for these research questions a review of the concept of expertise is necessary. There is little research available in the area of sports officiating, expertise, and age. Therefore the chapter discusses various definitions of expertise and approaches used to study expertise. Following the approaches used to study expertise is a review of research studies that compared expert and novice differences in consideration of age, experience,
and performance. The concept of anticipation is reviewed as a core skill in relation to differences of expert and novice performance sports as well as judging gymnastics. A brief discussion about age-related differences on basic cognitive tasks and implications for complex work environments will also be presented.

Literature in gymnastic judging was examined because it states how expert and novice judges focus on different body parts based on prior information given to them about the upcoming gymnast’s routine prior to the gymnast’s performance. This is similar to basketball officials knowing the plays most teams use during the course of a game. Basketball officials have specific areas on the basketball court in which they watch the players’ bodies and positions based on the position of the player on the court. A player’s movement also determines what body part a basketball official will focus upon.

Cricket umpire errors in the determination of whether or not batsmen stepped out of bounds are reviewed regarding the relatively short amount of time they have to make their decision (Chedzoy, 1997). This is similar to the basketball referees (officials) who have to make the majority of their decisions in a one to two second time period.

The speeded decision-making process used in sports is different from decisions made by chess masters when replicating chess pieces on a board. Chess masters are usually given five to seven seconds to study then duplicate the chess pieces on a board. Sports officials have only one to two seconds to view a play and make a decision. The time period may be different but the process for making a decision may be similar for experts in different fields.
General Concept

A main issue in the field of expertise is how to define and measure expertise. However, most definitions (Charness, 1991; Charness, Feddon, & Tuffiash, 2001; Chi, Glaser, & Farr, 1988; Masunaga & Horn, 2001; Meinz & Salthouse, 1998; Simon & Chase, 1973; Sternberg, 1982) are in agreement with Ericsson’s (1996) definition of expertise as consistent, exceptional, and extraordinary achievement/creativity in a particular domain. According to Ericsson (1996), expertise is defined as the highest level of performance and achievement in a specific domain (sports, arts, sciences, and games). Expertise has been an interest of empirical study for many years (Chase & Simon, 1973; Chi, Glaser, & Rees, 1982; deGroot, 1946/1978; Ericsson, 1996; Masunaga & Horn, 2001; Meinz & Salthouse, 1998; Rikers, Te Winkel, Loyens, & Schmidt, 2003; Ward & Williams, 2003).

Superior performance is exhibited under conditions that capture high level of skills in a specific domain. Chase and Simon (1973) believed in a 10-year preparatory period for the development of expertise in chess players and suggested similar prerequisites for other domains. To consistently perform at the highest level, an individual needs these years of experience and training. This is the deliberative and well-structured practice viewpoint of expertise (Ericsson, 1996) and it requires vast amounts of knowledge, practice, and experience in a particular domain.

Deliberative and well-structured practice (or deliberative practice) is goal directed, focused, programmatic, and carried out over extended periods of time. Deliberative practice involves conscious performance monitoring and evaluation by analyses of level of expertise reached, identification of errors, as well as procedures
directed for the elimination of errors. It requires feedback that is appropriate, objective, and immediate about the person’s performance. The feedback can be self-generated or be obtained from objective observers. Objective feedback helps the learner to become aware of the standards of expertise, to internalize how to identify and correct errors, to monitor progress, to set new goals, and to focus on overcoming weaknesses in performance.

Deliberative practice is goal directed in which specific goals are set at successive stages of expertise development. It requires the setting of goals that go beyond a person’s current level of performance. These goals may lead to failures or errors that result in one having a lowered performance on the task. The individual aspiring to become an expert develops the viewpoint that errors and failures are opportunities to improve performance.

Deakon and Coblentz (2003) gave an example of deliberative practice in sports with their research on elite figure skaters. The found that elite figure skaters spent more time on challenging jumps than their less elite counterparts. The elite skaters made more attempts on jumps they had not mastered but were needed to move up in expertise. In essence, the elite figure skaters repeated failed jumps and fell on the ice more than their counterparts but ultimately reached a higher level of performance.

Deliberative practice is how basketball officials are trained to become licensed state officials, to maintain their licensure, and become experts in high school basketball officiating. It is also how expert and novice officials were defined in the study. First, an individual who would like to become a licensed official (novice) must attend 8-10 weeks of classroom instruction on the rules and mechanics of basketball officiating. During this time period the actual officiating of basketball games is done under the observation of the instructors and other qualified licensed officials. During the training process scrimmage
games are used for instruction on the application of the rules and mechanics. Officiating scrimmages is a useful tool used in the training process because the game can be stopped for the appropriate, objective, and immediate feedback to be given on officiating rules and techniques. At the end of the training period the individual will take the State Licensure Test to become a C2 licensed official. After the novice official finishes his/her training and is assigned games, a qualified licensed official will attend some of the games with the novice official and observe the performance of the novice official. The qualified license official will critique the performance of the novice official at halftime and again at the end of the game. This assures the novice official gets immediate feedback on his/her performance. This dissertation used C2 officials with 3 years or less experience as novices.

To maintain licensure basketball officials must attend State Rules Interpretation and Changes meetings yearly. They must also attend at least four local chapter meetings. Those state basketball officials who want to excel and become experts will attend (at their own expense) basketball camps in which training is done by professional basketball officials. At these camps goals are set, especially in weak areas, and feedback on performance is given by objective observers (professional basketball officials) to improve performance. State officials who would like to become experts will also attend more than the required four local chapter meetings to improve officiating performance and increase their basketball knowledge. After 2 years of licensure as a C2 the official may take the State Licensure Test to become a C1 licensed official. It is only as a C1 may the official officiate varsity high school basketball games. This study used basketball officials with 10 or more years of deliberative practice at the high school varsity level as experts.
The first research question asked if experience mediates age effects between older and younger officials. It would be expected that experience mediates the effects of age between older and younger officials with the type of training and well-structured practice provided by deliberative practice. Performance differences between experts and novices would also be expected with this type of extended and intensive training.

Other researchers have debated whether expertise is an innate ability or a type of giftedness in talent versus a learned ability gained from distributed practice (Ericsson & Charness, 1994). When the performance of the best practitioners is superior to the performance of other highly experienced individuals in a particular field, it leads to the belief of expertise being a unique and qualitative innate attribute.

Some researchers define expertise as inter-relatedness between innate ability and deliberative practice. This concept of expertise argues potential ability within the individual is brought forth, expanded, and maintained through knowledge, practice and training, and experience (Campbell, 1960; Simonton, 1996; Skinner, 1972). Sternberg (2001) proposed a model of giftedness as developing expertise. His theory is based on an interface between high abilities (genetics) and achieved excellence (environments, coaching, and training).

Approaches of Expertise

Three approaches are discussed in the area of expertise. One approach is developmental and in the area of reading (Wagner & Stanovich, 1996). The second approach is the individual difference strategy of the life-span theory (Simonton, 1990). The third approach is subjective biographical based on interviews, historical fact, and observations of experts in a particular field (Howe, 1996).
The area of reading could be considered a developmental approach in explaining expertise (Wagner & Stanovich, 1996). An example of this developmental approach is to define expert performance at a level that is five or more standard deviations above the mean performance shown by individuals with one year of training. A second example is to define expertise in terms of mastery of performance-based criteria. This would be the ability to read material at a given level of readability, with a specified reading rate, and demonstrate a particular level of comprehension of the given material.

Another approach to expertise is to use a life-span approach of individual creative productivity. This approach may be categorized into the individual difference strategy for defining expertise used in Simonton’s Longitudinal Model (Simonton, 1997). It is a life-span approach to examine creative productivity of individuals in different domains through their life course. The life-span approach is based on the variation-selection theory (Campbell, 1960; Skinner, 1972). This theory posits that creativity is a Darwinian process that entails both variation and selection. A creative mind spontaneously generates ideational combinations in an unpredictable manner and small portions of these combinations are selected for further elaboration, testing, retention, and application.

In consideration of the variation-selection theory, Simonton (1990) proposed a life-span longitudinal model of creativity. It is a mathematical model that predicts how the output rate of creative products varies across the course of a person’s career. The number of times a professor’s publication was cited in other publications was used by Simonton as a measure of expertise. In this way, he addressed the issue of quantity (number of publications) and quality (number of times cited by other people’s publications) of the publication output.
These concepts (quantity and quality of production) can be related to basketball officials’ careers. The number of games a basketball official is scheduled to referee in a year would indicate the quantity of the career, which is similar to the number of publications. The quality of a basketball official would be the rating an official gets from a coach on how well the coach felt the official performed during a game. The higher the rating would be similar to the number of cites (coaches give low or no rating if they do not like an official’s performance). This process is very subjective and inaccurate.

Simonton (1990) described age-related productivity in many domains as an inverted backward-J curve. According to Simonton productivity or creative output tends to increase relatively rapidly up to a definite peak production age and then there is a gradual decline. For example, in artistic and scientific domains productivity begins somewhere in the 20s, attains a high point somewhere in the late 30s or 40s, and then starts to gradually decline.

Schulz and Curnow (1988) reported age-related patterns of performance in different sports. They found that performance by athletes that participated in different sports peaked at different times. In this study performance for swimming, sprinting, jumping, and tennis peaked in the early to mid 20s and then started to gradually decline. Performance in long-distance running, baseball, and golf peaked in the late 20s and early 30s and then started to gradually decline.

Schulz, Musa, Staszewski, and Siegler (1994) examined the relationship between age and major league baseball players’ performance. Results from this research indicated that the performance of the professional baseball players was similar to Simonton’s inverted backward-J curve. Performance increased rapidly from age 19 until mid to late
20s or early 30s and then gradually decreased. In a longitudinal review of the careers of the Hall of Fame baseball players, these researchers found that elite players are not only better throughout their entire careers but maintain their peak level of performance for a longer period of time than their counterparts. It was also found that the elite players’ performance declined at a slower rate than their counterparts.

Schulz et al. (1994) found a more differentiated picture of age-related performance when the peak performance ages by the type of tasks were examined. Some tasks (base stealing and striking out batters) followed the inverted backward-J curve. These findings suggested the physiological capacity (e.g., reaction time, hand speed, foot speed) had peaked in the mid 20s. Of interest was the fact that fielding ability appeared to increase with age even into the mid 30s. Although reaction time and speed were essential components of good fielding, it required other types of knowledge. For example, older defensive players fielding the ball knew where to play on the field for a particular opponent, had knowledge about the physical characteristics of different stadiums, and were able to make better decisions about what to do with the ball once they had caught it (fielded it). It appeared that older defensive players anticipated where to position themselves on the field in accordance to the offensive player at bat. The older defensive player knew the physical characteristics of the stadium baseball fields as to better anticipate how the baseball would roll or move on the field after it was hit, based on the stadium’s physical characteristics. Experience played a role in the increased and improved performance of fielding ability with age and may have mediated the possible effects of age.
Sterns and McDaniel (1994) reviewed several large meta-analyses to examine the relationship between age and job performance. Although this research was not done in the area of expertise, the relationship between age and performance was found to be weak ($r = .06$). Overall this relationship was found to be weak whether performance was measured by subjective supervisory ratings or more objective measures. In examination of nonprofessional occupations the relationship was positive but weak ($r = .06$), while age showed a slight negative relationship with performance for professional occupations ($r = -.08$). These researchers found that sample age range was the largest moderator of the relationship between age and job performance. Studies using younger samples with mean ages in the mid 20s, demonstrated a modest relationship between age and performance ($r = .16$). Studies that used higher mean ages had a weak relationship ($r = .04$). Age may be more predictive of younger workers than older workers. It could be that for younger workers, the association between age and job performance is greater because of the amount of job knowledge required to achieve satisfactory job performance. It is understood that these researchers discussed age range as the largest moderator between age and performance. However the amount of job knowledge gained from experience may be beneficial for older workers and experience may mediate age effects.

The third approach to expertise has been by the subjective collection of many historical facts, interviews, and observations about exceptional individuals in popular and academic biographies. Howe (1996) used this descriptive biographical approach to describe the general characteristics of the childhoods and early careers of geniuses. Howe compared these people in hopes of discovering similarities between exceptional individuals. Finding similarities would lead to a base for replicable skills used by
individuals that may be taught to non-experts in their efforts to become experts. Unfortunately much of the Howe’s biographical information was given by these exceptional individuals retrospectively many years after their accomplishments have been recognized by their peers (Ericsson, 1996). Howe’s work is worth noting because it was the first of its type but subjective.

These approaches focused on the search for general patterns of development across exceptional individuals. In essence, once knowledge, skills, abilities, and other attributes are identified, they may then be taught to novices to be used in their development of expertise over time in a particular domain.

Anticipation

One skill that appeared to surface in different fields of expertise is anticipation. This was evidenced with Schulz et al. (1994) with the increased performance of fielding ability with age. Ward and Williams (2003) found that anticipatory performance and situational probabilities were the best variables for discriminating across skill abilities between expert and novice soccer players. Ward and Williams (2003) found that regardless of age, elite soccer players were more successful at anticipating pass destinations than sub-elite soccer players. Helsen and Pauwell (1993) found expert soccer players could select more appropriate actions and had the ability to generate their actions faster than novice soccer players do. Abernethy (1991) found that elite athletes in racquet sports had better anticipation of opponent responses even before their opponent’s racquet made contact with the ball or birdie compared to the novice or less experienced players.

Some researchers have studied the expert-novice differences judging competitions in gymnastics. Bard, Fleury, Carriere, and Halle (1980) found that expert
judges focused more on different areas of the body than novice judges. Ste-Marie and Lee (1991) demonstrated how expert judges were more accurate in the identification of form errors in performance than novice judges.

Ste-Marie (1999) examined various sport-specific cognitive attributes that were believed to give experts an advantage in gymnastic judging. This research found that expert gymnastic judges were better at perceptually anticipating upcoming gymnastic elements from prior information than novice gymnastic judges. Basically, expert judges were better than novice judges in the use of advanced information about the competitors’ upcoming routine. Experts used the advanced information to anticipate upcoming elements in the routine to be performed (anticipation of body movements). The prior information helped experts decide where to focus their attention for the duration of each routine to score it. Gymnastics Canada certified all gymnastic judges with experience determining expertise, novices had 3 years or less and experts with 10 years or more judging experience. Implementing concept of the Canadian certification format for expertise, this dissertation determined expertise as 10 years or more for expert status and 3 years or less for novice status.

The similarity between the studies on expert soccer players (Ward & Williams, 2003), gymnastic judges, and professional baseball players (Schulz et al., 1994) in relation to replicable skills is that these officials anticipated the players’ movements. The gymnastic judges, professional baseball players, and expert soccer players need to make a speeded decision (within 1-2 seconds) based on their observations. These people must anticipate “the play” of their opponents to have superior performance. It is possible that
the anticipation of performance may be a replicable skill identified across different fields of expertise.

The Study and Variables

The study examined expert and novice differences between individuals who are licensed basketball officials in the State of Ohio at the high school and lower levels. This study examined the effects of knowledge, age, and experience on the novice/expert performance differences.

Age

Age is defined as chronological age in this study. For the purposes of this study the terms older adult and older official were analogous and defined as $\geq 37$ years. The terms younger/young official and younger/young adult were also analogous and defined as $\leq 36$ years.

Knowledge and Procedural Performance

In this study knowledge is a five part variable. Three parts of the knowledge variable are related to basketball officiating (declarative, procedural, and justification). Two parts of the knowledge variable are related to aging literature, crystallized abilities (maintain or increase with age), and fluid abilities (maintain or decrease with age).

The basketball officiating first knowledge variable was declarative knowledge. It is the knowledge of facts, concepts, principles, rules, etc. of the game of basketball. The second part of the knowledge variable was procedural knowledge, which is the application of the rules, mechanics, and consequences of each call. Procedural performance is also the free recall and demonstration of hand signals used in basketball officiating. The procedural performance measure part of this variable also included the
demonstration of the whether a foul or violation occurred while viewing videotape/DVD basketball scenarios. The third part of the knowledge variable was justification knowledge. It is a type of retrospective reporting of the players’ actions that occurred at the time of the foul or violation reported by the basketball official (usually given in a verbal explanation to a basketball coach). It was expected that basketball knowledge would mediate the effects of age between older and younger expert officials’ performance differences (refer to Figure 1).

![Experience model diagram]

Figure 1. Experience model.

The fourth knowledge variable was crystallized mental abilities (Gc). They are defined as skills that are a function of more organized, systematic, and acculturated learning (Hayslip & Panek, 1989). It was expected that older officials would have higher scores on measures of crystallized abilities than younger officials.

The fifth knowledge variable was fluid mental abilities (Gf). Fluid abilities are defined as the process of perceiving relationships and educing correlates, as well as the maintenance of a span of immediate awareness in reasoning, abstracting, conception formation, and problem solving (Hayslip & Panek, 1989). It was expected that younger officials would have higher scores on measures of fluid abilities than older officials.
Experience

The experience variable was broken down into two parts. One part of experience variable was called general experience. It was considered to be the total amount of experience an official has in the sport of basketball. It took into account the years officiating, playing, coaching, types/amount of training, camps attended, and state tournament game assignments. It was expected that the years officiating part of this variable would mediate the effects of age between older and younger expert officials’ performance differences (refer to Figure 1).

The second part of the experience variable was expertise. For the purposes of the study it was also called specific experience. Expertise as specific experience was defined in accordance with the State of Ohio guidelines as being classified either a Class 1 or Class 2. Experts were defined as Class 1 basketball officials with 10 or more years of basketball officiating experience. The person must then pass a closed book test on the rules and mechanics of officiating with a score ≥ 80% within 3 years of officiating experience. Novices were defined as Class 1 and 2 basketball officials with 3 years or less basketball officiating experience. Class 2 officials have 2 or less years officiating experience. A Class 2 official must also pass the rules and mechanics tests but the test is open book with a score ≥ 70%.

Anticipation

Another important reason for this study was the identification of anticipation (predicting players’ movements) as a core skill associated with developing expertise. It was identified as a skill used by experts in other fields (Ste-Marie, 1991, 1999; Ward & Williams, 2003) and is further described in Chapters II and III.
CHAPTER II
HISTORICAL CONCEPTS OF EXPERTISE

In order to understand expertise as experience it is necessary to understand some of the historical concepts of expertise. There are two major historical concepts of expertise. The first of these two concepts are the innate abilities or attributes that were considered to be gifts from the gods. The second concept of expertise is more related to the study. This concept describes expertise as a knowledge and pattern-based retrieval process. Expert performance was the result of the vast amount of knowledge and patterned-based retrieval acquired over many years of experience and practice (Ericsson & Charness, 1994). This chapter begins with a historical review of expertise.

Due to the exploratory nature of this study it is difficult to have one theory be applicable to the research and promote theory development. Although the theories discussed may not closely relate to the study, they may help in understanding adult cognition as we age and expertise development.

Rybash, Hoyer, and Roodin’s (1986) theory of adult cognition called the Encapsulation Model is discussed as well as Sternberg’s (2001) model of giftedness as “developing expertise.” A Molar Equivalence-Molecular Decomposition Strategy introduced by Neil Charness (1979, 1981, 1983) in his studies on skilled bridge and chess players/masters is discussed. This is followed up by Salthouse’s (1987) definition of
training as it bears similarity to Ericsson’s (1996) concept of deliberate practice in relation to age and expertise.

Other discussions in this chapter include public records of expertise as well as expertise in the judging of gymnastics. There is also a brief mention of cricket umpire errors and their effect on the game of cricket. Finally the chapter explains the concept of basketball officiating along with the purpose and variables of this study on expertise and amateur basketball officials in the State of Ohio.

Innate Abilities

Early Greek philosophers speculated that highly desirable individual attributes and exceptional skills in different types of handiwork were gifts from the gods, and only one gift was given per person (Murray, 1989a). Jon Stuart Mill, an 1800s British philosopher and economist, considered the concept of innate abilities to be man’s common tendency to consider any power that is not visibly the effect of practice. He considered innate abilities to be all skill which is not capable to being reduced to mechanical rules and the result of a particular gift (Murray, 1989b).

Ericsson and Charness (1994), in their review of the historical concept of innate abilities, believed the bias in attribution was linked to the immediate legitimatization of various activities associated with the gifts. This attribution bias led to the style of thinking that since the gods bestowed a special gift upon an individual, opposition about the gift’s origin would be minimal, and its development and facilitation is for everyone’s enjoyment (Ericsson & Charness, 1994).

Sir Francis Galton (1869/1979) was one of the first scientists to empirically investigate the possibility that expertise in diverse domains may have a common set of
causes. He argued that three factors had to be present for superior performance: innate ability, eagerness to work, and adequate power to do a great deal of laborious work. Two factors Galton mentions consider the role of motivation (eagerness to work) and effort (adequate power to do a great deal of work) along with an innate ability. This brought in the concepts of instruction and practice in conjunction with innate ability. Even though Galton acknowledged a role for instruction and practice in achieving exceptional performance/expertise, he believed performance increased monotonically as a function of practice toward an asymptote which represented a fixed upper bound on that performance. According to this view, performance achieved after extensive training is limited by components that cannot be modified, thus suggesting a genetic role in determining the ultimate level of performance.

The view that talent or giftedness is necessary to attain the highest level of performance in an activity is widely held among people in general. It is a particularly dominant theme in the domains of expertise related to chess, sports, music, and visual arts (Ericsson & Charness, 1994). Millions of people are active in these areas but only a relatively small number of people in proportion to the activity, reach the pinnacle of performance.

A prominent scientist who drew evidence from the exceptional performance of artists, scientists, and athletes for a biological theory on talent was Gardner. In his 1983 book, *Frames of Mind: Theories of Multiple Intelligences*, he put forth a theory proposing seven intelligences including: linguistic, musical, spatial, logical-mathematical, bodily kinesthetic, interpersonal, and intrapersonal intelligence. Each of these intelligences was considered an independent system with its own biological bases. His theory was a
refinement of an earlier theory where Gardner expressed a position on talent (especially musical) as being hereditarily based (Gardner, 1973).

He gave evidence for this hereditary basis on the discovery of musical talent in children between the ages of two through six years in homes where relatively little music was heard. Gardner’s (1983) writings defined talent as not being an innate structure or gift but rather a potential for achievement as well as the capacity to rapidly learn material relevant to one of the intelligences. Gardner believed that these intelligences made an individual so “blessed” that he/she not only has an easy time learning new patterns but also learns them so readily that it is virtually impossible for one to forget them.

In his 1999 book, *Intelligence Reframed: Multiple Intelligences for the 21st Century*, Gardner believed that two more intelligences could be added to the original seven. He thought that the two intelligences, naturalistic and existential, adequately met his eight criteria for intelligence. Naturalistic intelligence is the knowledge and expertise in the flora and fauna of one’s environment. Existential intelligence is the capacity to locate oneself with the respect to the furthest reaches of the cosmos, the infinite, and infinitesimal (Gardner, 1999). Existential intelligence also includes the capacity to locate oneself in relation to the features of the human conditions such as the significance of life, meaning of death, the ultimate fate of the physical and psychological worlds, and experiences in the love of another person or total immersion in a work of art (Gardner, 1999). Notice he used the term expertise in his definition of naturalistic intelligence and being an expert on one’s environment would qualify a person as a naturalist. A person, who demonstrates expertise on life, the meaning of life, and death would qualify a person as an existentialist.
Sternberg (2001) discussed a model of giftedness as developing expertise. He considered giftedness as an interface between high abilities and achieved excellence. This view considered giftedness to be the integration between the static and dynamic views of abilities – developing expertise. Sternberg theorized that giftedness was a stable attribute (static view) of individuals that develops as an interaction between heredity and environment. He further stated that giftedness might be found within a zone of proximal development – an unusual ability to advance attributes that are ready to be developed or the potential to be developed, to those attributes that are already developed (dynamic view). His theory proposed that giftedness was an interaction between these static and dynamic views with giftedness as a construct of developing expertise.

Sternberg (2001) argued that a static view of abilities isolates a slice of performance in time while a dynamic view of abilities isolates a region of performance in time. He expressed the belief that both static and dynamic abilities are completely intertwined with expertise. Both views represent approaches in the long-term continuum of developing expertise.

Understanding the concept of innate ability/giftedness in relation to expertise is an important part of the history in the study of expertise. One reason understanding innate ability is important to the study of expertise is due to the genetic aspects of the individual. Other reasons for knowledge of the innate ability concept are to recognize its relationship in the development of expertise theories, the popularity of its belief, and the amount of research promoted to prove or disprove the concept of innate ability. Unfortunately it is beyond the scope of this research to examine innate abilities of an individual and so it
must remain for other studies to research the innate ability or giftedness aspects of expertise.

Knowledge and Pattern-Based Retrieval

Not all researchers agree with the innate ability or giftedness/talent concepts. Chase and Simon (1973) believed expert performance in any skilled task was the result of vast amounts of knowledge and patterned-based retrieval acquired over many years (10 years, 7,000-10,000 hours) of experience and practice in the associated domain. This was the basis for the 10-year preparatory period in a particular domain to attain the status of expert.

The knowledge and pattern-based retrieval conception of expertise is consistent with the theories of skill acquisition (Anderson, 1983; Fitts & Posner, 1967). They are based on the assumption that knowledge is first acquired and then organized into procedures for responding to encountered situations. Practice allows appropriate actions to be assessed automatically through pattern-based retrieval.

Rikers, Winkel, Loyens, and Schmidt (2003) examined differences in expert (cardiologists), sub-expert (pulmonologists), and advanced medical students in diagnosing clinical cases within the domain of cardiology. The participants had to evaluate two cardiological clinical case descriptions. One was a case of aortic valve insufficiency and the second, a case of congestive heart failure. The clinical case descriptions were constructed by two experts in the field of cardiology and based on actual patients treated at the Maastricht University Hospital.

These clinical cases were divided into four components- patient history, physical examination, laboratory data, and additional findings. Participants’ reading times were
recorded, a diagnosis was given directly after completion of reading each clinical case, and then participants wrote down everything they remembered from the clinical case descriptions. These researchers expected to find that the students and sub-experts would focus on different aspects of the case components than the experts. This result was expected due to their (students and sub-experts) lack of specific expertise.

The results indicated that (as expected) experts were the most accurate at diagnosing the clinical cases and sub-experts were more accurate than the medical students at diagnosing the cases. However, there were no significant differences between the experts, sub-experts, and students in focusing on case components. All participants considered the patient’s history and physical examination of high diagnostic importance. The results showed that experts and sub-experts did focus more on additional information than the students. However, the students recalled more patient history than experts and sub-experts.

The main difference between experts, sub-experts, and students was not in the emphasis on a component in a clinical case, but the experts’ greater speed and accuracy of processing the clinical case. Only the experts possessed the ability to use and understand the additional information (signs and symptoms) displayed in these components and link this information to the main diagnosis. These researchers discussed the use of illness scripts (cognitive representations of diseases) by physicians to store information about diseases from patient-related clinical case histories. When diagnosing clinical cases, any information that matches a certain illness script activates that particular script (pattern-based retrieval). This is an automatic process for experienced
physicians and could be one reason for the experts’ greater speed and accuracy in processing and diagnosing of the clinical cases in this study.

Allard and Starkes (1991) examined expert performance beyond pattern-based retrieval. Drawing from evidence related to perceptual motor expertise in sports, these researchers found that elite athletes are able to extract and recall more information after brief exposure to representative game situations. The elite athletes are able to internally represent complex game situations that allow them to predict and anticipate future actions of opponents. Internal mental representations based on cues from game situations enabled elite athletes to anticipate opponents’ movements and select more appropriate actions.

The anticipatory preparation of future movement has been found in other sports. Ward and Williams (2003) found that regardless of age, elite soccer players were more successful at anticipating pass destinations than sub-elite soccer players. Helsen and Pauwell (1993) recreated standardized situations from world-class soccer games. They found expert soccer players could select more appropriate actions and had the ability to generate their actions faster than novice soccer players do. Abernethy (1991) found that elite athletes in racquet sports had better anticipation of opponent outcomes. These elite athletes anticipated their opponent’s response even before their opponent’s racquet made contact with the ball or birdie compared to the novice or less experienced players. It may be possible that anticipation of future actions helps older adult experts compensate for slower reaction time and physical movements (effects of aging). This also highlights the importance of acquiring mental representations through experience and gaining experience relates to increased chronological age (10-year preparatory period, Chase & Simon 1973).
Ericsson and Kintsch (1995) stated that mental representations are part of the acquired memory skills. These mental representations allow experts to increase the functional capacity of working memory for domain specific information stored in long-term memory. The domain-specific representation of complex activities in long-term memory enables experts to acquire and preserve other domain specific representations that aid in the planning, prediction, and evaluation of other domain specific situations.

Adult Cognition and Expertise

In relation to expertise and age, it must be remembered that as a person gains years of experience, practice, and knowledge he/she ages physically and chronologically. Rybash, Hoyer, and Roodin (1986) advanced a theory of adult cognition which they called the Encapsulation Model. Before discussing the model one needs to understand these researchers’ view of adult cognition and definition of encapsulation.

To be encapsulated is to put something within a container, capsule or category (e.g., domain-specific information). The model is based on the emergence and increased differentiation of domain-ordered knowledge specializations as we age. They argue that the organization of substantive knowledge plays a distinct role in adult development. Their argument is based on four issues. The first issue is a lack of age-ordered, biologically programmed development. The second issue is an emergence of a differentiated cognitive system based on experience that incorporates various affective and motivational variables (similar to Masunaga & Horn, 2001- experts’ independent working memory system). The third issue deals with the increased encapsulation of input analyzers as well as other aspects of the information processing systems (e.g., memory access) with age and experience within specific domains. The fourth issue incorporates
environmental press factors that encourage experienced-based cognitive differentiation through the development of domain-specific knowledge specialization. This is similar to the acquired mental representations of Ericsson and Kintsch (1995).

According to Rybash et al. (1986), the development of adult cognition is a priori unspecifiable and distinct from pre-adulthood cognitive development. It is these researchers’ belief that early years of cognitive development are relatively morphogenetic, inevitable, momentous, and uniform. They characterize adult cognition as experiential, irreversible, nonuniversal, and directed toward domain specific mastery. The extent that adult and pre-adult cognitive development is uniform can be attributed to commonalties in the experiences in adulthood. Therefore adult cognition is a priori unspecifiable due to the knowledge domain dependency and age-related interindividual differences in mastery in the selected domains. Rybash et al.’s (1986) position was that adult cognition changes in its overall form and organization with consequent changes in the acquisition of knowledge.

Rybash et al. (1986) promoted a functional view of knowledge acquisition, representation, and organization in which the degree of compartmentalization of cognition is a function of the individual being represented. This contrasts with Gardner’s (1983, 1999) view of multiple, hardwired intelligences. The functional view suggests that people create unique domains of knowledge differentiated in complexity. People build personal knowledge systems to foundations that represent how they use their mental resources. These domains of knowledge are representations of the individual’s different areas of cognitive involvement.
There may be some universality due to cultural and species factors. However, there are unique environmental and person-based factors involved in the evolution and structure of adult cognition. Therefore, the person plays an active role in the construction of knowledge domains and the allocation of psychological resources. These concepts are similar to Sternberg’s (2001) model of giftedness as “developing expertise.” Sternberg expressed the belief that both static abilities (psychological resources) and dynamic abilities (construction of knowledge domains) are completely “intertwined” with expertise.

The Encapsulation Model of Rybash et al. (1986) integrated three strands of adult cognition: processing, knowing, and thinking. Processing refers to the manner by which different mental abilities and psychological resources are used to encode and process information from the environment. Knowing refers to how this processed information is represented, stored, accessed, and used. Thinking refers to the way individuals develop an understanding/perspective on their knowledge. This model stipulates that informational control processes and fluid mental abilities become increasingly related to and encapsulated within particular domains of knowledge throughout adult development. As one’s general processes and abilities are encapsulated within a particular parameter of knowledge domain (or domain-ordered knowledge systems), extant knowledge becomes more accessible, differentiated, usable, and “expert” in nature.

The acquisition of new, unrelated knowledge may become increasingly less efficient with advances in age (Salthouse, 1991). According to the Encapsulation Model the reduced capacity to acquire new, unrelated knowledge may be compensated for by the development of encapsulated expert knowledge. Once adults conceptualize their domain
specific knowledge in relativistic, dialectic, and open-ended manner, they are capable of solving life’s ill-defined problems, find new ways and perspectives to solve problems, and produce creative as well as sophisticated works within the defined areas of expertise (Rybash et al., 1986). The athlete’s ability to anticipate an opponent’s future movements and then select appropriate reactions to the anticipated moves could be due to the encapsulation of domain-specific knowledge and experience in relation to the particular sport.

Masunaga and Horn (2001) conducted research that examined concepts similar to encapsulation. These concepts were expert deductive reasoning and expertise working memory. Expert deductive reasoning was considered to be a form of deductive reasoning that characterizes the complex problem-solving abilities of experts. This reasoning is dependent on a person’s ability to perceive relationships and draw inferences based on these relationships from complex stimuli.

Masunaga and Horn’s (2001) concept of expertise as a working memory that is a domain-specific memory system built up and developed over time. Expertise working memory’s span and flexibility is a function of the extent to which material is important and meaningful to the person remembering the stimuli. The expert’s recall and recognition of the domain-specific information is greater and more lasting than for information that is not domain-specific.

In short, Masunaga and Horn’s (2001) research found that expertise deductive reasoning and expertise working memory were factors independent of fluid reasoning abilities and short-term working memory. Expertise deductive reasoning is a separate type of reasoning that is independent of fluid reasoning and expertise working memory.
may be another separate memory system independent of short-term working memory. Encapsulation of domain-specific knowledge may be a way for a person to develop expertise deductive reasoning skill and expertise working memory.

Other researchers have also believed that experts can use a different form of storage than short-term working memory (Ericsson, 1996; Ericsson & Kintsch, 1995). Ericsson and Kintsch (1995) referred to this different form of storage as long-term working memory. The difference between the expertise working memory concept and long-term working concept is that Masunaga and Horn (2001) proposed it operates in the short-term.

Horn and Masunaga (2007) in review of their 2001 study and others (Ericsson, 1996; Ericsson & Kintsch, 1995) reported that the evidence of the research indicates expertise working memory differs from short-term memory in four ways. First, the amount of information stored in expertise working memory is larger. Second, the information that is stored in expertise working memory is less affected by disruption and distraction. Therefore resumption of a task after disruption is more effective, and more information is retained during multi-tasking. Third, the order of recall is more flexible so it can differ from the order of presentation. Fourth, information is encoded in long-term memory and can be retrieved when recall is requested unexpectedly. Either way of defining what the evidence from the research presents, encapsulation of domain-specific knowledge may be a way for a person to develop expertise deductive reasoning skill and expertise working memory.

Other research results of Masunaga and Horn (2001) indicated factors that increase the level of expertise. For example, well-defined practice and intense practice
may stop the age-related decline of intelligence in the domain-specific abilities of expertise. With this in mind, a review of the molar equivalence-molecular decomposition strategy and deliberate practice would be appropriate. Molar equivalence-molecular decomposition strategy could be a method to discover replicable skills and deliberate practice as an example of well-defined/intense practice.

Molar Equivalence-Molecular Decomposition Strategy

Salthouse (1987) believed that the terms expertise, experience, practice, and training needed clarification in relation to aging. His definition of expertise was that extremely high levels of skills within a particular domain occur as a consequence of experience. He distinguishes practice from training in that training is an attempt to control the nature of the acquisition of experience, while practice had little direction or control in the acquisition of experience. Salthouse (1984, 1987) elaborates on the Molar Equivalence-Molecular Decomposition Strategy to examine how people of different ages and different amounts of relevant experiences accomplish the same overall level of performance.

The Molar Equivalence-Molecular Decomposition Strategy involves selecting a sample of adults from a wide range of ages and proficiency on a particular molar activity that exhibits no correlation between age and overall competence. The molar activity is then broken down into its molecular processes (component parts/processes) to examine if any age trends can be detected in the individualized components. The advantage of this strategy is the focus on the mechanisms responsible for a given level of molar performance. It allows the researcher to determine what compensatory mechanisms (if any) might allow older adults to overcome deficits experienced with increased age.
The Molar Equivalence-Molecular Decomposition Strategy was first introduced by Neil Charness (1979, 1981, 1983) in his studies on skilled bridge and chess players (masters). A consistent finding in this research was that memory for domain-relevant information was positively related to skill levels and negatively related to the player’s age. Expertise in a given domain is associated with more extensive and better organized declarative (factual) and procedural (how to) knowledge relevant to a particular domain. These are the consequences of relevant practice and experience within a specific domain (Salthouse, 1987).

This was the research strategy used by Salthouse (1984) in a study that examined the skill level of older and younger adult typists. He studied anticipatory movements of older skilled typists. The older skilled typists looked two letter characters ahead in the text segments that would be typed moments later. The use of an increased preview window gave older adult typists the ability to type as quickly and efficiently as the younger skilled typists. The compensatory mechanism used by the older adult typists was the increased preview window in which they looked two characters (approximately 350 milliseconds) ahead in the text versus younger adult typists. The younger typists relied strictly on their faster perceptual motor speed, which was determined to be faster using the Molecular Decomposition Strategy in this study.

Deliberate Practice

Salthouse’s (1987) definition of training as an attempt to control the nature of the acquisition of experience with the manipulation of the quality and quantity of the relevant experience received by an individual is similar conceptually to Ericsson’s (1996) concept of deliberate practice. Ericsson defined deliberate practice as a well-defined task with an
appropriate level of difficulty for a particular individual, informative feedback, and an 
opportunity for repetition and correction of errors (see Chapter I for a review of 
Ericsson’s concept of deliberative and well structured practice). Ericsson believed that 
when all these elements were present it characterized appropriate training activities for 
deliberate practice and the development of expertise in a specific domain (encapsulation).

Accordingly, the development of unique cognitive structures is the basis for 
expert performance. Once developed they are maintained and expanded through 
deliberate practice and training and activities related to the expert performance domain. 
In summary, the maintenance of expert performance could be due to the unique structures 
acquired through expert performance, deliberate practice/training, or both.

The most marked age-related decline is generally observed in the physical motor 
performance displayed in many types of sports (Ericsson & Charness, 1994), and an 
individual must maintain high levels of deliberate practice and training to attain the 
physiological adaptation found in expert performance (Ericsson & Charness, 1994; 
Salthouse, 1987). Most of these adaptations require maintenance of practice, for without 
practice; there can be a decline in performance. Thus some age-related decline in 
performance may be attributed to a reduction or termination in practice and training.

Inquiry of Public Records

In another line of inquiry in relation to expertise, public records, information 
obtained about the highest level of performance from several domains (reading, chess, 
sports, music, and creativity) indicated that peak performance was obtained several years 
after physical maturation. The gathered evidence demonstrated that elite performance 
was attained gradually after approximately 7-10 years of intense preparation in the
specific domain. This time period as well as the intense preparation was necessary to acquire an international level of skilled performance (Ericsson, 1996).

Expert performance is historically bound. The best performances of a time period are only outstanding based on the level of other performances of that time period. Historical records in many domains demonstrate that the increases in performances usually occur as time increases. A classic example of this is the breaking of many records by athletes who participate in both amateur (high school and Olympic levels) and professional sports (Ericsson, 1996).

Although the person’s unique athletic ability is often recognized, one only has to attend a sporting event and hear the comments or jeers of the spectators to realize the different expectations based on these talents. Not only are athletes under critical review, the men and women who officiate these sporting professional and amateur events are under observation as well.

Cricket Umpiring and Gymnastics Judging

Although there is an abundance of expertise literature on athletes in sports (Abernethy, 1987, 1988, 1990; Abernethy, Neal, & Konig, 1994; Allard & Starkes, 1991; Helsen & Pauwels, 1993; McPherson & Thomas, 1989; Nielsen & McGown, 1985; Shank & Haywood, 1987; Shea & Paull, 1996; Starkes, Deacon, Allard, Hodges, & Hayes, 1996 to list a few), and coaches (Cote, Salmela, & Russell, 1995a; Cote, Salmela, Trudel, Baria, & Russell, 1995b; Salmela, Draper, & LaPlante, 1993), a review of the literature on sports officiating indicated little research in area of expertise in officiating. With the scrutiny at which the general public critiques the officials’ performance one would expect a need for this line of inquiry.
Research in the area of expert-novice differences in sports officiating has been done in area of judging gymnastics. Umpiring errors in the sport of cricket have also been examined, although there were not any expert-novice comparisons in the study. Chedzoy (1997) examined umpire errors in the dismissal of batsmen. He found these umpire dismissals require rapid decision making and that incorrect dismissal by umpires can have a significant effect on the outcome of a game. The misjudgments are part of a binary decision process that can lead to feelings of injustice on the part of a team and spectators as well as the batsmen. These are the same type of feelings that may occur when spectators, coaches, and players believe an error in judgment or a “bad call” has been made by any sports official (e.g., basketball official).

In the research pertaining to expert-novice differences in gymnastic judging, Bard, Fleury, Carriere, and Halle (1980) found that expert judges watched different areas of the body than did novice judges. Ste-Marie and Lee (1991) demonstrated how expert judges were more accurate in the identification of form errors in performance than novice judges. These two studies, however, were limited in the aspects of expertise examined because they only dealt with the visual detection component of judging.

Ste-Marie’s (1999) research examined various sport-specific cognitive attributes that were believed to give experts an advantage in gymnastic judging. The research found that expert judges were better than novice judges at perceptually anticipating upcoming gymnastic elements from advanced information. The gymnastic elements that were correctly anticipated were judged more accurately than elements incorrectly anticipated by both expert and novice judges. Experts also demonstrated significantly greater depth and breadth in their declarative knowledge base. These findings are consistent with other
expertise research that has indicated an expert advantage related to acquired processing strategies (Abernethy, 1991; Abernethy et al., 1994; Allard & Starkes, 1991; Helsen & Pauwell, 1993; Ward & Williams, 2003).

Basketball Officiating

Goldstein’s (1993) training literature may be used as a guideline in approaching the topic of basketball officiating. A training needs assessment could be converted into an officiating needs assessment. The training needs assessment is comprised of three parts: organizational analysis, task/knowledge/skills/ability assessment and person analysis. The three parts could be used to develop an officiating needs assessment. All three parts of the training/officiating needs assessment have to be put into behavioral terms for measurement and identification purposes.

An organizational analysis would assess the short- and long-term goals of officiating. The trends and rule changes that would have an impact on an official’s decision in relation to the sport/game being officiated must be considered in this phase of the officiating assessment. Another aspect of this type of analysis focuses on the types of training programs and support systems available in which officials participate.

The second step of the officiating needs assessment would require a task, knowledge, skill, and ability analysis. This would be an assessment of the job to be performed by the officials. A job analysis and job description would be done to identify the necessary knowledge, skills, and ability (KSAs) to determine who could be an official.

The third step in the officiating needs assessment is a person analysis. This part of the analysis indicates the actual performance level of the official in relation to the
necessary KSAs to officiate a particular sport/game. An important aspect of person analysis is the determination of the existing levels of KSAs and what an official needs to learn to improve his/her officiating skills. These steps are used to determine existing skill level and what training is needed for improvement of job performance. This training guideline may be used to identify what core skills are needed to become an expert in a given field.

The Study: Amateur Basketball Officials

The current research studied expertise and performance/skill level of people who officiate/referee amateur basketball in the State of Ohio. It examined the effects of knowledge, age, and experience on the novice/experts performance differences. The study looked for skill differences between amateur basketball officials, young expert basketball officials, and older expert basketball officials.

First is a definition of the state-required qualifications to be a licensed basketball official in the State of Ohio, as well as the different classes of basketball officials. A current challenge for sports officials is that athletes that are faster and stronger than those of the previous decades. As a result, the officials of today are held to a higher level and standard of professionalism than those of the past due to this higher quality of athleticism (Officials’ NFHS Quarterly, 2002).

In Ohio, at the high school level of sports competition, officials must attend courses that teach the rules and mechanics to officiate these sports (Referee, 2002). After completion of the coursework, an official must pass the state-sanctioned test (70% correct responses, open rule book test), to be a licensed official for junior varsity (JV- 9th & 10th
grades) and lower levels of athletic competition (elementary and middle schools). This licensure is certified as a Class 2 official in the State of Ohio.

To officiate sports at the varsity level a Class 2 official must have 2 years officiating experience at the JV and lower levels, attend the yearly State Rules Interpretation Meeting, attend four local meetings for officials (per year), and pass the state-sanctioned varsity level test (80% correct responses, closed rule book test). A person is then reclassified and licensed as a Class 1 official for that particular sport. To maintain this licensure a person must still attend the State Rules Interpretation Meetings and four local meetings (yearly). This is the standard procedure for licensure to become a Class 1 varsity official in the State of Ohio for any sport.

There are additional requirements held for varsity officials by the people who assign basketball games for a particular school district (i.e., assignors). Some districts/leagues may not use assignors and have the Athletic Directors of the particular school assign games to officials. To officiate varsity games, some assignors require a person to have a Class 1 licensure, a minimum of 4-5 years experience in officiating the sport, and a minimum of one attendance to a three-man officiating camp sponsored or recognized by the state. Different assignors also send observers to different games to rate the officials’ performance while doing a game. The officials may or may not know when they are being rated, the observer has the option to inform or not inform the officials of his/her presence. The rater is always another Class 1 official. Each assignor has his/her individual requirements for different rating levels.

In sections of the state that have Athletic Directors who assign games to officials, there may be a league commissioner who observes and rate officials’ performances. A
report is sent to the state as well as to the officials, indicating the rating of individual officials and the team of officials as a whole.

Based on these different qualifications, this study defined an expert official as a person with a Class 1 licensure and a minimum of 10 years officiating or refereeing experience. A novice official is a person with a Class 1 or Class 2 licensure with 3 years or less basketball officiating experience. The licensing body is the Ohio High School Athletic Association (OHSAA) in conjunction with the National Federation of State High Schools (NFHS).

As stated earlier this study examined the expert and novices differences between individuals who officiate or referee amateur basketball in the State of Ohio in relation to age, knowledge, expertise, and experience. Participants were licensed State of Ohio basketball officials as described above. The study attempted to identify the effects of knowledge, age, and experience on expert/novice differences. There are three other variables related to this study: anticipation, complexity, and levels of information. The study focused on the concepts of age, experience, and expertise.

In relation to mediation two mediators were expected, experience and knowledge. It was expected that experience would mediate the effects of age on procedural performance differences between older and younger expert officials. It was further expected that knowledge would mediate the effects of age on procedural performance differences between older and younger expert officials. Mediation was expected due to the encapsulation of knowledge from experience.

In examination of expertise the study expected significant expert/novice differences in declarative, procedural, and justification knowledge in relation to
procedural performance. The expert/novice differences would be greater with increases in the levels of complexity and decreases in level of information (Allard & Starkes, 1991).

Anticipation was also examined in terms of expertise. The anticipation of player movements was identified as a core skill identified in accounting for differences between expertise levels of officiating. The anticipation of players’ or athletes’ movements has been seen in other sports. It was determined to be a difference between elite (expert) and sub-elite (novice) soccer players’ skills as well as other areas of expertise (Abernethy, 1991; Helsen & Pauwell, 1993; Ward & Williams, 2003). Anticipation of body movements was a skill difference between expert and novice judges in the judgement of gymnastic competition (Ste-Marie, 1999; Ste-Marie & Lee, 1991). If anticipation of player movements is a skill found in this study, it would be a core skill identified that crosses different fields of expertise. Future studies could develop different methods of teaching this skill.

Study Variables

This section describes the study variables of age, knowledge, experience, level of information, anticipation, and complexity.

Age

In sports an athlete is considered old at approximately 35 years of age. The study defined an older/old official as being ≥ 37 years of age. A younger/young official was defined as ≤ 36 years of age. Ericsson (1990) found that maximal heart rate and reaction time indicate an age-related decline when older master athletes are compared to younger master athletes. However if experience mediates the affects of age, it was expected there
would be no significant procedural performance differences between older and younger expert officials with significant expert/novice procedural performance differences.

Salthouse (1984) found that older adult typist typed as many words as young adult typist. The older adult typist experience enabled them to look approximately two characters ahead to compensate for age-related decline in reaction time. As a person ages and gains more time, experience, and practice as an official, he/she should gain more knowledge and encapsulate this knowledge for the development of expertise in the domain-specific field of basketball officiating.

Knowledge

This was an important variable to define in order to determine its impact on expertise in basketball officiating. For an individual to have knowledge about basketball officiating he/she would have to be more than a student of the game. A person would have to know the rules of basketball as well as the specific mechanics to officiate two and three man crew games. Not only would one have to know the particular rules and mechanics but also an official has to have an understanding of the application of these rules and mechanics.

For the purposes of this study there were three types of knowledge in relation to basketball officiating. They were declarative, procedural, and justification. Declarative knowledge involves facts, concepts, principles, and laws. Sternberg (2001) defined declarative knowledge as “knowing that”. In basketball officiating, it is knowledge of the rules, mechanics, and the consequences for each foul or violation (call) in basketball. To be a licensed high school basketball official in the State of Ohio an individual must pass a two- part test over the rules and mechanics administered by the state (two-man
mechanics). Declarative knowledge can be measured by the use of the actual questions the State of Ohio administers to people for licensure.

Written vignettes were used to determine knowledge differences between the participants. The vignettes consisted of written game situations used by the State of Ohio in the casebook administered to all Class 1 and 2 officials. The vignettes were of three different complexity levels.

Procedural knowledge is knowledge of procedures and strategies, defined by Sternberg (2001) as “knowing how.” In basketball officiating, procedural knowledge is the actual application of the rules, mechanics, and consequences for each call. Procedural knowledge is a measure of contextual task performance variables/measures. It was measured by use of videotapes from actual high school basketball game situations in which a foul or violation (call) may have occurred. The game situations were selected to be of three levels of complexity and two levels of information provided prior to making the calls.

Another procedural knowledge variable is the knowledge of hand signals used to officiate high school basketball. Participants/officials were asked to free recall and demonstrate all of the 36 hand signals used in officiating basketball for the State of Ohio for a call (foul or violation). Hand signals were considered a procedural knowledge variable because it forces an official to think of the whole game process in order to recall all of the hand signals. At this point it is important to know the definition of a call. A call in basketball is either a foul or violation and each one has specific signals, mechanics for reporting the call, and consequences for play related to the call.
A foul by definition is an infraction of the rules, which is charged to individual player(s), coach/coaches, and/or team(s) and a call has a penalty attached to it. A violation is one of three types of rule infractions: Type 1- any kind of floor violation (traveling, out-of-bounds) including offensive basket interference, Type 2- defensive basket interference or goaltending, and Type 3- Free throw violation other than those involving basket interference or goaltending. A violation has no penalty attached to it but can result in the loss of ball-control (turnover), gain of ball-control (possession), or an additional free throw depending on the violation.

The final knowledge variable in relation to basketball was justification knowledge. Many times in a basketball game an official is asked to justify or explain the reason for the call to a coach. For the justification of the call the official must remember multiple actions that occurred at the time of the call. For example, on any call made by an official, he/she should be able to account for the number of players involved in the situation (foul or violation). An official must be able to recall the players’ jersey numbers, players position on the court floor, bodily positions of the players (verticality or horizontal), the rules, application of the rules, and the mechanics for reporting the call (hand signals, reporting procedures, etc.). An official must retrospectively recall and report this information while explaining/justifying the call to a coach. This type of information defines justification knowledge.

The use of retrospectively reporting the justification for a call viewed on the videotape was used to measure justification knowledge. The participant was asked a question, “why did you make the call or what did you see that determined your call?” This helped to identify the reasoning for a particular call. In reality, many times these are
the exact questions a coach will ask in a high school game situation. The retrospective reporting procedure enabled the determination of novice and expert decision-making differences in the information and types of schemas used in the process. In line with the prior research (Masunaga & Horn, 2001; Rikers, Te Winkel, Loyens, & Schmidt, 2003; Rybash, Hoyer, & Roodin, 1986; St-Marie, 1999; Ward & Williams, 2003) it was expected that older and younger expert officials would recall significantly more bits of information during the retrospective reporting than older and younger novice officials.

The last parts of the knowledge variable were crystallized mental abilities (Gc) and fluid abilities (Gf). To measure the participants’ crystallized mental abilities the Mill-Hill test was administered. The participants’ fluid mental abilities were measured by administration of the Test of “g”: Culture Fair-Scale 2, Form B. This type of test for fluid abilities is considered to be one of the best ways to test for fluid abilities because it required the detection of patterns in abstract and unusual material (Hunt, 2007).

Evidence of decline in abilities during adult development comes from both cross-sectional and longitudinal studies. Even though these two kinds of studies control for and reveal different kinds of influences, and have different strengths and weaknesses, they are in agreement in respect with many findings (Horn & Masunaga, 2007). Longitudinal findings suggest that the points in adulthood at which declines occur are later in the lifespan than are indicated in cross-sectional studies. However the evidence of which abilities decline, and which decline more or less than others is basically the same (Horn & Masunaga, 2007).

The abilities that are particularly vulnerable to conditions associated with aging are also vulnerable to conditions associated with are related brain change (Horn, 1985;
Raz, 2000). One of these abilities that may decline with age is fluid abilities. Decline in fluid abilities is seen with measures of syllogisms, concept formation, reasoning with metaphors and analogies, comprehending series (figural, letter, and number), mental rotations, and figural relations. In each case the evidence for fluid decline is most pronounced when the elements of the test are novel or equally familiar to all participants (Horn & Masunaga, 2007).

In many of the studies that documented age related decline for measures of fluid abilities, no evidence of decline was found for measures of crystallized abilities in the same sample of participants (Horn & Masunaga, 2007). On average there is an increase with age in crystallized abilities. Some studies demonstrate an increase in these abilities in the 60s, 70s, and 80s. These abilities indicate a breadth of knowledge, consolidation in learning, and a fluency in the retrieval of information from memory (sounds like expertise). There are, however, some studies that indicate a decline in these abilities that appear in the late 60s. The decline is small at first but accelerating, by the 90s there is a notable decline (Schaie 1996, 2000). When the differences for formal education are statistically controlled, the increment of crystallized abilities through the 70s is increased. The evidence is not clear if the declines beyond this age are reduced by controlling for education (Horn & Masunaga, 2007).

Experience

The experience variable encompassed two parts: general and specific. General experience is the total amount of experience a person has in the sport of basketball: years officiating (used for mediation of age effects), coaching, playing, and assignments of
state tournament games. The more experience a person has in officiating basketball the more knowledge encapsulation would occur (Rybash, Hoyer, & Roodin, 1986).

The second variable for experience was specific experience, expertise. The variable is based on experience and State of Ohio licensure (Class 1/Class 2).

Experience, both general and specific, would allow for the development of a working memory specific to basketball officiating (Masunaga & Horn, 2001). With experience, officials receive more training. For example, an official attends state rule interpretation meetings, local association meetings, classes, camps, and other forms of instruction on the rules and mechanics of basketball including self-study. Examples of self-study includes but is not limited to the practice of hand signals in front of a mirror and reviewing videotapes of their performance in games. According to Salthouse (1987), this would increase the quantity and quality of the relevant experience an individual would receive.

Ericsson (1996) would consider this experience as a form of deliberate practice: well-defined task with an appropriate level of difficulty, informative feedback, and opportunities for repetition and correction of errors. Therefore, it was expected that experience would mediate the effects of age on expertise. This would be due to the encapsulation of knowledge from experience.

Level of Information

Another reason for the errors in judgment of a basketball official may be the amount or level of information received at the time of a call. Information overload occurs whenever the amount of information exceeds an individual’s information processing resources (O’Reilly, 1980). The proper processing of the large amount of information in a
short period of time will show expert/novice differences in judgment (Rikers et al., 2003).

Not enough information to make an accurate call may also result in errors. To determine levels of information the videotaped game situations were divided into equal number of 2-seconds (low level) and 7-seconds (high level) of prior information prior to a call being made.

In basketball refereeing/officiating, mechanics and techniques are taught so only the most relevant information is observed and used in the decision-making for the call. The mechanics, court positioning, and understanding which part of the basketball floor is a particular official’s primary responsibility is part of a team process and designed to lessen the amount of information an official must process. A team process oriented viewpoint requires the referees/officials to carryout interrelated activities to make the correct call.

Kock (2000) believed the execution of process activities incorporates repetitive and standardized procedures. He felt that individuals need to operate as members of a team to accomplish the task and exchange of information among the team members to ensure the activities can be effectively carried out. According to Kock, there needs to be an understanding of the specific knowledge, skills, abilities, strengths, and weaknesses of each team member so each member can be effectively used to accomplish the task.

Basketball training and camps teach referees how to work as a process-oriented team in order to make the correct calls. That is the importance of knowing court responsibility and position to reduce information overload. Expert officials referee their areas of court responsibility and communicate with hand and eye signals to be sure all parts of the floor are being observed. Novice officials tend to just watch the ball and area
it is in or try to watch the whole court, which can lead to more errors. Experts work as a team and communicate during pre-game, timeouts, and halftime to ensure all officials are aware of situations that have occurred or may occur during the game. The experts also communicate where they are having trouble or problems seeing their court area of responsibility and ask for help in those areas where they may have their court vision blocked. This leads to less errors or incorrect calls for officials. Novice officials either do not realize the problems or are afraid to admit they are having problems and this can lead to more errors or incorrect calls.

Kock’s (2000) research supports the process-oriented view for reduction of information overload. It was found that there was no relationship between the amount/level of information (information overload) the efficiency or quality of task performance. It was also found that individual factors more than task factors influence information overload. Individual factors, such as decision-making style and amount of expertise, affect task completion time more than task factors (amount of information processed- pages read, written; task complexity- number of work related decisions, number of work related activities; amount of work information exchange activities). Working as a process-oriented team can reduce errors and increase task efficiency. The more expertise an official obtains and gains team process-oriented experience the better official, and less errors or incorrect calls are made. Process-oriented teams can reduce information overload and it can be the reason for the difference for the number errors between novice and expert calls. Again, it is because the more experienced expert officials realize their weaknesses and area of the basketball court they are responsible to referee.
The process-oriented team approach to officiating is important because of the one to two second time-frame in which the basketball official has to make the determination of whether a foul or violation was committed (i.e. time-frame in which a call must be made). Kock (2000) found that the time pressure for task completion was a strong determinant of information overload. The process-oriented team approach to refereeing/officiating in which each official knows his/her floor coverage responsibility, knowledge of-and rule application, as well as officiating experience helps to limit and/or eliminate information overload. Also, the process oriented-team approach helps to limit the amount of individual factors that influence information overload and develop schemas used by individuals (officials) to interpret, make decisions, and perform actions in response to the sensorial stimuli (Kock, 2000). The encapsulation of knowledge through experience should nullify any differences between young and older adult experts, thus the mediation of experience between the variables of the study and procedural performance.

**Anticipation**

It is hypothesized that the mediating effects of experience will decrease the age-effects related to procedural performance. An older expert official with vast experience may be able to better anticipate a call versus a younger expert or novice official. Since the experience of seeing many different situations and plays in basketball would help the older expert anticipate the movements of players, anticipation may be a compensatory mechanism to help negate any older and younger expert differences.

In training classes for basketball officials they are taught to anticipate the play but not the call (i.e., referee the defense). An example of this would be watching for vertical positions in rebounding situations after a shot, try, or attempt at a basket is completed. A
player going for a rebound after a missed shot at a basket may not break the vertical body plane of another player (from the opposing team) while attempting to catch the basketball. An older expert may already have this imaginary line drawn between the players to watch for a break in the verticality. A younger expert may just watch the body movement of the players rather than a territorial break in the plane. There the younger expert may make an incorrect call due to anticipating the call rather than the play.

The procedural performance related variable in the videotape of game situations has an anticipation variable to measure this type of ability. The anticipation variable was simply after presentation of a game situation (of either 2 or 7 seconds) the videotape was stopped and the official was asked what he/she would be looking for next. After answering, a series of probe questions were asked to help clarify expert novice differences in what was looked for in anticipation. If anticipation is a core skill that transcends fields of expertise as it was found in other research (Abernethy, 1991; Helsen & Pauwell, 1993; Ste-Marie, 1991 & 1999; Ward & Williams, 2003), there should be significant expert/novice differences.

*Complexity*

Another variable built into the study is complexity of a call. Calls were defined as minimum, medium, or maximum complexity level. Subject matter experts were used to determine the complexity level of the call in both the game situations presented in vignettes and videotapes. Refer to Figure 1 for a more detailed explanation of the experience/expertise model.
Hypotheses

1. There will be significant expert/novice differences in declarative, procedural, and justification knowledge measures in relation to procedural performance.
   a. Expert officials will recall significantly more information than novice officials for justification knowledge measures in procedural performance.
   b. Experts will have significantly more correct answers on the declarative and procedural knowledge tests.
   c. Expert officials will significantly recall and demonstrate more hand signals than novice officials on procedural knowledge measures.

2. Younger officials will have significantly higher scores than older officials on tests of fluid abilities.

3. Older officials will have significantly higher scores on tests of crystallized mental abilities.

4. Knowledge will mediate the effects of age on procedural performance differences between older and younger expert officials (refer to Figure 1).
   a. When age and knowledge are both included in the hierarchical regressions age will not account for any significant variance on the performance between young and older expert officials.

5. Expert officials will make more correct calls in all scenarios of low level information (2 seconds) than novice officials.

6. Expert officials will make more correct calls in all scenarios of high levels of information (7 seconds) than novice officials.

7. Anticipation of the play or player movements will be a core skill identified in accounting for differences between novice and expert officials.
   a. Expert officials will have a significant number of more correct calls than novice officials on all procedural performance measures of anticipation.
   b. As complexity level increases, there will be no significant difference in number of correct calls between older and younger expert officials on all procedural performance measures of anticipation.
   c. As information level decreases, there will be no significant difference in number of correct calls between older and younger expert officials.
d. There will be significant age effects with older officials having significantly more responses in relation to watching an area on the court, versus watching the ball/player with the ball, than younger officials. In particular, older expert officials will have more responses than younger expert officials in relation to watching an area on the court.

8. Experience (years officiating) will mediate the effects of age on procedural performance differences between older and younger expert officials (refer to Figure 1).

a. When age and experience are both included in the hierarchical regressions age will not account for any significant variance on the performance between young and older expert officials.
CHAPTER III

METHOD

Participants

The participants were 25 Class 1 and 15 Class 2 basketball officials licensed by the State of Ohio to officiate basketball games. Class 2 officials were licensed to officiate basketball games at the grade school through high school junior varsity level. Class 1 officials were licensed at the grade school through high school varsity level. Some of the Class 1 officials also refereed basketball at the college level. All officials were qualified for both men’s and women’s basketball games. Novice officials were considered to be officials with 3 or less years of officiating experience with a Class 1 or Class 2 license. The expert officials had a minimum of 10 years officiating experience and a Class 1 license.

Procedure

This section discusses the recruitment process, administration of measures, the types of measures used.

Participant Recruitment and Administration Procedures

To recruit officials, different state rules interpretation meetings and various local meetings were attended. At each meeting, time was given to explain the study and ask for volunteers. Names, phone numbers, and e-mail addresses were recorded. In addition, listings of state officials from different state local chapters were obtained and e-mails
were sent out to request their participation. To specifically recruit novices with one year or less experience, two different basketball officiating classes, one in the northern part of Ohio and one in the southern part of Ohio, were visited to request participation. The two time parts of the study’s testing procedures and purpose of the study were described. It was explained that due to the amount of time required by each participant the study was separated into two parts. Part one part of the study could be done in the “comfort of their home.”

The second part of the study had to be completed “face-to-face” with the researcher. Participants were told the first part of the study should take about 45 minutes to complete. The second part of the study should take 1 to 2 hours. Part one of the study was e-mailed to the participants. It consisted of consent forms, demographic forms, knowledge measures (rules test, mechanics test, paper vignettes of game situations), and the crystallized abilities measure (Mill Hill Vocabulary Test). The participants were asked to complete these measures and then contact (via e-mail) the researcher to schedule a face-to-face appointment. Participants were told they could either e-mail part one to the researcher or bring it to the appointment. It was also explained that the researcher would come to a location that was most convenient for the participant to administer part two of the study.

Two hundred seventy-three e-mails were sent to officials who reported being willing to participate in the study. One hundred twenty officials said they would participate in the study. Of the 120 officials only 88 e-mailed part one of the study back to the researcher. Forty of the 88 officials scheduled appointments to complete the second part of the study. Although this study only had 40 participants, it is believed to be an
accurate representation of the basketball officials in the State of Ohio. This belief is due to the participants being from different regions in the state.

The second part of the study consisted of the fluid ability measure (Test of “g”: Culture Fair, Scale 2, Form B), verbal free recall and demonstration of the 36 hand signals used by basketball officials, the procedural performance measure (DVD of game situations), anticipation measure (DVD of game situations to predict consequences, anticipation verbal questions), and the justification knowledge measure (retroactive recall).

The second part of the study was administrated as follows: first the fluid abilities test was administered and participants had no time limit in which to complete each part of the test. Next participants were asked to verbally recall and physically demonstrate the 36 different hand signals used by basketball referees during a basketball game. This was followed by the procedural performance measures. The first four game situations were to help the participant gain familiarity with the procedure through practice. They viewed each game situation and gave an explanation for their call (justification knowledge measure). After each practice trial, participants were asked if they had any questions and that this was the time for questions. It was explained that once the experimental trials of game situations begin, no questions would be allowed. After the practice trials participants viewed the videotapes of 45 actual high school basketball game situations.

While viewing the first 45 game situations officials were told to make a call (foul, violation or no call) and each response was recorded. Then participants were asked to justify or give the reason for their call and all justifications were recorded (justification knowledge measure). Participants viewed the last 10 game situations in which the game
situation was interrupted/stopped (the first two were practice with same instructions as prior practice). Following each stoppage of the game situation, participants were told to anticipate and tell what action was going to happen next on the in the game situation. After recording participants’ responses, the tape was restarted from the point where it was stopped, and responses were scored as correct or incorrect according to the action on the videotaped game situation viewed.

Demographic Information

The demographic information collected consisted of: name, gender, current age, age first started officiating basketball, age when officiated first high school basketball game, total years experience in basketball, numbers of years officiating, number of years playing, number of years coaching, number of games officiated (on average) in a basketball season, total number of basketball games officiated in career, number of state tournament games (sectional, district, regional, and/or final four/championship). The demographic information also included questions about age of first training, basketball official classes attended, the type and length of skills training or classes, the number of state rules interpretation meetings attended, the number of local association meetings attended, amount of time viewing videotape game situations or self in game situations, and amount of time practicing hand signals in front of a mirror.

Knowledge Measures: Declarative, Procedural, and Justification

The variables used to assess knowledge of basketball officiating consisted of measures of declarative knowledge, procedural knowledge, and justification knowledge.
**Declarative Knowledge**

After completion of the demographic information the participants were given paper and pencil measures to indicate the amount of declarative basketball knowledge. The knowledge measures consisted of the rules of high school basketball as stated by the National Federation of High Schools (NFHS), the two-man mechanics for officiating state high school basketball as listed by the NFHS and game situation vignettes of different degrees of complexity.

The rules measure consisted of 25 true/false statements about the basketball rules and fundamentals as indicated in the *NFHS Basketball 2004-05 Rules Book*. The 25 true/false statements about the basketball rules were taken from the actual test used by the State of Ohio/NFHS to qualify individuals to be officials.

The mechanics measure of declarative knowledge consisted of 25 true/false statements about the proper court position, areas of responsibility, basketball signals, and communication in relation to two-man mechanics as indicated in the *NFHS Basketball 2001-03 Officials Manual*. The basketball official’s manual is based on procedures adopted for use by groups associated with the NFHS. Two man mechanics are used in elementary school through ninth grade in most regions of Ohio. Basic mechanics are similar for each state associated with the NFHS, and must be flexible enough to accommodate certain conditions in each state. The mechanics measure had 25 true/false statements used are also the actual questions used by NFHS and the State of Ohio to qualify people for state licensure (Class 1 and 2). The scores (number of correct answers 1-25 per test) were one part of the declarative knowledge variable. For a review of the rules and mechanics tests see Appendix F.
The third part of declarative knowledge was measured by use of game vignettes. All vignettes were situations selected from the *NHFS Basketball 2001-02 Casebook*. These game vignettes consisted of 15 different game situations with five multiple-choice responses. A vignette may have more than one response apply to the game situation. All correct responses had to be selected for credit as a correct answer, for each game situation. In order to correctly answer the vignette questions one must have knowledge of the rules of basketball. Since vignettes are considered a declarative knowledge measure they should correlated significantly with other declarative knowledge measures and this can be seen in the Chapter IV correlations section.

These vignettes were of different levels/rating of complexity as judged by subject matter experts (SMEs) and there were five vignettes per level/rate of complexity for a total of 15. The first level/rate of complexity was minimal, the second level/rate of complexity was medium/average, and the third level/rate of complexity was maximal. These ratings and scores in each level are discussed later in the determination of complexity section.

The basketball casebook has been designed as an official supplement to the rules book by the NFHS. The casebook is universally used by officials who are interested in upgrading and updating their skills and knowledge in the administration of the basketball game. It is also used by coaches and trainers/instructors as a textbook for study by basketball teams and in sports officiating classes. The vignettes in the casebook are game situations contributed by basketball leaders in all sections of the country. The rulings and comments are based on the NFHS rules and guidelines. It was decided to use the 2001-02 casebook to minimize any biases between expert and novice officials (both would have
had to equal time to read the manual). The scores (number of correct answers) on the vignettes give a measure of declarative knowledge.

_Procedural Knowledge_

Procedural knowledge was measured by use of videotaped situations of actual high school basketball games converted to a DVD (procedural performance) and demonstration and recall of the 36 hand signals. Participants watched one single DVD game situation at a time. After viewing the individual game situation the DVD was stopped. Next the participants made a basketball call (violation/foul) or no call (no violation or foul committed) according to the game situation viewed. The number of correct calls is a measure of procedural performance. Participants viewed 45 different game situations in this measure. The 45 game situations consisted of different complexity levels/ratings on the same scale (from 1-3) as the vignettes. There were 14 maximum, 14 medium/average, and 17 minimum complexity level/rated calls. The DVD game situation were also divided into two parts of level of information presented (23 low level situations and 22 high level situations).

Another measure of procedural knowledge was the physical hand signals mechanic test, hand signals used by officials. Hand signals were considered a procedural knowledge measure because to describe and use them an official has to state them and also demonstrate the signal. For recall of hand signals an official must think of the starting procedures for a game, what fouls and violations may occur in a game, the stoppage procedures of a game during play and time outs, and procedures required for conclusion of a game under a variety of situations. Basketball has 36 physical signals used by officials to indicate fouls, violations, time outs, start or stop the clock, ball
direction, etc. Participants were asked to free recall and physically demonstrate all the physical signals used in officiating high school basketball games. If a signal was not remembered and demonstrated, the participant did not get credit for the signal. The total number of remembered and correctly demonstrated served as the dependent variable.

**Justification Knowledge**

Justification knowledge was measured by retrospective reporting. After viewing the videotape of a game situation and making a call, the participant was asked to give the reason for his/her call or no call. The responses were recorded and reviewed for comparative novice and expert differences as well as older and younger adult expert differences. Categories for the responses were determined by subject matter experts (see below).

**Crystallized Abilities**

This type of adult cognition refers to how processed information is represented, stored, processed, and used. Crystallized mental abilities were tested by administering the Mill-Hill Vocabulary Test. This test consists of 34 words to define. An individual is given the word with six possible responses (other words) in which one response defines the word of interest.

**Fluid Abilities**

Fluid mental abilities refer to the way individuals develop an understanding and use of their knowledge. It is the ability to use their knowledge in novel ways. Fluid mental abilities were measured using the Test of “g”: Culture Fair-Scale 2, Form B. This fluid ability tests consists of four individual tests. Test 1 was a series test in which the individual had to pick the item/pattern that completed the series. Test 2 was a test of
classification in which the individual had to mark the item in each row that does not belong with the others. Test 3 consisted of matrices that required the individual to mark the item that correctly completes the matrix or pattern. Test 4 was a test of conditions. The individual had to insert a dot in one of the alternative designs so as to meet the internal conditions in the sample design. The reliabilities for this scale are in the .60s (Anastasi, 1982). Scattered studies of concurrent and predictive validities show moderate correlations with various academic and occupational criteria (Anastasi, 1982). There were no time limits imposed on the tests.

**Anticipation**

To measure the anticipation of a call, participants were shown 10 different DVD game situations (2 practice trials, 8 scored trials). The DVD was stopped after either 2 seconds or 7 seconds. The levels of complexity consisted of 3 maximum, 3 medium, and 2 minimum. While the DVD was stopped, each participant was asked to report what he/she believed would happen next, or would be looking for, in the game situation being viewed. Then participants were asked to express their reason for their expectation/belief. The videotape was then restarted and the correct number of responses was recorded in accordance with the game situation viewed. Next a series of probe questions were asked to help clarify what the official did that influenced the decision. The probe questions were asked accordingly: To make your decision on what will happen next or be looking for-

1. Did you watch the ball and what was done with the ball only?
2. Did you watch the player with the ball only?
3. Did you watch the player who was guarding the person with the ball?
4. Did you watch the off ball play:
   a. At the top of the key? Why?
   b. In the lane? Why?
   c. Under the basket, outside the lane on the ball-side? Why?
   d. Under the basket, outside the lane opposite ball-side? Why?

Levels of Information

The videotape game situation had different levels of information available to make a call. In some game situations a participant had two seconds of prior information before the call had to be made. In other game situations there were seven seconds of prior information before a call was to be made. The levels of information were divided as follows: 45 game situations for foul, violation, no call = 23 – two-second and 22 – seven-second; 8 anticipation = 4 – two-second and 4 – seven-second.

Videotapes/DVD

The videotaped game situations were stored on DVD. Henceforth in this paper DVD and videotape may be used interchangeably. The game situations consisted of 53 total game situations. There were 45 game situations in which basketball players at the high school varsity level (actual varsity games) committed either violations, fouls, or no call/no foul. Each foul, no call or violation game situation was categorized by level of complexity rated on a scale of 1-3 as judged by subject matter experts. There were 17 minimum complexity level/rated game situations (rated 1), 14 medium/average complexity level/rated situations (rated 2), and 14 maximum complexity level/rated situations (rated 3). In these 45 game situations the participants may have to make a
choice if a foul (20 game situations), violation (14 game situations), or make no call (11 game situations) depending on the game situation viewed.

The eight anticipation game situations had two minimum complexity level/rated game situations (rated 1), three medium/average complexity level/rated situations (rated 2), three maximum complexity level/rated situations (rated 3). The level of information load game situations were divided into two parts of 27 two-second game situations and 26 seven-second game situations. The total 53 game situations are broken down into 17 maximum complexity level/rate, 17 medium/average complexity level/rate, and 19 minimum complexity level/rate calls. The 27 two second level of information load situations has 10 minimum complexity level/rate calls, 10 medium complexity rate calls, and 7 maximum complexity level/rate calls. The 26 seven second level of information load situations each have 9 minimum complexity level/rate calls, 7 medium/average complexity level/rate calls, and 10 maximum complexity level/rate calls.

Random draws without replacement was used to determine which situations would be of low or high level information. The subject matter experts (SMEs) determined the reasoning for random draw. It was believed that in actual game situations an official does not know how much information will be received before making a call. Since an official did not know the amount of information that was received per call, random draw added realism to the measure.

Subject Matter Experts

Four subject matter experts (SMEs) helped develop the measures used in this experiment and make decisions about content. Each expert had a minimum of 10 years experience as a basketball official and was licensed and/or qualified to referee
school and college basketball. Three of the four experts were trainers for new/beginning basketball officials and had been trainers for a minimum of 7 years.

Determination of Complexity

All SMEs were initially interviewed using a standardized questionnaire (17 open-ended questions) to obtain demographic information and their ideas about the differences between novice and expert high school officials in relation to minimum, medium/average, and maximum level/rated complexity of basketball calls made in game situations. Minimum level/rate of complexity was defined as a basketball call that both novice and experts would be able to make with the least/minimum amount of errors (easy calls to make in a clearly defined game situation). Medium/average level/rate complexity was defined as calls that either novice or expert may make errors with more errors expected for a novice versus expert (more difficult call for both expert and novice due to less clearly defined game situation as compared to minimum complexity). Maximum level/rate of complexity was defined as calls that both experts and novices would be most likely to make errors with the least amount of errors being made by experts (least clearly defined game situations as determined by the SMEs).

Based on these criteria, vignettes and DVD/videotaped game situations were presented to the experts at the first interview to be classified into the different levels/rates of complexity. At the second interview the SMEs classified the vignettes and DVD/videotaped game situations were intermixed and again presented to the experts for complexity classification as minimum, medium/average, or maximum level/rate basketball calls. The different complexity levels/rates were then intermixed and presented at a third interview to the SMEs. They were asked again to categorize each of the items
viewed as minimum, medium/average, or maximum complexity level/rate basketball
calls. Only items with a 75% agreement rate between the SMEs were left in the
complexity categories. Each SME stated that in determining a complexity level/rating it
made no difference whether a basketball call was a foul or violation. Either one could be
considered as minimum, medium/average, or of a maximum complexity level/rating. The
information from the interviews was also used to develop some of the other knowledge,
anticipation, and expertise measures.
CHAPTER IV

RESULTS

The chapter discussed the sample, hypotheses, and their analyses. Before beginning any of the analyses of each hypothesis, a Cronbach’s Alpha was performed on all measures to determine their reliability. Adjustments were done to the measures to improve their reliability. The adjustments eliminated the low/negative items that did not fit well with the other items. Hypotheses 1-3 used both univariate and regression analyses to test for significance. Hypotheses 1 and 2 had similar results when both approaches were used. Hypothesis 1 has the results reported using the univariate analyses. Hypotheses 2 and 3 have the results reported using the regression approach. Where it was feasible factor analyses were performed as well. Chapter IV focuses on the results of all analyses with emphasis on variables that had significant results.

Sample

The total sample of 40 individuals consisted of 25 expert and 15 novice officials. There were a total of 25 older officials and 15 younger officials. The age range of the older officials was 41-67 years with a mean age of 50.8 years with a standard deviation (SD) of 7.6 years. The younger officials’ ages ranged from 16-36 years with a mean age of 29.1 years with a SD of 6.1 years (refer to Table 1). The overall range for years of officiating for expert officials was 10-37 years with a mean of 17.8 years with a SD of
Table 1

Age of the Study Participants by Novice, Expect, Younger, and Older

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<tr>
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<th>Younger</th>
<th>SD</th>
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<th>SD</th>
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<tr>
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<tr>
<td>M</td>
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</tr>
<tr>
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<td>8</td>
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<td>17</td>
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<td>25</td>
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</tr>
<tr>
<td><strong>Overall</strong></td>
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<td></td>
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<td></td>
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<tr>
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<td>41-67</td>
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<td>40</td>
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</tbody>
</table>

8.2 years. The overall range for years of officiating for novice officials was 1-3 years with a mean of 1.7 years with a SD of .90 years (refer to Table 2). The sample gender composition consisted of 37 males and 3 females. Two females were experts and one was a novice.

Experts consisted of 17 older officials and 8 younger officials. The age range of the older expert officials was 41-67 years with a mean age of 52.2 years with a SD of 8 years. The range for years of officiating experience for the older expert officials was 10-37 years with a mean of 21 years with a SD of 8.2 years. The age range for younger expert officials was 28-36 years with a mean of 32.4 years with a SD of 2.4 years. The range for years of officiating experience for the younger expert officials was 10-14 years with a mean of 11.1 years with a SD of 1.5 years.
The novices consisted of 8 older officials and 7 younger officials. The age range of the older novice officials was 41-59 years with a mean age of 47.3 years with a SD of 5.8 years. The range for years of officiating experience for the older novice officials was 1-3 years with a mean of 1.6 years with a SD of .98 years. The age range of the younger novice officials was 16-36 years with a mean of 25.9 years with a SD of 7 years. The range for years of officiating experience for the younger novice officials was 1-3 years with a mean of 1.7 years with a SD of .87 years.

Table 2

Years Officiating

<table>
<thead>
<tr>
<th></th>
<th>Younger</th>
<th>Older</th>
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</tr>
</thead>
<tbody>
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<tr>
<td>Range</td>
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<td>N</td>
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<td>15</td>
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<td>Expert</td>
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<tr>
<td>M</td>
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<tr>
<td>Range</td>
<td>10-14</td>
<td>10-37</td>
<td>10-37</td>
</tr>
</tbody>
</table>

An interesting aspect to the sample which may be due to the selectiveness of the sample was that some officials refereed other sports. Twenty of the 25 expert officials that participated in the study officiated at least one other sport (7 young experts, 13 old experts). According to our definition they all qualified as an expert official in the other sport(s). Nine of the 15 novice officials officiated at least one other sport (4 young novice, 5 old novice). One young novice and three older novice officials qualified as an expert official in the other sport(s).
Correlations

Correlations were calculated between the variables used in the study. Refer to the results in Table 3. It can be seen that when age is a continuous variable, chronological age (CA) is significantly correlated with experience (Exp) and has a correlation of .38. However when age is a dichotomous variable (AgeD), it is not correlated with experience due to the loss of information. It can further been seen that vignettes are significantly correlated with other declarative knowledge variables such as basketball rules (BBR, .58) and both justification knowledge variables (JKa, .36; JKc, .58).

Hypothesis 1

Hypothesis one examined significant expert/novice differences in justification, declarative, and procedural knowledge measures. Hypothesis 1 has three parts (1a, 1b, and 1c) and results are discussed in the following paragraphs.

Hypothesis 1a

It was expected that experts compared to novices, would recall significantly more justification knowledge based on responses to DVD basketball scenarios. Participants had viewed the DVDs during the testing process for procedural knowledge and anticipation variables. During the completion of these tests they were asked questions about what went through their minds as the DVD scenarios were being viewed. The responses were then classified us into six categories: (a) other plays (general response about plays); (b) similar plays or situations in other games (mentioned specific game that a play/situation was seen or specific teams that run the play); (c) area of court responsibility; (d) referee the offense or defense; (e) position of partner on court; and (f) own position on court (view of the scenario made them feel as if they were the trail, center, or lead position).
Table 3
Correlations of the Study Variables

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<td>.76**</td>
<td>.18</td>
<td>.40**</td>
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</table>

Note: CA- chronological age; AgeD- dichotomous age (coded as 1-young, 2-old); Expt- expert (coded as 1-novice, 2-expert); HS- hand signals; JKa- justification knowledge total score; BBM- basketball mechanic; BBR- basketball rules; Vig- vignettes; PPT- procedural performance total score; PPL- procedural performance low level of information; PPH- procedural performance high level of information; AnL- Anticipation low level of information; AnH- Anticipation high level of information; Gc- crystallized abilities; JKe- justification knowledge responses C and F; Gf- fluid abilities; AnT- anticipation total score.

*p ≤ .05, **p ≤ .01
An individual could be categorized into more than one category based on responses to scenarios. For example, an official could respond that he/she refereed the defense and watched underneath the basket in the lane. Then go on to state the reason for the area on the court that he/she watched was because of remembering a similar play in another game. This type of response may be recorded in two categories B and D. Responses were categorized and coded by use of SMEs’ agreement as described previously. The code was 0 if absent from category and 1 if response was present.

The last category from these responses in the justification knowledge variable was the total number of responses given by an individual. This study was exploratory in nature so a Cronbach’s Alpha was used to view the reliability of the justification knowledge measure’s six categories (Pedhazur & Schmelkin, 1991). The Cronbach Alpha level was .51. A Maximum Likelihood factor analysis was then performed on the six categories to determine if the six categories loaded on the same factor. Three of the six categories had higher loadings on other plays (.999), similar plays or specific plays in other games (.781), and referee the defense then offense (.372).

Another type of Justification Knowledge measure that resulted from factor analysis was one that examined the amount of information recalled in relation to an official’s position on the court (factor loading of .287- own position on court) and the area of responsibility required to be observed due to the position on the court (factor loading of .281- area of responsibility). For a review of all factor loadings see Appendix M. Different scenarios seen by the officials (novice and expert) gave them a feeling of being the lead, trail, or center position. The scenarios were not intentionally designed for this to occur. However, it resulted in an added dimension to the study. A note about why
the high loading of -0.793 for position of partner on court was not included in analysis. In discussion with SMEs it was expressed due to the way DVD scenarios were viewed position of the partner was not an issue of concern. It was not expressed as a major concern by participants and they felt it did not affect their call or a major thought in their mind at the time of viewing the scenarios. Based on advice from SMEs this variable was not included in the analyses.

The first Justification Knowledge measure used to test hypothesis 1a was other plays, similar plays or situations in other games, and referee the defense then offense. This Justification Knowledge measure is examining the expert knowledge base of recall of plays, specific situations or teams that use the play, and/or viewing offensive or defensive players. The three categories in this Justification Knowledge measure had a Cronbach’s Alpha of .74.

A Univariate ANOVA statistical test, 2 (expertise- novice/expert) X 2 (age-young = ≤ 36 years of age/older = ≥ 37 years of age) design, was performed to test Hypothesis 1a. It was done to determine if there were significant expert/novice mean differences at the $p < .05$ level and also to test for an interaction between expertise and age. A review of Table 4 demonstrates not only an expert/novice significant mean differences with $F(1, 36) = 7.14, p < .05$, but also a significant expert x age interaction with $F(1, 36) = 4.64, p < .05$. Refer to Table 5 for the means and Standard Deviations (SDs) for these groups of participants.
Hypothesis 1a was confirmed with experts recalling significantly more information than novices using this measure of justification knowledge. This measure examined the recall of other plays, specific plays or game situations, and referee defense then offense. Although no age differences were found there was an interaction between expertise and age. These results indicated that the advantage of experts on this measure was due primarily to the performance of older officials (refer to Table 5).

Table 4

Justification Knowledge: Univariate ANOVA on Expertise and Age

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
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<td>4.81</td>
<td>7.14</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
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<td>.11</td>
<td>.16</td>
<td>.69</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1.36</td>
<td>3.13</td>
<td>4.64</td>
<td>.04*</td>
</tr>
</tbody>
</table>

Note. *p < .05.
R Squared = .31.
Adjusted R Squared = .25.

Table 5

Justification Knowledge Expert and Novice Mean Age Differences

<table>
<thead>
<tr>
<th>Age</th>
<th>Younger</th>
<th>Older</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Novice Mean</td>
<td>1.86</td>
<td>1.38</td>
<td>1.60</td>
</tr>
<tr>
<td>SD</td>
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<tr>
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<td>8</td>
<td>15</td>
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</tbody>
</table>
Table 5

Justification Knowledge Expert and Novice Mean Age Differences (continued)

<table>
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<th>Age</th>
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<th>Older</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Expert Mean</td>
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<td>2.48</td>
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<tr>
<td>SD</td>
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<td>N</td>
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<td>25</td>
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<tr>
<td>Total Mean</td>
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<tr>
<td>SD</td>
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<tr>
<td>N</td>
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<td>25</td>
<td>40</td>
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</tbody>
</table>

Next the Justification Knowledge measure that had responses in relation to an official’s position on the court and area of responsibility was examined. The Cronbach’s Alpha was .52 for this measure. This reliability is low, but because this study is exploratory it was decided to analyze the measure.

A Univariate ANOVA statistical test, 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) design, demonstrated significant mean differences for expertise with F (1, 36) = 9.12, p ≤ .05 (refer to Table 6). There were no significant age differences.
Table 6

Justification Knowledge Univariate Analysis: Expertise and Age Differences on Own Court Position and Area of Responsibility

<table>
<thead>
<tr>
<th>Source</th>
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<th>F</th>
<th>Significance</th>
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</thead>
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<td>.02</td>
<td>.33</td>
<td>.86</td>
</tr>
</tbody>
</table>

Note. *p = ≤ .05.
R Squared = .22.
Adjusted R Squared = .16.

Table 7 shows the means and SDs for examining Hypothesis 1a using this measure of Justification Knowledge (own court position and area of responsibility). Table 7 indicates experts recalled more than twice as much information as novices (expert mean = 1.32, SD = .75; novice mean = .53, SD = .74). Experts again recalled more information than novices.

Table 7

Justification Knowledge Own Court Position and Area of Responsibility: Expert and Novices Mean Age Differences

<table>
<thead>
<tr>
<th>Age</th>
<th>Younger</th>
<th>Older</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Mean</td>
<td>.43</td>
<td>.63</td>
<td>.53</td>
</tr>
<tr>
<td>SD</td>
<td>.79</td>
<td>.74</td>
<td>.74</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>8</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 7

Justification Knowledge Own Court Position and Area of Responsibility: Expert and Novices Mean Age Differences (continued)

<table>
<thead>
<tr>
<th>Age</th>
<th>Younger</th>
<th>Older</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1.25</td>
<td>1.35</td>
<td>1.32</td>
</tr>
<tr>
<td>SD</td>
<td>.87</td>
<td>.70</td>
<td>.75</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>Mean</td>
<td>1.12</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>.78</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>25</td>
<td>40</td>
</tr>
</tbody>
</table>

In conclusion, Hypothesis 1a was confirmed by both measures of Justification Knowledge. Experts reported significantly more information than novices after completing the procedural performance part of the study.

**Hypothesis 1b**

This hypothesis investigated age and expertise effects on measures of Declarative Knowledge and Procedural Knowledge. It was predicted that experts would have significantly more correct answers than novices on both Declarative and Procedural Knowledge variables.

Three declarative knowledge measures were collected consisting of the basketball rules test, the basketball mechanics test, and responses to written vignettes. Both the basketball rules and the mechanics tests have 25 questions in a true/false format. The written vignettes have 15 scenarios that have three levels of complexity consisting of five
scenarios of minimum complexity (4, 6, 7, 12, 14), five scenarios of medium complexity (2, 5, 9, 11, 15), and 5 scenarios of maximum complexity (1, 3, 8, 10, 13).

The Basketball Rules Test (BBR) is the actual test used by the State of Ohio to qualify officials. Cronbach’s Alpha level for the full set of test items was .43. After eliminating the low/negative items the remaining 21 items’ Cronbach’s Alpha level increased to .63. The Univariate ANOVA statistical test, 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) found no significant effects (refer to Table 8).

Table 8
Declarative Knowledge BBR Univariate Analysis: Expertise and Age Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>30.94</td>
<td>.98</td>
<td>.41</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>.58</td>
<td>.06</td>
<td>.82</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>1.41</td>
<td>.13</td>
<td>.72</td>
</tr>
</tbody>
</table>

Note. *p = ≤ .05.
R Square = .08.
Adjusted R Square = .00.

The Basketball Mechanics Test (BBM) is also the actual test given by the State of Ohio to qualify officials for licensure and its original Cronbach’s Alpha level was .19. After adjustments were completed the measure had 15 items with a Cronbach’s Alpha level of .52. A Univariate ANOVA statistical test, 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) design also found no significant mean differences (refer to Table 9).
Table 9

Declarative Knowledge BBM Univariate Analysis: Expertise and Age Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>.76</td>
<td>.14</td>
<td>.71</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>5.56</td>
<td>1.03</td>
<td>.32</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>4.67</td>
<td>.86</td>
<td>.36</td>
</tr>
</tbody>
</table>

Note. *p = ≤ .05.
R Square = .05.
Adjusted R Square = .03.

Although both the Basketball Rules and Mechanics Tests are the actual State of Ohio testing procedure and requirements for basketball licensure, there were no expert/novice or age significant mean differences. It is believed these were measures were not valid for this sample. The majority of the novices had recently, within a month, taken these tests for their C2 license prior to participation in the study. The measures were not used further in the study.

The third Declarative Knowledge measure was written vignettes (VIG). The vignettes used were taken from the casebook used in updating training for knowledge of rules and they represented three levels of complexity. Since they are used to update rules for basketball, they were considered to be a measure of declarative knowledge. The original Cronbach’s Alpha level for the 15 vignettes was .57. They were coded 1 for a correct answer and 0 for an incorrect answer. A repeated measures ANOVA, 2 (expertise-novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) X 3 (levels of complexity-minimum, medium, and maximum) design was performed.

There were expert/novice significant mean differences (refer to Table 10). Age had no
significant effects for vignettes. For a review of the age and expertise means and SDs by complexity refer to Table 11.

Table 10

Declarative Knowledge VIG Repeated Measures Analysis: Expertise and Age Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>24.66</td>
<td>4.01</td>
<td>.05*</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>.37</td>
<td>.06</td>
<td>.81</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>6.15</td>
<td>.52</td>
<td>.77</td>
</tr>
</tbody>
</table>

Note. *p = < .05.

The effects for complexity of the vignettes were also significant F (2, 36) = 71.86, \(p \leq .05\). However there were no significant interactions of complexity with age or expertise. As the complexity levels increased the mean performance consistently decreased (minimum- expert mean = 3.20, SD = .96, novice- mean = 2.53, SD = 1.19; medium- expert mean = 2.16, SD = 1.28, novice- mean = 1.87, SD = 1.36; and maximum- expert mean = .60, SD = .82, novice- mean = .20, SD = .41).

In conclusion, for Declarative Knowledge part of Hypothesis 1b there were significant effects for expertise and complexity. There were no significant effects for age. It was also believed the basketball rules and mechanics tests were not valid measures for this study.
Table 11

Declarative Knowledge VIG Complexity: Age and Expertise Mean Differences

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Minimum</th>
<th>Medium</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Young</td>
<td>2.43</td>
<td>1.86</td>
<td>.29</td>
</tr>
<tr>
<td>Mean</td>
<td>1.51</td>
<td>1.57</td>
<td>.49</td>
</tr>
<tr>
<td>SD</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Novice Older</td>
<td>2.63</td>
<td>1.88</td>
<td>.13</td>
</tr>
<tr>
<td>Mean</td>
<td>.93</td>
<td>1.25</td>
<td>.35</td>
</tr>
<tr>
<td>SD</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Novice Total</td>
<td>2.53</td>
<td>1.87</td>
<td>.20</td>
</tr>
<tr>
<td>Mean</td>
<td>1.19</td>
<td>1.36</td>
<td>.41</td>
</tr>
<tr>
<td>SD</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Expert Young</td>
<td>3.00</td>
<td>2.25</td>
<td>.88</td>
</tr>
<tr>
<td>Mean</td>
<td>1.31</td>
<td>1.67</td>
<td>1.13</td>
</tr>
<tr>
<td>SD</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Expert Older</td>
<td>3.29</td>
<td>2.12</td>
<td>.47</td>
</tr>
<tr>
<td>Mean</td>
<td>.85</td>
<td>1.11</td>
<td>.62</td>
</tr>
<tr>
<td>SD</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Expert Total</td>
<td>3.20</td>
<td>2.16</td>
<td>.60</td>
</tr>
<tr>
<td>Mean</td>
<td>.96</td>
<td>1.28</td>
<td>.82</td>
</tr>
<tr>
<td>SD</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

Procedural Knowledge measures consisted of a DVD with 45 scenarios with varying levels of complexity (17 minimum, 14 medium, and 14 maximum). Participants
made a basketball call of foul, violation, or no call. There were 21 scenarios with fouls, 10 scenarios with no calls, and 14 scenarios with violations. The Procedural Knowledge measure had a Performance Total Score which was the total number of correct answers on all 45 DVD scenarios. Another Procedural Knowledge measure was the hand signals discussed in Hypothesis 1c.

Cronbach’s Alphas were performed on the Procedural Knowledge Minimum, Medium, and Maximum Complexity levels’ scenarios. After adjustments were completed on the different complexity levels Minimum Complexity had 7 scenarios with a Cronbach Alpha of .66 (originally .29). Medium Complexity had 9 scenarios with a Cronbach’s Alpha of .50 (originally .09). Maximum Complexity had 10 scenarios with a Cronbach’s Alpha of .55 (originally .40). Next a computed proportion was calculated to account for the unequal number of questions and participants in the different levels of complexity. To calculate a computed proportion the correct number of responses per level was divided by the number of questions per level. Next a Repeated Measures ANOVA, 2 (expertise-novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) X 3 (levels of complexity- minimum, medium, and maximum) design was performed on the adjusted variables to compare the means proportion correct. The results demonstrated complexity was significant with F (2, 36) = 57.24, p ≤ .05. A complexity by age interaction was significant with F (2, 36) = 3.45, p ≤ .05. As the complexity levels increased the sample means consistently decreased. However, the main difference between older and young officials was in the medium complexity level (minimum- older mean = .79, SD = .23, young- mean = .87, SD = .21; medium- older mean = .64, SD = .18, young- mean = .47, SD = .17; and maximum- older mean = .34, SD = .18, young- mean = .31, SD = .21). For
a review of all the means and SDs for Complexity levels refer to Table 12. There were no significant effects for age or expertise.

Table 12

Procedural Knowledge Complexity Levels: Age and Expertise Mean Differences

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Minimum</th>
<th>Medium</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Young</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.93</td>
<td>.38</td>
<td>.26</td>
</tr>
<tr>
<td>SD</td>
<td>.08</td>
<td>.17</td>
<td>.10</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Novice Older</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.79</td>
<td>.61</td>
<td>.31</td>
</tr>
<tr>
<td>SD</td>
<td>.30</td>
<td>.17</td>
<td>.16</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Novice Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.86</td>
<td>.50</td>
<td>.29</td>
</tr>
<tr>
<td>SD</td>
<td>.23</td>
<td>.20</td>
<td>.13</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Expert Young</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.80</td>
<td>.54</td>
<td>.35</td>
</tr>
<tr>
<td>SD</td>
<td>.26</td>
<td>.14</td>
<td>.27</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Expert Older</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.79</td>
<td>.65</td>
<td>.35</td>
</tr>
<tr>
<td>SD</td>
<td>.20</td>
<td>.19</td>
<td>.19</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Expert Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.79</td>
<td>.61</td>
<td>.35</td>
</tr>
<tr>
<td>SD</td>
<td>.21</td>
<td>.18</td>
<td>.21</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
A Principal Axis factor analysis was then performed on the Performance Total Score scenarios that were eliminated from the original measure to determine if there were other factors that had significant expertise/age mean differences (refer to Appendix L for factor loadings). Eight factors were determined by this factoring extraction method. Univariate ANOVAs (same as above) were completed on all eight factors. Only one factor (factor 1) had an expert/novice significant mean difference with $F(1, 36) = 6.11, p < .05$ (refer to Table 13 for a review of Univariate ANOVA results). There was no significant main effect for age.

Table 13

Procedural Knowledge Performance Total Score Factor Analysis: Univariate Analysis on Expert and Novice Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>1.20</td>
<td>6.11</td>
<td>.02*</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>.16</td>
<td>.79</td>
<td>.38</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>.16</td>
<td>.79</td>
<td>.38</td>
</tr>
</tbody>
</table>

Note. *$p = \leq .05$.

Factor 1 consisted of the three scenarios in the maximum complexity category (refer to Appendix L for factor loadings). To make a correct call for the scenarios it was necessary to referee the defensive players while viewing the scenario. The first scenario showed that the offensive player stepped out-of-bounds when he was trapped in the corner of the court with the basketball (out-of-bounds - factor loading .368). Another scenario showed the offensive player fouling a defensive player away from the player with the ball (off ball - factor loading .789). The third scenario was a situation in which
an official had to be sure the defensive player did not foul the offensive player with the ball to cause the travel (traveling - factor loading .555). Only the expert officials made the correct call on these scenarios (refer to Table 14 for means, SD, and total number of correct responses). There were not any significant age mean differences.

Table 14

Procedural Knowledge Factor 1: Expert and Novice Mean Differences

<table>
<thead>
<tr>
<th>Expertise</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Total Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>15</td>
<td>.00</td>
<td>.00</td>
<td>00</td>
</tr>
<tr>
<td>Expert</td>
<td>25</td>
<td>.32</td>
<td>.55</td>
<td>8</td>
</tr>
</tbody>
</table>

In conclusion, with Hypothesis 1b Procedural Knowledge tests for expert/novice mean differences, the results are as follows. The variable that had significant expert/novice differences was from the factor analysis of eliminated scenarios (Procedural Knowledge Maximum Complexity- referee offense/defense). Only experts answered these two scenarios correctly. The ability for the experts to anticipate the person’s movements with the ball (referee the offense) and to anticipate the defensive players’ movements (referee the defense), made it possible for the expert officials to make the correct call. Although there were no significant effects for age or expertise in complexity levels, the effect for complexity was significant. It was due to lowered accuracy as complexity increased. There was also a significant complexity by age interaction. Means for young and older officials were similar for the minimum and maximum complexity levels. Older officials appeared to do better with medium complexity level scenarios (refer to Table 12).
Hypothesis 1c

Hypothesis 1c examined mean differences between experts and novices in the recall and demonstration of basketball hand signals (HS). It was predicted that experts would demonstrate and recall more basketball hand signals. This was another measure of Procedural Knowledge.

There were 36 hand signals listed in the basketball rules book. Participants had to name each hand signal (free recall) and then demonstrate it to be credited with a correct answer/response. A Univariate ANOVA 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) design, was performed on the scores to test for expert/novice mean differences (refer to Table 15). The results of this analysis demonstrated significant mean differences for expertise with $F(1, 36) = 19.58, p < .05$. Age also demonstrated significant mean differences with $F(1, 36) = 4.91, p < .05$.

Experts (mean = 31.12, SD = 2.54) had significant more correct hand signals than novices (mean = 26.13, SD = 4.34) and older officials (mean = 30.36, SD = 3.15) had significantly more correct hand signals than young officials (mean = 27.40, SD = 4.87).

For a review of the means and SDs refer to Table 16.

Table 15

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>200.21</td>
<td>15.58</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>50.15</td>
<td>4.91</td>
<td>.03*</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>2.67</td>
<td>.26</td>
<td>.61</td>
</tr>
</tbody>
</table>

Note. *$p = < .05$.  
R Square = .44.  
Adjusted R Square = .39.
Table 16

Procedural Knowledge HS: Expert and Novice Mean Age Differences

<table>
<thead>
<tr>
<th>Age</th>
<th>Younger</th>
<th>Older</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>Mean</td>
<td>24.57</td>
<td>27.50</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.41</td>
<td>2.83</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Expert</td>
<td>Mean</td>
<td>29.88</td>
<td>31.71</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>2.70</td>
<td>2.31</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>Mean</td>
<td>27.40</td>
<td>30.36</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>4.87</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

In conclusion, the Hypothesis 1c results for Procedural Knowledge variable of hand signals free recall and demonstration had significant mean expert/novice and age differences. Expert and older officials significantly recalled and demonstrated more correct basketball hand signals than novice officials. Hypothesis 1c was confirmed.

Hypothesis 2

This hypothesis predicted that younger officials would have significantly higher scores on tests of fluid abilities than older officials. Fluid ability (Gf) was tested using Cattell and Catell’s (1961) Test of “g”: Cultural Fair, Scale 2, Form B.
To test hypothesis 2 it was important to reconstruct the variables to guard against the possible confound between age and expertise. The dependent variable was the total scale score for this measure (Gf). Second, a contrast code was created for the expert variable (e.g., -1 for novice and +2 for expert). Third, a centered age, continuous age variable, was constructed from chronological age. It was done by calculating the mean age score for the entire sample, and then taking each participant’s age and subtracting the mean age score. Fourth, a multiplicative interaction term was created by multiplying the centered age variable times the expert variable.

After construction of the centered age, contrasted expert variable, and multiplicative interaction term a hierarchical regression analysis was completed in which three models were estimated. Model 1 had the Gf variable regressed on the centered age variable. Model 2 regressed the Gf variable on both the centered age variable and expert variable. Model 3 regressed the Gf on the centered age variable, the expert variable, and multiplicative interaction. There were not any significant results for the hierarchical regression analysis (see Table 17).

Table 17
Fluid Abilities Hierarchical Regression

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R SQ</th>
<th>Adjusted R SQ</th>
<th>F change</th>
<th>df1</th>
<th>df2</th>
<th>Sig F change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.24</td>
<td>.06</td>
<td>.03</td>
<td>2.36</td>
<td>1</td>
<td>38</td>
<td>.13</td>
</tr>
<tr>
<td>2</td>
<td>.24</td>
<td>.06</td>
<td>.01</td>
<td>.04</td>
<td>1</td>
<td>37</td>
<td>.84</td>
</tr>
<tr>
<td>3</td>
<td>.32</td>
<td>.10</td>
<td>.03</td>
<td>1.73</td>
<td>1</td>
<td>36</td>
<td>.20</td>
</tr>
</tbody>
</table>

Note. *p < .05.
In conclusion, neither age nor expertise is a significant predictor of fluid abilities. There were no significant expert/novice or age mean differences. Finally there was no significant effect for interaction variable. Hypothesis 2 was not confirmed.

Hypothesis 3

This hypothesis predicted older officials would have significantly higher scores on the measure of crystallized abilities. The measure used to test for crystallized abilities (Gc) was the Mill Hill Vocabulary Test. There were 34 words with six choices (only one correct choice per word) for a participant to choose the word with the same meaning as the word of interest. This hypothesis was tested using the same procedure and independent variables that were used to test hypothesis 2. The only difference for the analysis was that the Gc variable replaced the Gf variable as the dependent variable regressed on the independent variables. Table 18 has the results for the hierarchical regression. It can be seen that age was a significant predictor of crystallized ability in all models. Age predicts crystallized abilities over and above any expertise effects in model 2. Model 3 demonstrated a significant age x expertise interaction.

Table 18

Crystallized Abilities Hierarchical Regression

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R SQ</th>
<th>Adjusted R SQ</th>
<th>F change</th>
<th>df1</th>
<th>df2</th>
<th>Sig F change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.41</td>
<td>.16</td>
<td>.14</td>
<td>7.48</td>
<td>1</td>
<td>38</td>
<td>.01*</td>
</tr>
<tr>
<td>2</td>
<td>.42</td>
<td>.18</td>
<td>.13</td>
<td>.48</td>
<td>1</td>
<td>37</td>
<td>.49</td>
</tr>
<tr>
<td>3</td>
<td>.64</td>
<td>.41</td>
<td>.36</td>
<td>14.52</td>
<td>1</td>
<td>36</td>
<td>.01*</td>
</tr>
</tbody>
</table>

Note. *p ≤ .05.
To interpret the age x expertise interaction the following formula was used:

Predicted Crystallized Abilities = Y + Age B coefficient (Centered Age) + Age x Expert B coefficient (Center Age) (Expert).

Table 19 provided the Unstandardized B coefficients. Centered age was standardized as 10 (approximately 52 years old) for older officials and -10 for younger officials (approximately 32 years old). Expert used the contrast code of 1 for expert and -1 for novice. Results indicated the scores for young and older experts remained fairly stable with no significant differences (.65 to .67 respectively). While the scores for young and older novices were significantly different (.55 to .77 respectively).

Table 19

Crystallized Abilities Hierarchical Regression: Coefficients Age and Expertise

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficient B</th>
<th>Standardized Coefficient Beta</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>.638</td>
<td>32.11</td>
<td>.01*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.004</td>
<td>.406</td>
<td>2.74</td>
</tr>
<tr>
<td>2</td>
<td>Constant</td>
<td>.663</td>
<td>30.53</td>
<td>.01*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.004</td>
<td>.363</td>
<td>2.43</td>
</tr>
<tr>
<td></td>
<td>Expert</td>
<td>.016</td>
<td>.112</td>
<td>.69</td>
</tr>
<tr>
<td></td>
<td>Model</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td>Constant</td>
<td>.663</td>
<td>34.08</td>
<td>.01*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.005</td>
<td>.455</td>
<td>3.23</td>
</tr>
<tr>
<td></td>
<td>Expert</td>
<td>.006</td>
<td>.026</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>Age x Expert</td>
<td>.006</td>
<td>-.492</td>
<td>-3.76</td>
</tr>
</tbody>
</table>

Note. *p ≤ .05.
In sum there is an age effect for crystallized abilities as well as an age x expertise interaction. Although these results must be interpreted with caution, it appeared that the interactive effects were due to the higher scores of the older novice officials. Hypothesis 3 was confirmed.

Hypothesis 4

This hypothesis predicted knowledge would mediate the effects of age on procedural performance differences. Hierarchical regressions were completed in two steps on the Procedural Knowledge variables. The first step was a model with the dependent variable of interest regressed on age as the predictor. The second step regressed the dependent variable of interest on age (dichotomous), Justification Knowledge, and Declarative Knowledge (Vignettes Total Scores). The dependent variable of interest was the procedural performance variable that had significant mean age and expert/novice differences, Hand Signals. Tables 20 (Model Summary), 21 (Coefficients), and 22 (ANOVA) give the summary of the hierarchical regression results with hand signals as the dependent variable.

Table 20 results indicated that both models were significant: Model 1 with $F(1, 38) = 10.42, p < .05$, and for Model 2 with $F(3, 36) = 5.81, p < .05$. Table 19 demonstrated that step 2/model 2 did not add significant variance, with $F(2, 36) = 2.97, p > .05$. Table 21 results indicated a significant effect for age in Model 1 with $t = 3.23, p \leq .05$. Model 2 also demonstrated a significant effect for age ($t = 2.23, p \leq .05$) and Justification Knowledge ($t = 1.97, p \leq .05$). Taken together the results demonstrate no mediation effects for knowledge variables since age is significant in both models.
Table 20
Hierarchical Regression Dependent Variable Hand Signals: Model Summary for Age, JK, and Vig

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R SQ</th>
<th>Adjusted R SQ</th>
<th>F change</th>
<th>df1</th>
<th>df2</th>
<th>Sig F change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.46</td>
<td>.22</td>
<td>.19</td>
<td>10.42</td>
<td>1</td>
<td>38</td>
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<tr>
<td>Age</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.57</td>
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<td>.27</td>
<td>.11</td>
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<td>36</td>
<td>.06</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05.

Table 21
Hierarchical Regression Dependent Variable Hand Signals: Coefficients for Age, JK, and Vig

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficient B</th>
<th>Standardized Coefficient Beta</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>23.02</td>
<td></td>
<td>11.42</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td>.15</td>
<td>.46</td>
<td>3.28</td>
<td>.01*</td>
</tr>
<tr>
<td>2</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>21.17</td>
<td></td>
<td>10.06</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td>.11</td>
<td>.33</td>
<td>2.23</td>
<td>.03*</td>
</tr>
<tr>
<td>JK</td>
<td>1.33</td>
<td>.31</td>
<td>1.97</td>
<td>.05*</td>
</tr>
<tr>
<td>Vig</td>
<td>.17</td>
<td>.10</td>
<td>.70</td>
<td>.49</td>
</tr>
</tbody>
</table>

Note. *p < .05.
Table 22
Hierarchical Regression Dependent Variable Hand Signals: ANOVA for Age, JK, and Vig

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of SQ</th>
<th>df1</th>
<th>df2</th>
<th>Mean SQ</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Age</td>
<td>140.17</td>
<td>1</td>
<td>38</td>
<td>140.17</td>
<td>10.42</td>
<td>.01*</td>
</tr>
<tr>
<td>2 Age JK Vig</td>
<td>212.48</td>
<td>3</td>
<td>36</td>
<td>70.83</td>
<td>5.81</td>
<td>.01*</td>
</tr>
</tbody>
</table>

Note. *p < .05.

In conclusion Hypothesis 4 was not confirmed. The results indicated that knowledge, Declarative Knowledge (Vignettes Total Score) and Justification Knowledge did not mediate the effect of age. Tests for mediation were done with a number of other regressions using other knowledge variables and procedural knowledge variables. The results from these analyses demonstrated low correlations between age and the mediators, as well as low correlations between the mediators and outcome variable. Due to these low correlations there were no mediation effects.

Hypotheses 5 and 6

Hypotheses 5 and 6 examined age and expert/novice differences in procedural performance scenarios of low (Hypothesis 5) and high (Hypothesis 6) levels of information. It was predicted that experts would make more correct calls.

The scenarios for a low level of information had of two-second scenario time limits for viewing. Participants viewed the scenario for two seconds and then make a call.
(foul, violation, or no call). There were 23 scenarios of two second time length viewed. The original Cronbach’s Alpha level for these scenarios was .29. Items with negative correlations that lowered the alpha level were eliminated from the measure and the Cronbach’s Alpha level increased to .62 with the remaining 10 scenarios.

High levels of information had seven-second scenario time limits. Participants viewed the scenario for seven seconds and then had to make a call (foul, violation, or no call). There were 22 scenarios of seven second time length viewed. The original Cronbach’s Alpha level for these scenarios was .29. When items with negative correlations that lowered the alpha level were eliminated from the measure, the Cronbach’s Alpha level increased to .62 with the remaining 10 scenarios.

A Repeated Measures ANOVA 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) X 2 (levels of information- low/high) design, was performed on the resulting items (refer to Table 23). There were expert/novice significant means differences with $F(1, 36) = 4.19, p < .05$. Experts had more correct responses than novices overall. There were no significant age effects. Level of information was significant with $F(1, 36) = 19.76, p < .05$. No interactions were statistically significant. Table 24 has the means and SDs. It can be seen that means increase as level of information increases.
In conclusion, expert officials made more correct calls on procedural performance scenarios of low and high levels information. There were no effects for age so older officials were not hindered when they received less information. Hypotheses 5 and 6 were confirmed.
Table 24

Procedural Knowledge Level of Information: Expertise and Age Mean Differences

(continued)

<table>
<thead>
<tr>
<th>Levels of Information</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.73</td>
<td>7.13</td>
</tr>
<tr>
<td>SD</td>
<td>2.22</td>
<td>2.10</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Expert Young</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>5.63</td>
<td>7.75</td>
</tr>
<tr>
<td>SD</td>
<td>2.00</td>
<td>1.73</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Expert Older</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.29</td>
<td>7.71</td>
</tr>
<tr>
<td>SD</td>
<td>1.86</td>
<td>1.36</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Expert Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.08</td>
<td>7.72</td>
</tr>
<tr>
<td>SD</td>
<td>1.89</td>
<td>1.46</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Age Total Young</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.60</td>
<td>7.53</td>
</tr>
<tr>
<td>SD</td>
<td>2.13</td>
<td>1.64</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Age Total Older</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6.16</td>
<td>7.48</td>
</tr>
<tr>
<td>SD</td>
<td>1.89</td>
<td>1.81</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
Hypothesis 7

Anticipation of the play or player movements would be a core skill identified in accounting for differences between experts and novices. There were eight scenarios in the anticipation measure. Four of the eight scenarios were of low level information (2 seconds) and four were of high level information (7 seconds). The eight scenarios had two scenarios of minimum complexity, three medium complexity, and three maximum complexity. There are four parts to Hypothesis 7 and each will be discussed.

Hypotheses 7a and 7b

These parts of Hypothesis 7 state that expert officials will have significantly more correct calls on all the of anticipation scenarios (7a), and as complexity level increases, there will be no significant differences in number of correct calls between older and younger experts (7b). Anticipation minimum complexity level on anticipation consisted of two scenarios with a Cronbach’s Alpha of .43. Anticipation medium level of complexity originally consisted of three scenarios. Cronbach’s Alpha level for these scenarios was .31. The item with the lowest correlation that lowered the alpha level was eliminated from the measure and the Cronbach’s Alpha level increased to .41. Anticipation maximum level of complexity originally consisted of three scenarios. Cronbach’s Alpha level for these scenarios was .50. The item with the lowest correlation that lowered the alpha level was eliminated from the measure and the Cronbach’s Alpha level increased to .53.

Next a repeated measures ANOVA, 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) X 3 (levels of complexity- minimum, medium, and maximum) design was performed on the adjusted variables to compare the s
proportion correct means. The effect for complexity was significant with $F(2, 72) = 6.72, p \leq .05$. There were no significant interactions between age or expertise and complexity. The results indicated a significant effect for expertise with a $F(1, 36) = 40.22, p < .05$.

There were no effects for age (refer to Table 25). The expert overall mean was 1.36 with a SD of .70 for minimum complexity; medium complexity expert mean = 1.64, SD = .80; and maximum complexity mean = 1.08, SD = .70. The novice overall mean was .73 with a SD of .70 for minimum complexity; medium complexity mean = .93, SD = .57; and maximum complexity mean = .27, SD = .46 (for a review of all means and SDs refer to Table 26).

Table 25
Anticipation Complexity Repeated Measures Analysis: Expertise and Age Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>13.06</td>
<td>40.22</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>.21</td>
<td>.67</td>
<td>.42</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>.44</td>
<td>1.38</td>
<td>.25</td>
</tr>
</tbody>
</table>

Note. *$p = \leq .05$.*

Table 26
Anticipation Complexity Level: Expertise and Age Mean Differences

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Minimum</th>
<th>Medium</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Young</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.71</td>
<td>1.38</td>
<td>.43</td>
</tr>
<tr>
<td>SD</td>
<td>.49</td>
<td>.89</td>
<td>.53</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

95
Table 26

Anticipation Complexity Level: Expertise and Age Mean Differences (continued)

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Minimum</th>
<th>Medium</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Older</td>
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<td>.75</td>
<td>.13</td>
</tr>
<tr>
<td></td>
<td>.89</td>
<td>.71</td>
<td>.35</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Novice Total</td>
<td>.73</td>
<td>.93</td>
<td>.27</td>
</tr>
<tr>
<td></td>
<td>.70</td>
<td>.57</td>
<td>.46</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Expert Young</td>
<td>1.38</td>
<td>1.64</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>.74</td>
<td>.80</td>
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<tr>
<td></td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Expert Older</td>
<td>1.35</td>
<td>1.65</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>.70</td>
<td>.49</td>
<td>.70</td>
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<tr>
<td></td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Expert Total</td>
<td>1.36</td>
<td>1.64</td>
<td>1.08</td>
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<td></td>
<td>.70</td>
<td>.80</td>
<td>.70</td>
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<td></td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Age Total Young</td>
<td>1.07</td>
<td>1.40</td>
<td>.73</td>
</tr>
<tr>
<td></td>
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<td>.82</td>
<td>.70</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Age Total Older</td>
<td>1.16</td>
<td>1.36</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>.80</td>
<td>.70</td>
<td>.76</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>25</td>
<td>15</td>
</tr>
</tbody>
</table>
Hypothesis 7c

Anticipation low level of information (2 second scenarios) originally consisted of three scenarios. Cronbach’s Alpha level for these scenarios was .20. The item with the lowest correlation that lowered the alpha level was eliminated from the measure and the Cronbach’s Alpha level increased to .40. Anticipation high level of information (7 second scenarios) originally consisted of three scenarios. Cronbach’s Alpha level for these scenarios was .30. The item with the lowest correlation that lowered the alpha level was eliminated from the measure and the Cronbach’s Alpha level increased to .46.

A repeated measures ANOVA 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) X 2 (levels of information- low/high) design was performed on the adjusted variables, the mean proportion correct. Level of information was not significant with F (1, 36) = .13, p > .05. There were no significant interactions between complexity and age or expertise. Results between subjects indicated a significant effect for expertise with F (1, 36) = 36.94, p < .05. There were no effects for age (refer to Table 27), thus older officials were not hindered by less information. Experts had an overall mean of 1.64 with a SD of .57. The novice overall mean was .80 with a SD of .77. A review of the means and SDs (refer to Table 28) explains why levels of information was not significant. Table 28 demonstrated the expert and novice means with less information presented.
Table 27

Anticipation Levels of Information Repeated Measures Analysis: Expertise and Age Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>4.21</td>
<td>36.94</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>.58</td>
<td>2.11</td>
<td>.16</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>.73</td>
<td>2.65</td>
<td>.11</td>
</tr>
</tbody>
</table>

Note. *p = < .05.

Table 28

Anticipation Level of Information: Expertise and Age Mean Differences

<table>
<thead>
<tr>
<th>Levels of Information</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Young</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.14</td>
<td>1.00</td>
</tr>
<tr>
<td>SD</td>
<td>.90</td>
<td>.82</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Novice Older</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.75</td>
<td>.63</td>
</tr>
<tr>
<td>SD</td>
<td>.71</td>
<td>.74</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Novice Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>.93</td>
<td>.80</td>
</tr>
<tr>
<td>SD</td>
<td>.80</td>
<td>.77</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 28
Anticipation Level of Information: Expertise and Age Mean Differences (continued)

<table>
<thead>
<tr>
<th>Levels of Information</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expert Young</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.63</td>
<td>1.63</td>
</tr>
<tr>
<td>SD</td>
<td>.74</td>
<td>.82</td>
</tr>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Expert Older</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.65</td>
<td>1.65</td>
</tr>
<tr>
<td>SD</td>
<td>.49</td>
<td>.49</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td><strong>Expert Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.64</td>
<td>1.64</td>
</tr>
<tr>
<td>SD</td>
<td>.57</td>
<td>.57</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Age Total Young</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.40</td>
<td>1.33</td>
</tr>
<tr>
<td>SD</td>
<td>.83</td>
<td>.82</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>Age Total Older</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.36</td>
<td>1.32</td>
</tr>
<tr>
<td>SD</td>
<td>.70</td>
<td>.75</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

**Hypothesis 7d**

This hypothesis predicted that older officials will have significantly more responses in relation to watching an area of the court rather than watching the ball or player with the ball, than younger officials and novices. In particular, older expert
officials were expected to have more responses than younger expert officials in relation to watching an area of the court.

A Univariate ANOVA 2 (expertise- novice/expert) X 2 (age- young = ≤ 36 years of age/older = ≥ 37 years of age) design, was performed on the measure (refer to Table 29). Watching an area had expert/novice significant means differences with F (1, 36) = 5.38, p ≤ .05 (expert mean = .80, SD = .41; novice mean = .40, SD = .51). There were significant age mean differences F (1, 36) = 5.38, p ≤ .05 (older official mean = .80, SD = .41, and younger official mean = .40, SD = .51). Table 30 has the means and SDs.

Table 29
Watch Court Area Univariate Analysis: Expertise and Age Differences

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert</td>
<td>1,36</td>
<td>.95</td>
<td>5.38</td>
<td>.03*</td>
</tr>
<tr>
<td>Age</td>
<td>1,36</td>
<td>50.15</td>
<td>5.38</td>
<td>.03*</td>
</tr>
<tr>
<td>Expert x Age</td>
<td>1,36</td>
<td>2.67</td>
<td>.64</td>
<td>.43</td>
</tr>
</tbody>
</table>

Note. *p = ≤ .05.
R Square = .30.
Adjusted R Square = .24.
In review of Hypothesis 7, Hypotheses 7a and 7b showed significant expert/novice mean differences. As predicted, experts made significantly more correct total calls than novices on anticipation scenarios. Hypothesis 7b demonstrated experts made a significant number of more correct calls than novices in all levels of complexity (minimum, medium, and maximum). There were no significant effects for age as complexity level increased. Hypothesis 7c showed experts made significantly more correct calls than novices in anticipation conditions of low and high levels of information. There were not any significant effects for age as levels of information decreased.
Hypotheses 7a, 7b, and 7c had no significant age differences in number of correct calls and all of these hypotheses (7a, 7b, and 7c) were confirmed.

Hypothesis 7d, watching an area of the court, had expert/novice significant mean differences with expert officials reporting to have watched a court area more times than novices. There were significant mean age differences in the responses of watching a court area. This hypothesis (7d) was confirmed. There was a significant effect for age. Older officials made significantly more responses to watching an area of the court than young officials. In particular the older expert officials’ means were higher than the younger expert officials’ means.

In conclusion, Hypothesis 7 was confirmed. Anticipation is a core skill identified in this study that did account for expert novice differences.

Hypothesis 8

This hypothesis examined the possibility that experience will mediate the effects of age on procedural performance. Experience was defined as the total number of years officiating basketball. Hierarchical Regression analyses were performed on hand signals, a procedural performance variable. The hand signals variable was used as the dependent variable because of the significant effects for it had for both age and expertise. The first model of the hierarchical regression had the dependent variable regressed on the independent variable age. The second model of the hierarchical regression had the dependent variable regressed on the independent variables age and experience. For the results of these analyses refer to Table 31 (Model Summary), Table 32 (ANOVA), and Table 33 (Coefficients).
Table 31
Hierarchical Regression Dependent Variable Hand Signals: Model Summary for Age and Experience

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R SQ</th>
<th>Adjusted R SQ</th>
<th>F change</th>
<th>df1</th>
<th>df2</th>
<th>Sig F change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.46</td>
<td>.22</td>
<td>.19</td>
<td>10.42</td>
<td>1</td>
<td>38</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.59</td>
<td>.35</td>
<td>.31</td>
<td>7.53</td>
<td>2</td>
<td>37</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05.

Table 32
Hierarchical Regression Dependent Variable Hand Signals: ANOVA for Age and Experience

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of SQ</th>
<th>df1</th>
<th>df2</th>
<th>Mean SQ</th>
<th>F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82.14</td>
<td>1</td>
<td>38</td>
<td>140.17</td>
<td>10.42</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>280.71</td>
<td>2</td>
<td>37</td>
<td>113.32</td>
<td>9.87</td>
<td>.01*</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exp</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. *p < .05.
Table 33

Hierarchical Regression Dependent Variable Hand Signals: Coefficients for Age and Experience

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficient B</th>
<th>Standardized Coefficient Beta</th>
<th>t</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>23.02</td>
<td>11.42</td>
<td>.01*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.15</td>
<td>.46</td>
<td>3.23</td>
</tr>
<tr>
<td>2</td>
<td>Constant</td>
<td>24.49</td>
<td>12.64</td>
<td>.01*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.06</td>
<td>.20</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>Exp</td>
<td>.18</td>
<td>.45</td>
<td>2.74</td>
</tr>
</tbody>
</table>

Note.*p < .05.

Table 31 demonstrates that Model 2 predicted significant variance over and above Model 1, F (2, 37) = 7.53, p < .05. Table 32 ANOVA demonstrates that both models are significant. Model 1 had F (1, 38) = 10.42 p < .05. Model 2 had F (2, 37) = 9.87, p < .05.

Table 33 demonstrates that experience as defined by number of years officiating does mediate the effects of age on the procedural performance variable hand signals. It shows that when both experience and age were included in the hierarchical regression, experience is a significant predictor (t = 2.74, p < .05) while age is not (t = 1.19, p > .05).

In conclusion, Hypothesis 8 was confirmed. The results for Hypothesis 8 indicated that experience, as defined by number of years officiating, did have a mediation effect on age resulting in age not being a significant predictor of procedural performance (Hand Signals) when both were included in the hierarchical regression. Experience was a
significant predictor of procedural performance (Hand Signals) when both were included in the hierarchical regression.
Chapter V discusses the results of the study in relation to expertise, age, mediation, new/developed measures of expertise, future directions, and anticipation as a core skill. This dissertation is best described as exploratory in its nature.

Exploratory Study

This study was exploratory in its nature because it is not testing any specific theory. No studies were found in the literature that explored expertise in basketball officiating. It was also exploratory because measures had to be developed in order to test for two different concepts of interest inquired about by the study, justification knowledge and anticipation. New measures were studied in conjunction with standard measures.

The concept of justification knowledge was a new type of knowledge variable developed specifically for this study. It was necessary to develop a measure to test for this variable. Anticipation was not a new concept or variable to the area of expertise and sports. Anticipation in relationship to expertise and basketball officiating was a new concept and a measure was developed to test the variable.

Expertise

Expertise was defined as a State of Ohio Class 1 basketball official with equal to or greater than 10 years experience. It was found that expert officials recalled significantly more justification knowledge information, by number of responses, than
novices in relation to knowledge of other plays, specific plays or game situations, and by refereeing either the offense or defense $F(1, 36) = 7.14, p \leq .05$. There was an interaction between expertise and age, $F(1, 36) = 4.64, p \leq .05$. The results indicated that the advantage of experts was primarily due to the performance of older officials (refer to Table 4).

Similar to how expert gymnastic judges focused on different body parts (Bard, Fleury, Carriere, & Halle 1980), expert basketball officials focused on specific court areas (own court position, area of responsibility). As the participants viewed the different game scenarios they reported “feeling” as if they were in the lead, trial, or center positions on the court. Although this dimension was not intentionally a design of the research, it led expert officials to have a significant number of more responses in regard to their own position on the court or their area of responsibility as if they were in the lead, trial, or center position with $F(1, 36) = 9.12, p \leq .05$ (refer to Table 6).

Experts had a significant number of more correctly answered written vignettes than novice officials. To answer the question correctly an individual must mentally visualize the different scenarios in his/her mind then mentally recall the rule(s) that apply to the situation to correctly answer the vignette question. The vignettes had expert/novice significant means differences $F(1, 36) = 4.01, p \leq .05$ (for review of means and SDs refer to Table 10).

This finding is similar to results in Allard, Graham, and Paarsalu’s (1980) research of the differences between varsity and intramural basketball players. Their participants were presented with static, structured game play, and non-game scenarios.
They were asked to recall player positions under time pressure. Varsity players recalled more positions in the structured conditions only.

Experts were better able to anticipate players’ movements when they reviewed the particular DVD scenarios of maximum complexity in procedural performance. The scenarios required the participants to referee the defense first and then the offense. There was a significant effect for expertise with $F(1, 36) = 6.11$, $p < .05$. The interesting finding was that only expert officials made correct calls for the scenarios. This result lends credence to Allard and Stark’s (1991) research in looking beyond pattern-based retrieval. These researchers found that elite athletes were able to extract and recall more information after brief exposure to representative game situations. Elite athletes in Allard and Stark’s (1991) research were able to internally represent complex game situations that allowed them to predict and anticipate future opponents’ actions. Internal mental representations based on cues from game situations may have enabled expert officials to select the correct responses for the scenarios.

In aspects of free recall and a physical demonstration of basketball hand signals, the experts recalled and demonstrated a significantly greater number of hand signals than novices. Expertise had $F(1, 36) = 19.58$, $p < .05$. Expert mean = 31.12, SD = 2.54 while the novice mean = 26.13, SD = 4.34.

Experts made significantly more correct calls when level of information decreased (2 second time frame scenarios). The expertise effect was significant $F(1, 36) = 5.94$, $p < .05$. The expert mean = 6.08, SD = 1.89, while the novice mean = 4.73, SD = 2.22.

Experts made significantly more correct anticipation calls (predicting what would happen next after seeing a portion of a DVD scenario) than novices, even when
complexity levels increased. Expertise had $F(1, 36) = 40.22, p < .05$ (refer to Table 25). To review the expert/novice means and SDs in relation to complexity level refer to Table 26.

Experts made significantly more correct anticipation calls (predicting what would happen next) in both low (2 seconds) and high (7 seconds) levels of information, $F(1, 37) = 36.94, p < .05$. For low levels of information the expert mean = 1.64, SD = .57, while the novice mean = .93, SD = .80. The high levels of information expert mean = 1.64, SD = .57, while the novice mean = .80, SD = .77.

Experts had significantly more number of responses in relation to watching an area of the court rather than watching the ball. Expertise had $F(1, 36) = 5.38, p < .05$. The expert mean = .80, SD = .41 while the novice mean = .40, SD = .51.

In sum the experts in this study were officials that recalled significantly more information in relation to other plays, specific game situations, and when to referee the defense first and then the offense. They had a good understanding of their position on a court and their area of responsibility for making correct calls. The expert officials were able to read paper vignettes and answer more of the questions correctly.

In relation to their procedural performance, participants had to recall and physically demonstrate basketball hand signals and make correct calls while reviewing DVD scenarios of different game situations. The expert officials recalled and physically demonstrated significantly more hand signals than novices. There were scenarios of maximum complexity in which only the experts made correct calls. They knew where to look in anticipation of players’ movements. In addition the experts knew what to look for in anticipation of the reactions of the offensive players. This skill was based on the
technique of refereeing a specific area of the court, the defensive player(s) in that part of the court, and then anticipating the movements of the offensive player(s) in that area.

While viewing the DVD scenarios, as the level of information decreased from 7 seconds to 2 seconds experts made significantly more correct calls than novices. All these results are understandable because experts also had significantly more responses in relation to watching a court area rather than the ball than novices. To know what area of the court to watch meant the official had the ability to anticipate or predict where the ball would go next or where the next action on the court would take place.

The experts in this study were able to anticipate/predict what would happen next a significantly more number of times than novices. As complexity level increased in the anticipation measure experts were able to anticipate/predict what would happen next a significantly more number of times than novices. Experts anticipated/predicted what would happen next a significantly more number of times than novices in both levels of information (2 seconds and 7 seconds). Anticipation was found to be a core skill in high school basketball officiating for experts.

Age

When the procedural performance measure Hand Signals was examined, the age effect was significant $F (1, 36) = 4.91, p < .05$. The older official mean $= 30.36$, $SD = 3.15$ while the young official mean $= 27.40$, $SD = 4.87$. Older officials recalled and physically demonstrated a number of more basketball hand signals than young officials.

When the complexity levels of procedural performance were examined there was a complexity by age interaction with $F (2, 36) = 3.45, p < .05$. Only in the medium complexity level is there a significant effect for age.
Age effects did occur for the measure Watch Court Area. Age had $F(1, 36) = 5.38, p \leq .05$. The older officials’ mean = .80, SD = .41 while the young officials’ mean = .40, SD = .51 (for a review of the means refer to Table 30). Older officials reported to watch a particular area of the court more often than young officials.

Although Justification Knowledge had no significant effects for age there was an interaction between expertise and age (mentioned above). Expertise x age was significant $F(1, 36) = 4.64, p \leq .05$. The results indicated that the advantage of experts was primarily due to the performance of older officials.

Not having age effects can also be a positive issue for older officials. If one would consider fluid abilities, it would be expected for young officials to have higher scores than older officials according to the research ((Hayslip & Panek, 1989; Horn, 1985; Horn & Masunaga, 2007; Raz, 2000). No age effects indicated that older officials performed as well as younger officials on the tests of fluid abilities. These results may also be due to the selectiveness of the sample.

Effects for age were significant in the tests of crystallized abilities including a significant age x expertise interaction. Results indicated little difference between the scores of the younger and older experts. The age effect was due to the difference between the scores of younger and older novices. Older novices not only had significantly higher scores than younger novices, but also higher scores than both the younger and older experts creating the interaction. The results again may be due to the selectiveness of the sample.
There were also no significant age effects in relation to levels of information. This result simply means that older officials were not hindered when they received less information and had less time to view the DVD game scenarios.

Overall the older officials in this study recalled and physically demonstrated more basketball hand signals than young officials. Older officials reported to watching an area of the court more often/more responses rather than watching the ball. They were not hindered when receiving less information while making a call. Older officials performed as well as young officials on measures of fluid abilities and better than young adults on measures of crystallized abilities.

**Mediation**

Experience, defined as number of years officiating, was used to determine if it mediated the effects of aging on procedural performance. Hand signals was the procedural performance measure chosen to be the dependent variable because it had significant effects for both expertise and age. A look at Table 31 demonstrates that both models were significant: Model 1, Age- $F(1, 38) = 10.42, p < .05$; Model 2, Age/Experience- $F(2, 37), p < .05$. When both experience and age were included in the hierarchical regression, experience remained a significant predictor ($t = 2.74, p < .05$) while age did not ($t = 1.19, p > .05$). The results indicated that experience mediated the effects of age on procedural performance (hand signals).

Experience defined as number of years officiating was the only mediator found in the study. Many other tests for mediation were done. Due to low correlations between mediators and age, as well as between mediators and outcome variables, no other mediation effects for age.
Study Limitations

One concern for the study was the unequal group sizes caused a non-orthogonality between the variables. Many times in field research the variables, both independent and dependent, are non-orthogonal or correlated (Tabachnick & Fidell, 1996). When variables are correlated, they have shared or overlapping variance. It means the main effects and interactions may not be totally independent of each other. This leads to the possibility of an inflated alpha and increase in Type 1 error (Tabachnick & Fidell, 1996).

With variables being correlated there is also the issue of multicollinearity and singularity. With multicollinearity variables are usually very highly correlated at .90 and above (Tabachnick & Fidell, 1996). The highest correlation in the sample was .80 between performance total score and performance low level of information. The next highest correlation was between anticipation high level of information and the total score for anticipation (.76) Chronological age and dichotomous age had a correlation of .74.

Singularity is a redundancy in the variables because one of the variables is a combination of two or more of the variables due to high correlations (Tabachnick & Fidell, 1996). The majority of the correlations between the variables were in a low to moderate range when significant (refer to Table 3).

There are limitations in reference to the sample. First the sample size was small and could have affected power to get results. Second it was a selected sample due to the nature and type of participants (basketball officials). Third the sample was self selected. Two hundred seventy-three e-mails were sent out to officials. One hundred twenty reported they would participate. Eighty-eight of these 120 officials completed the first
part of the tests and e-mailed them back. Of the 88 who completed the first part of the tests, only 40 completed the final tests.

Even though the sample has limitations, it was believed there was strength in using this sample. Due to officials being recruited from all parts of the State, the sample was a good representation of basketball officials in the study.

Summary

The overall results of the study demonstrated that basketball expert officials were better able to perceive large meaningful patterns such as specific plays or game situations (Chase & Simon, 1973), had greater memory for other plays in short term recall (Chase & Ericsson, 1982), and their automaticity in many portions of skills (referee offense or defense) freed up greater resources for storage to improve their decision making (Chi & Glaser, 1988). Only expert officials made the correct calls in the maximum complexity level scenarios of procedural performance that required an official to referee the defense first and then the offense. Experts were better able than novices to perceive the patterns of information and determine the correct call (Chase & Simon, 1973).

The type of working memory demonstrated by the expert basketball officials may be independent of short-term memory (Ericsson & Kintsch, 1995; Masunaga & Horn 2001). However, the study was not able to determine if it was a type of long-term working memory (Ericsson & Kintsch, 1995) or that it operates in the short-term thus expertise working memory (Masunaga & Horn 2001).

Encapsulation Theory states that as general processes and abilities are encapsulated within a particular parameter of knowledge, the domain extant knowledge
becomes more accessible, differentiated, usable, and “expert” in nature. Encapsulation of knowledge allows for larger and more integrated cognitive units to be stored.

Some study results may be of interest to Sternberg’s (2001) model of developing expertise. He believed that both static and dynamic abilities were intertwined with expertise due to the continual updating, training, and experience a basketball official gained as the craft was learned. There were not any significant age effects in the measures for Justification Knowledge, yet there are significant mean expert/novice differences. Expert/novice differences could possibly be also explained by Allard and Stark’s (1991) research that looked beyond pattern-based retrieval when the internal mental representations based on cues from game situations may have enabled expert officials to select the more correct responses.

Expert/age significant effects for Hand Signals expected experts to have better scores than novices, but not older officials to have better scores than young officials. The reason older officials did so well may be attributed to some older officials being expert officials in other sports. Twenty of the 25 expert officials that participated in the study officiated at least one other sport (7 young experts, 13 old experts). According to our definition, they all qualified as an expert official in the other sport(s). Nine of the 15 novice officials officiated at least one other sport (4 young novice, 5 old novice). One young novice and three older novice officials qualified as an expert official in the other sport(s).

What is important about the results with the procedural knowledge/measures of procedural performance use of the DVD scenarios is that the results bring up the idea of expertise possibly transferring across domains. *The Officials’ Quarterly Summer 2007*
Magazine (the official magazine for NFHS officials) also supports this idea. It discussed how officials were expected to be professional (experts) at all times, not only in sports but on their jobs. Many officials, both novice and expert, are physicians, teachers, high school principals, professors, detectives, politician, etc. A glance through the magazine a person can also find that many officials also meet the criteria for being experts in multiple sports. However, there is no research available that supports the transference of expertise across domains.

In relation to no effects for age with fluid abilities, evidence of decline in fluid abilities during adult development came from both longitudinal and cross-sectional studies (Horn & Masunaga, 2007). Decline of fluid abilities was due to vulnerable conditions associated with aging (Horn, 1985; Raz, 2000). One of the measures of fluid abilities (in Horn, 1985; Raz, 2000 studies) indicated a decline in figural relations/pattern recognitions. The Test of “g”: Culture Fair-Scale 2, Form B was considered one of the best ways to test for fluid abilities because it requires detection of patterns in abstract and unusual ways (Hunt, 2007). It was a positive finding that older officials performed as well as younger officials on tests of fluid abilities. Keeping in mind that this is a select group of individuals, results may vary with different target populations. Other research did demonstrate fluid ability does not have to decline with age but can be maintained and developed (Hayslip & Panek, 1989). Age-related decline in performance can be circumvented with specific and sustained practice (Hodges, Starkes, & MacMahon, 2007). Basketball officials have sustained practice in fluid abilities when officiating a basketball game due to recognition of different play patterns and movements of players.
Experts made more correct calls than novice officials as level of information decreased with no age effects. The experts had more correct calls in the 2-second scenarios but no significant mean differences in the 7-second scenarios. Seven seconds is a long period of time in terms of basketball officiating to make a determination if a foul or violation (make a call) occurred. Two seconds is about the total length of time in terms of basketball officiating to decide if a call needs to be made or not. One may have expected expertise differences, and in favor of young officials, especially young expert officials, in relation to a 2-second time limit due to slower reaction time of older officials. It was not surprising that older officials did as well as or better than the younger officials in 2-second scenarios since older officials were found to watch a particular area of the court.

In discussion of reaction time and watching a particular court area, Salthouse (1984, 1991) discussed the slower reaction time of older adults. Salthouse found no significant differences between older and younger typists in overall typing speed. In fact this typing research reported that measures reflecting complex expertise-related mechanisms, such as the speed of typing letters with alternate hands, or the eye-hand span (i.e., the number of letters they looked ahead prior to the execution of the actual keystrokes), accounted for more than 70% of the inter-individual differences in overall typing speed. It is important that the measure of general processing speed (repetitive typing of the same letter), showed typical age related decline and accounted for only 42% of the variance in his sample. Whereas the correlation between age and overall typing speed was essentially zero. Older typists demonstrated larger eye-hand spans compared to younger typists. Similar to Salthouse (1984), there were no differences between older and
younger experts in performance in the 2-second condition in the current study. Older experts may have anticipated where the action on the court (due to the position of the players) was going to occur next, so they watched an area of the court before making their call. This would be similar to the eye-hand span in typing. Salthouse concluded the successful maintenance of typing skills in his older experts relied on cognitively complex mechanism. Extensive anticipation as demonstrated by the older skilled typists’ larger eye-hand spans was the cognitively complex mechanism for which the successful maintenance was attributed. Since this study was influenced by Salthouse (1984, 1991) there is a similarity. In Salthouse 1984 older typists looked two characters ahead while typing to compensate for slower reaction time. This study demonstrated older officials looked ahead to an area of the court in anticipation of play. It may be the reason for no age differences. Anticipation will also be discussed later in the chapter.

Expert Improvement: Asset Age or Experience

What the prior research and this study demonstrated was the heterogeneity (individual differences) of the older adult and older basketball official population. A question whether experts improve overall after a 10-year preparatory period (Chase & Simon, 1973) is difficult to answer based on this research. One must also cautious when interpreting results due to the homogeneity between the experts in the sample. The experts have similar training, local meetings, and rule interpretation meetings. The mix of heterogeneity of age and homogeneity of expertise adds to the difficulty of the problem. If the sample was a perfect sample with the younger and older officials having the same number of years officiating, the question may be answered.
Based on the study results, it was determined that the ability of the older expert officials to referee a basketball game did not decline in relation to the younger expert officials. The findings demonstrated no significant age differences. When there were age differences, they favored older officials. This was indicative that overall older expert officials’ performances were comparable to the young expert officials.

The comparability of performance between younger and older expert basketball officials was impressive based on the issues of loss or lessening in physical abilities as a person ages. Older expert officials may not be as “fleet of foot” as the younger expert officials. Older expert officials’ reaction time may not be as fast as younger expert officials. Older adults may be slower in their processing of information (Salthouse, 1991). Yet there were no age differences in performance for this study. This leads to the question as to whether or not age is an asset in basketball officiating ability or is the real asset experience. Based on the results of our study it was found that experience mediates age effects on the performance of older expert basketball officials. Does this answer the question as to whether experts’ performances improve after the 10-year preparatory period? Not really, but according to this study their performance did not decline and experience mediated the age effects.

New Measures for Expertise

The study was exploratory in the area of expertise, age, and sports officiating. Due to the exploratory nature of the study new measures had to be developed for hypotheses testing. It was decided to use DVD scenarios of actual game situations to develop the measures used in this study. This decision led to the development of the
Justification Knowledge measure, the Procedural Knowledge/procedural performance measure, and the anticipation measure.

The Justification Knowledge measure was designed to determine if experts recalled a significant number of more responses after they reviewed DVD game situations/scenarios. This measure was designed not only for the number of responses recalled by participants but also for the types of response (i.e., other plays, specific plays in other games, referee offense/defense, own position on court, and area of responsibility). Justification Knowledge’s purpose was to determine what thoughts/schemas differentiated the types of calls made by experts and novices. Using SMEs to determine if a particular response fit in one category or another was a benefit to the development of this measure.

The procedural performance measure that used DVD scenarios required officials/participants to view a scenario and make a basketball call of foul, violation, or no call (a foul or violation did not occur). Whether a scenario had a type of call or no call was determined independently by SMEs. Built into the scenarios were the measures of complexity level and level of information. Complexity level was independently determined by SMEs. The participants had to make a call viewing a scenario that was of a different complexity as well as a different level of information.

The anticipation measure also made use of the DVD game situations/scenarios. They had complexity levels and levels of information built into the measure. The unique concept about this measure was that the participant had to accurately tell the researcher (predict) what would happen next immediately after viewing a scenario. This gave a direct measure of anticipation after viewing actual action on the basketball court.
Another measure developed particularly for this study was the Hand Signal measure of procedural performance. It was a free recall and physical demonstration of the hand signals used to officiate a high school basketball game.

The uniqueness of these measures, other than not having been used in the field of expertise, was that they are of an applied nature. The measures tested the ability of an official to recall information immediately after he/she reviewed a scenario. It tested the ability of an official in making a basketball call while viewing the call as it happened in the scenario. Finally, the measures tested for direct and immediate anticipation.

As mentioned above, SMEs were used in the measurement development process. Their use was a benefit and asset to the research. The use of SMEs added to the face validity and applicability of the measures. This was an important consideration for the study due to its exploratory nature.

Future Directions

To improve upon the research, the data collection should be designed so novices had either not taken the licensure test or taken the test one year prior to participation in the study. An extension on the current study would be to compare performance differences and similarity in skills between high school, college, and professional officials. The type of research designed and measures developed in this study could be adjusted for multiple sports evaluation.

More research in the field of expertise needs to be designed to identify another core skill. This study helped to explain expertise as a learned ability/skill. Sternberg (2001) expressed the belief that static and dynamic abilities are “completely intertwined”
in the continuum of developing expertise. Other core skills need to be found for the development of expertise to improve and train people to have outstanding performance.

Krampe and Charness (2007) stated that “outstanding performance can be fruitfully examined in sports” because of the financial incentives to excel are extremely high. A future direction could be to develop new and adjust current measures to evaluate the performance of professional officials to search for other core skills. Due to the amount of money involved in professional sports this type of evaluation could also be used as a training tool to develop and improve officials’ skills.

In relation to sports, it would also be interesting to find out if a person could be an expert official in more than one sport. Some pro athletes have participated professionally, at a high level, in more than one sport. This goes against the suggestion of other researchers in relation to expertise. Ericsson and Lehmann (1996) reported that if the claims of expertise were restricted to individuals who perform at very high levels in one domain, the research is clear that people hardly ever reach an elite level in more than a single domain. Glaser and Chi’s (1988) indicated that expertise not transferring to other domains is the most enduring finding in the study of expertise. Ericsson et al. (2007) claim there is little transfer from high-level proficiency in one domain to proficiency in other domains even when the domains were similar. It would be interesting to find out if a person has the unique abilities to be an expert in more than one sporting domain.

In the area of general employment not sports related, the identification and development of the anticipation and other core expertise skills would improve an employee’s productivity. This type of research design is flexible and can be used in other fields of employment.
Expertise may be a skill that can be taught and trained so it could be used to improve an individual’s performance in industry. It would improve productivity of the workforce and enable corporations to be more competitive in the fast paced economics of today’s marketplace. Self-improvement is an ever evolving area in which anticipation may play a role.

Anticipation: Core Skill

Anticipation was a core skill of expertise identified in this study. It is a core skill of expertise that transfers across boundaries of different sports. The importance of this finding means that expertise is a skill that can be taught and learned. Sternberg expressed the belief that both static abilities (psychological resources) and dynamic abilities (construction of knowledge domains) are completely “intertwined” with expertise. If the abilities are intertwined, it means expertise can be taught through setting up training programs with deliberate practice.

One way anticipation was defined included watching an area of the court rather than watching the ball or player with the ball. This part of the anticipation hypothesis predicted that older expert officials will have significantly more responses (during retroactive interviews) in relation to watching an area of the court rather than watching the ball or player with the ball, than younger expert officials and novices. It was designed and influenced by Salthouse’s 1984 and 1991 research on typing mentioned in the prior paragraphs. Basically Salthouse’s research found that the older typist looked approximately two characters ahead in the reading of text to be typed (eye-hand span). This was one explanation as to why there were no significant differences in the performance between older/younger typists. Similarly if older officials were watching an
area of the court in relation to anticipation of the play (versus anticipation of the call to made) it explained some of the reason for no significant mean differences between older/young expert officials in procedural performance. It helped to identify anticipation as a core skill for expertise across different areas of expertise.

If one core skill can be found that is universal across different fields of expertise, then other skills must exist. Once other skills are identified then they can be taught and learned. It then becomes possible for the idea of a person to become an expert in more than one field.

To come full cycle with the study, the three original research questions need to be answered. The first question asked if knowledge mediated the effects of age on expertise. It may be answered with a simple no, not in this study. Question two asked if anticipation would be a core skill identified in the study. To answer this question a simple yes would be appropriate. The third research question asked if experience mediated the effects of age on procedural performance. This question’s answer is yes, when experience was defined as the number of years officiating basketball.
REFERENCES


APPENDIX A

EXPERIMENT GUIDELINES/INSTRUCTIONS

EXPERTISE & BASKETBALL OFFICIATING

READ THE FOLLOWING INSTRUCTIONS:
Thank you for participating in this research study. First, I would like to read you the informed consent document {hand the informed consent to person}. It explains any benefits and risks to you in participating.

Purpose of Study: The purpose of this study is to examine age and performance differences between expert and novice high school basketball officials. There will be approximately 80 officials participating.

Procedures: Participants will be asked to do multiple tasks:
- Fill out a questionnaire that gives information on their basketball experience.
- Complete fluid and crystallized ability tests
- Complete 50 question true/false basketball rules and mechanic test (25 questions on each)
- Recall and demonstrate high school basketball hand signals
- Answer written vignettes on high school basketball scenarios
- View 40-50 high school basketball scenarios on a DVD, make a call either foul/violation type or no call, and give brief explanation for call

It will take approximately 1 hour to complete the tasks. There are no known risks or discomforts associated with this research. Do you have any questions? If yes- answer questions. If no- let’s begin… Please sign the consent form and hand it to me.

Demographic Questionnaire:
Please complete the questionnaire.

Mill-Hill Crystallized Ability Test:
{HAND OUT THE TEST} Please fill out this vocabulary test to the best of your ability. Fill in the circle next to the answer you feel bests defines the word above. Even if you are not sure what the right answer is or what the word means, make your best guess. It is important the entire test be completed. Do you have any questions? If yes- answer questions. If no- let’s begin…
Culture Fair Fluid Ability Test:
{HAND OUT THE TEST} This test is made up of 4 parts. Each part is timed. I’m going to explain each part and go over a couple examples in each part. Do you have any questions? If yes- answer questions. If no- let’s begin…

Test 1:
Look at the boxes on the left of the page and notice the pattern that is represented in the sequence. Decide which of the boxes on the right will look correct in the empty box. Mark that number in the answer space provided.

Test 2:
There are 5 figures in a row, 4 are the same but one is different in some way. Decide which of the boxes is different and mark its number in the answer space provided.

Test 3:
Look first at the large square with the 4 boxes, one of them is dotted and empty. Decide which of the 5 boxes on the right would look correct in the empty box and mark its number in the answer space provided.

Test 4:
Look at the box on the left, look carefully at where the dot is found (inside what shapes, outside what shapes, etc.). Then find the box on the right where you could do just the same with the dot, and mark that answer in the space provided.

Basketball Rules and Mechanics Test
{HANDOUT Basketball Rules & Mechanics Test} Questions 1-25 relate to the knowledge of the rules of basketball and their application in the situation described. Questions 26-50 are related to the two-man mechanics of basketball and their application to the situation as described. Please circle T if you believe the sentence as stated is true. Please circle is F if you believe the sentence as stated is false. Do you have any questions? If yes- answer questions. If no- let’s begin…

Written Vignettes
{HANDOUT Written Vignettes} There are 15 vignettes. Please circle the correct response(s)/letter(s) that correctly apply to the vignettes scenarios. More than one response may apply to the vignette’s scenario. Do you have any questions? If yes- answer questions. If no- let’s begin…

Physical Demonstration of Basketball Hand Signals
Please state then physically demonstrate each of the basketball signals used in high school basketball officiating. Do not tell how many hand signals are used!!!
Do you have any questions? If yes- answer questions. If no- let’s begin…

DVD of Actual High School Basketball Game Situations
Please view these game situations and make a specific basketball call. The call will be a foul, violation, or no call. If the call is a foul or violation please state the particular foul or
violation that relates to that situation. There will be some trials for practice. Do you have any questions? If yes- answer questions. If no- let’s begin…

**Debrief**
Do you have any questions about anything you have done today/evening/morning? Is there anything you’d like to talk about? Are you feeling alright? Thank you again for your help and participation.
APPENDIX B
DEMOGRAPHIC QUESTIONNAIRE

1. Name: ________________________

2. Official’s License Number: ____________________________ C1 C2 (circle licensure whether you are currently a C1 or C2)

3. Age: ________

4. Age started officiating basketball: __________

5. Age you obtained C1 licensure: _______

6. Number of years officiating basketball: ________

7. Number of years with C 1 license: _______ (if applicable)

8. Number of years with a C 2 license: ________ (if currently a C1 how many years were you a C2 before obtaining C1 licensure)

9. Number of years coaching basketball: ________

10. Number of years playing basketball: ________

11. Number of tournament games officiated: sectional ______, district _____, regional _____, finals ________.

12. Age officiated first tournament game: ________

13. Age officiated last tournament game: ________

14. Total number of years involved with basketball: ________
APPENDIX C

DVD ANSWER KEY

KEY FOR ADMINISTRATOR ON ANSWER SHEET FOR DVD SCENARIOS
Scenarios 1-4 are practice trials. Scenario 5 starts the testing. There are 2 second scenarios and 7 second scenarios to view. Please circle answer with a F if a foul was committed and report the type of foul. Circle answer with a V if a violation was committed and report the type of violation (if violation is out of bounds tell who gets ball possession). If you believe no foul or violation was committed please circle answer with a NC for no call.

1. Practice 7-sec.- shot, rebound, pass down court—F, V, NC (out of bounds-whose possession)
2. Practice 2 sec.- guarding situation- F, V, NC (don’t forget type of F or V)
3. Practice 7 sec.-drive to basket- F, V, NC (don’t forget type of F or V)
4. Practice 2 sec.- Pass- F, V, NC (don’t forget type of F or V)
5. 7 sec.- pass in front court (NC)
6. 2 sec.- shot underneath
7. 7 sec.- scramble on rebound- reach in for ball
8. 2 sec.- drive lane to basket
9. 7 sec.- top of key shot, rebound situation
10. 2 sec.- out of bound (possession ? With V)
11. 7 sec.- drive baseline-pass
12. 2 sec.- rebound, center lane, reach
13. 7 sec.- out of bounds, F, V, NC, baseline
14. 2 sec.- Block, charge, NC
15. 7 sec.- trapped ball in corner
16. 2 sec.- 3 pt. shot baseline corner
17. 7 sec.- rebound, shot/put-back in lane
18. 2 sec.- shot in lane
19. 7 sec.- rebound, steal
20. 2 sec.- drive in lane to basket
21. 7 sec.- block on baseline
22. 2 sec.- drive, block, out of bounds (possession? With V)
23. 7 sec.- drive, block, NC
24. 2 sec.- pass in key, block, push
25. 7 sec.- guarding out front
26. 2 sec.- travel, fumble
27. 7 sec.- 3 pt. shot, rebound, 3 pt. shot opposite court
28. **2 sec.-** over the back/displacement
29. **2 sec.-** shot, F or NC
30. **7 sec.-** rebound, out of bounds (possession? With V)
31. **2 sec.-** pass, out of bounds (possession? With V)
32. **7 sec.-** pass in lane, F, NC
33. **2 sec.-** travel, top of key, front
34. **7 sec.-** drive in lane, off ball call on rebound
35. **2 sec.-** out of bounds (possession? With V)
36. **7 sec.-** shot, F or NC
37. **2 sec.-** steal, out of bounds (possession? With V)
38. **7 sec.-** 3 pt. shot, rebound
39. **2 sec.-** closely guarding
40. **7 sec.-** drive from baseline
41. **2 sec.-** steal, drive to basket
42. **7 sec.-** in bound pass to top of key, travel
43. **2 sec.-** pass from lane to baseline
44. **7 sec.-** F or V (possibly jump-ball)
45. **2 sec.-** shot in lane
46. **7 sec.-** Jason Kern make sure floor spread
47. **2 sec.-** travel or foul
48. **7 sec.-** drive lane, possible foul from behind
49. **2 sec.-** drive lane

Please answer the questions I am going to ask you:

**Anticipation:** The first 2 scenarios are practice trials. Number 53 starts the testing. Again there are 2 and 7 second scenarios. First you will view the 2 or 7 second scenario, then briefly state what you think will happen next. For example:

- 51. Practice 7 sec.- pass to top of key—three point shot.
- 52. Practice 2 sec.- foul after basket.
- 53. **7 sec.-** pass and shot missed
- 54. **2 sec.-** drive baseline and lose ball out of bounds
- 55. **7 sec.-** save and then out of bounds
- 56. **2 sec.-** pass in lane, pass again
- 57. **7 sec.-** jump-ball
- 58. **2 sec.-** pass out from top of key
- 59. **7 sec.-** foul on 3 pt. shot
- 60. **2 sec.-** pass down low in lane

Please answer the questions I am going to ask you:
APPENDIX D

TEST ANSWERS

Answers to Vignettes:
1: a, b, c, d
2: a, c
3: a, b, c, d, e
4: a
5: a, b, d
6: a, b, e
7: a, b, d
8: b, d, e
9: b, e
10: b, c, d
11: c, d, e
12: d, e
13: e
14: a
15: a, b, c, d, e

Answers to Rules and Mechanics Test:
1. F
2. F
3. T
4. T
5. F
6. F
7. F
8. T
9. F
10. T
11. T
12. T
13. F
14. F
15. F
16. F
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41. T  
42. F  
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**Answers to Fluid Ability Tests:**

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APPENDIX E

BASKETBALL HAND SIGNALS (HS) SCORE SHEET

Check each signal stated and demonstrated correctly. Put a plus (+) by each signal stated but not demonstrated or not demonstrated correctly. Put a minus (-) by each signal demonstrated but not stated. Leave blank if signal is not stated or demonstrated. Do not tell how many hand signals are used!!!!

1. Start Clock ______
2. Stop Clock ______
3. Stop Clock for jump/held ball ______
4. Stop Clock for foul (with or without bird dog) ______
5. Directional Signal ______
6. Designated Spot ______
7. Visible count ______
8. Beckoning in substitutes ______
9. 60-sec. Time-out ______
10. 30-sec. Time-out ______
11. No Score ______
12. Goal Counts ______
13. Point(s) Scored use 1 or 2 fingers after Goal Counts signal _____
14. Three Point Attempt ______ and if successful ______
15. Bonus free throw for second throw, drop one arm- for 2 throws use one arm with 2 fingers- for 3 throws use one arm with 3 fingers ______
16. Delayed lane violation ______
17. Traveling ______
18. Illegal Dribble (double dribble) ______
19. Palming/carrying the ball ______
20. Over and back ______
21. Three-Sec. Violation ______
22. Run the Lane ______
23. Five-sec. Violation ______
24. Ten- Sec. Violation ______
25. Free Throw or designated spot from violation ______
26. Excessively Swinging of Arm(s) or Elbow(s) ______
27. Kicking ______
28. Illegal Use of Hand ______
29. Hand Check ______
30. Holding ______
31. Blocking ______
32. Pushing or Charging ______
33. Player Control Foul ______
34. Intentional Foul ______
35. Double Foul ______
36. Technical Foul ______
APPENDIX F

BASKETBALL RULES (BBR) AND MECHANICS (BBM) TEST

The statements one through twenty-five are related to the knowledge of the rules of basketball and their application in the situation described. Please circle T if you think the sentence as stated is true. Please circle F if you think the statement as stated is false. There is only one correct answer per statement and it will either be true or false accordingly.

The statements twenty-six through fifty are related to the two-man mechanics of basketball and their application in the situation described. Please circle T if you think the sentence as stated is true. Please circle F if you think the statement as stated is false. There is only one correct answer per statement and it will either be true or false accordingly.

In the exam situations, A refers to the offensive team and B refers to the defensive team (their opponents). A1 and B1 are players of Team A and Team B. Unless otherwise stated: a single foul or free throw exists; are equipment, acts, and situations are legal; a tap is toward the tapper’s basket; and it is a two-point field goal. No errors or mistakes are involved unless noted.

1. If tapper A1 gains control of the referee’s toss during the opening jump ball, Team B gains the first possession and the arrow is set toward A’s possession.  T  F

2. Assistance coaches may stand to confer with bench personnel during dead ball periods.  T  F

3. A red light is permitted behind each backboard to supplement the audible timer’s signal that time has expired for a quarter or extra period.  T  F

4. Music, both band and sound effects, shall only be permitted prior to a game, during time-outs; at intermission, and post game.  T  F

5. A held ball occurs when dribbler A1 is closely guarded anywhere in A’s frontcourt for five seconds.  T  F

6. An airborne shooter is a player who has released the ball on a try for goal and has returned to the floor.  T  F
7. A false double foul differs from a double foul in the following way—the same team commits both fouls.  
8. If two B players commit a multiple foul on A1 during an unsuccessful 3-point try, A1 is awarded four free throws.  
9. A free throw cannot end until it is either touched by another player or becomes dead because an official sounded a whistle.  
10. A ball in contact with A1 or the court is in the frontcourt if neither the ball nor A1 is touching the backcourt.  
11. A player is entitled to an erect (vertical) position, even to the extent of holding the arms above the shoulders.  
12. Contact, which does not hinder the opponent from participation in normal defensive and offensive movements, should not be considered illegal.  
13. The ball becomes live when it is tapped.  
14. A tap by A1 becomes dead when an official’s whistle is blown for a foul by B1.  
15. Any official can rule on points not specifically covered in the rules.  
16. Only the referee may penalize the player for flagrant unsporting conduct.  
17. A player is out of bounds when he/she touches the floor, or any object other than a player, on or outside a boundary.  
18. A player is disqualified if he/she has been charged with one technical foul and four personal fouls.  
19. A free throw by A1 is credited to A1 and Team A regardless in which basket the attempt is made.  
20. A disqualified player who returns and participates has committed a flagrant technical foul.  
21. On a throw-in, a ball becomes live when it touches an inbound player.  
22. Players may be seated during a thirty-second time-out provided they do not cause a delay in resuming play.  
23. Each quarter or extra period begins when the clock starts.
24. A commemorative/memorial patch may be worn on the uniform jersey provided it is above the neckline or in the side insert. T F

25. The number 00 is a legal uniform number. T F

26. On a try, the trail should immediately retreat in order to be ahead of any play to the other end. T F

27. Jump balls, throw-ins, and free throw administration dictate officiating positions. T F

28. The lead official has primary responsibility for calling a three-second violation. T F

29. Officials will usually be opposite each other as they move up and down the court. T F

30. The trail official covers the three-point line only behind or outside the free-throw line extended. T F

31. Officials do not need to observe the second half warm-up activities. T F

32. The officials’ jurisdiction ends when all the officials leave the visual confines of the playing court. T F

33. Officials should assemble and leave the court together. T F

34. If the score is tied after the fourth quarter has ended and then a technical foul is called, the free throws will determine if an extra period must be played. T F

35. If a goal has been scored, signal to count the goal as soon as it is legally scored. T F

36. All officials should signal the clock to be stopped on a foul. T F

37. If a throw-in follows, the calling official should indicate the throw-in spot before reporting the foul to the scorer. T F

38. As the calling official is moving into the reporting area, he/she may begin communicating with the table officials. T F

39. The free official(s) is responsible for the activity around the bench area while the calling official is reporting the foul. T F

40. An immediate signal is given if the defensive team commits a free-throw violation. T F
41. The lead official is responsible for observing the first space on the near lane and all lane spaces on the opposite side of the lane.  T  F

42. Officials do not change positions on a player-control foul.  T  F

43. Following the tap, if possession is in the team’s backcourt, the umpire becomes the trail.  T  F

44. The referee counts the number of visiting players and the umpire counts the home teams players so the referee can verify this with the score book.  T  F

45. Carefully check scoring and timing facilities before each half and at intervals during the game.  T  F

46. The referee must notify the coach on a player disqualification and shall advise him/her that 30 seconds are allowed for replacement.  T  F

47. At the warning signal to end the time-out, the officials shall move directly to their proper positions to resume.  T  F

48. The administrating official shall designate the throw-in spot and hand or bounce the ball to the thrower.  T  F

49. The trail’s primary coverage area includes the area to the far lane line extended, above the free-throw line.  T  F

50. During a 60-second time-out, the non-administering officials are positioned at the top of the free-throw line.  T  F
APPENDIX G

BASKETBALL VIGNETTES (VIG)

Vignettes Background from Case Book

The National Federation of State High School Associations (NFHS) designed the casebook as an official supplement to the rules book. The case book is universally used by officials who are interested in basketball game administration, and by coaches and trainers as a textbook for directed study sports officiating courses. Basketball leaders in all sections of the country have contributed accounts, reports and summaries of situations in games under their jurisdictions.

Vignettes Format

A1 and B1 are the players of Team A and B respectively. A2 is a teammate of A1. Unless stated, all plays involved a two-point field goal or try and not a three-point field goal or try. The calling official is the referee/umpire that called the foul or violation. The non-calling official is the referee/umpire that is the partner who did not call the foul or violation. Please circle the letter for the responses that correct apply to the vignette’s scenario. There are five response choices. More than one response may apply to a vignette’s situation.

Vignettes


a. Both A1 and B1 are charged with a flagrant technical foul.

b. Both A1 and B1 are disqualified.

c. A1’s action is defined as fighting when the taunting caused B1 to retaliate by fighting.

d. The calling official shall give the designated hand signal for the flagrant technical foul first to his/her partner and then to the scorer’s table.

e. The official who did not call the foul explains the situation to both coaches.
Situation 2: A1 drives to the basket with B1 in pursuit. As A1 begins the act of shooting, B1 gets a hand on the ball from behind and the subsequent contact takes A1 forcefully to the floor and out of bounds.

a. If the contact is judged to be excessive, an intentional foul shall be charged even though B1 is playing the ball.

b. After the free throws the ball is put into play at the division line.

c. The calling official should make eye contact with the non-calling official and give the correct hand signal for the type of foul and number of shots to be awarded.

d. The non-calling official should go report the foul to the scorer’s table.

e. B1 shall be disqualified.

Situation 3: A1 drives for a try and jumps and releases the ball. Contact occurs between A1 and B1 after the release and before airborne shooter A1 returns to the floor. One official calls a blocking foul on B1. The other official calls a charging foul on A1.

a. Both officials should move to a position on the court to discuss the situation where neither the players nor coaches can hear or interfere with their conversation.

b. Even though airborne shooter A1 committed a charging foul, it is not a player-control foul because the two fouls result in a double personal foul.

c. The double foul does not cause the ball to become dead on the try and the goal is scored.

d. An alternating possession throw-in results.

e. The ball is put in play at the spot of the double foul.

Situation 4: B1 has obtained legal guarding position on A1 and moves to maintain it. A1 moves laterally and contacts defender B1 but does not get his/her head and shoulders past the torso of B1. Contact occurs on the side of B1’s torso.
a. This is a player-control foul by A1.

b. An alternating possession throw-in results.

c. This is a personal foul on B1.

d. The calling official should make eye contact with the non-calling official and give the correct hand signal for the type of foul and number of shots to be awarded.

e. The non-calling official should go report the foul to the scorer’s table.

Situation 5: Thrower A1 in-bounds the ball to A2. A2 immediately throws the ball back to A1. When A1 touches the pass, he/she has: (a) both feet touching in-bounds; or (b) one foot touching in-bounds and the other one out of bounds; or (c) one foot touching in-bounds and the other not touching the floor.

a. The ball remains live in (a) and (c).

b. A1 has caught the ball out of bounds in (b).

c. An alternating possession throw-in results in (b).

d. The calling official should make eye contact with the non-calling official and give the correct hand signal for the type of violation.

e. The non-calling official should go report the violation to the scorer’s table.

Situation 6: While A1’s try or tap is in flight, A2 and B2 legally obtain potential rebounding positions. B2’s position has his/her back to A2 and is directly between A2 and the basket. As the unsuccessful try or tap rebounds from the ring: (a) B2 moves backward and pushes/displaces A2 from his/her legal position; or (b) A2 “beats” B2, getting his/her head and shoulders past the front of B2’s torso. B2 then moves laterally and pushes/displaces A2.

a. A foul on B2 in (a).

b. A foul on B2 in (b).

c. A foul on A2 in (a).

d. A foul on A2 in (b).
e. The ball is put in play at the spot of the foul.

Situation 7: B1 commits a common foul by holding A1 during a field goal try, but after A1 has completed the act of shooting. The foul occurs before the bonus rule applies. The attempt is: (a) successful; or (b) unsuccessful.
   a. A personal foul is charged to B1 in (a).
   b. A personal foul is charged to B1 in (b).
   c. Free throws are awarded in both (a) and (b).
   d. The ball is put in play at the spot of the foul.
   e. The ball is put in play at the baseline after the awarded free throws are administered.

Situation 8: Dribbler A1 catches the ball with the right foot touching the floor and then jumps off that foot and alights on both feet simultaneously: (a) with feet parallel: or (b) with one foot in advance.
   a. In (b), it is not a violation if A1 pivots on either foot.
   b. In (b), it is a violation if A1 pivots on either foot.
   c. In (a), it is not a violation if A1 pivots on either foot.
   d. In this situation the position of the feet has no significance even though they land on the floor simultaneously.
   e. In both (a) and (b), it is a violation if A1 pivots on either foot.

Situation 9: A1 while holding the ball in-bounds near the sideline, touches B1, who is out of bounds.
   a. A1 is out of bounds.
   b. A1 is not out of bounds.
   c. A1 has fouled B1.
   d. B1 has fouled A1.
e. To be out of bounds, A1 must touch the floor of some object on or out of boundary, play continues.

**Situation 10:** A1 is standing with one foot inside and the other outside the three-second restricted area. A1 lifts the foot from the restricted area and stands and returns it there without touching it first to the non restricted area.

a. No violation. This act does terminate the three-second count. The count stops since merely lifting foot from the restricted space is interpreted as an attempt to not evade the rule and its purpose.

b. Violation, the count goes on since merely lifting foot from the restricted space is interpreted as an attempt to evade the rule and avoid its purpose.

c. This act does not terminate the three-second count.

d. However, there is no three-second count during rebounding action or during a throw-in or interrupted dribble.

e. The count on a player in the restricted area is suspended when that player begins to try for goal.

**Situation 11:** A1 is in A’s backcourt and has dribbled for nine seconds and then passes the ball forward towards A2 in the frontcourt. While the ball is in the air traveling from backcourt to frontcourt, the 10-second limit is reached. RULING:

a. No violation, the ball gained frontcourt location.

b. The release of the ball by A1 terminated the ten second count.

c. Violation by Team A as the ball has not gained frontcourt location.

d. It is B’s ball for a throw-in at the out-of-bounds spot closest to where A1 released the ball in the pass toward A2.

e. The count was not terminated by the release of the ball by A1.
**Situation 12:** While dribbling in A’s front court, A1 is closely guarded by B1. After two seconds, B2 also assumes a closely guarded position on A1 and B1 leaves to guard A2.

a. The closely guarded count does not continue.

b. There is a requirement for the defensive player to remain the same during the count. as long as A1 is closely guarded throughout.


d. The closely guarded count does continue on A1.

e. There is no requirement for the defensive player to remain the same during the count as long as A1 is closely guarded throughout the count.

**Situation 13:** The coach of team A leaves the bench area and goes to the table to seek information other than a correctable error: (a) during a timeout, or (b) during the intermission between the first and second quarters.

a. No foul or violation in either (a) or (b).

b. A coach is permitted at the scorer’s table for this purpose.

c. A technical foul is charged directly to the coach A coach is permitted at the scorer’s in (a) but not (b).

d. A technical foul is charged in (b) but not (a).

e. A technical foul is charged directly to the coach in both (a) and (b), a manager or statistician must obtain this information.

**Situation 14:** B1 attempts to steal the ball from stationary A1 who is holding the ball. B1 misses the ball and falls to the floor. In dribbling away, A1 contacts B1’s leg, loses control of the ball and falls to the floor.

a. No infraction or foul has occurred and play continues.

b. B1 has committed a blocking foul against A1.

c. A1 has committed a charging foul against B1.

d. This is a double personal foul situation.
e. This is a multiple foul situation.

Situation 15: A1 is running toward A’s goal but is looking back to receive a pass. B1 takes a position in the path of A1 while A1 is ten feet away. (a) A1 runs into B1 before receiving the ball, (b) A1 receives the ball but before taking a step runs into B1.
   a. A1 is responsible for the contact in both (a) and (b).
   
   b. In (a) B1’s position is legal.
   
   c. In (b) B1’s position is legal.
   
   d. In (a) the foul is charged to A1.
   
   e. In (b) the foul is committed by A1 and is a charging foul.
APPENDIX H
CONSENT FORM

Title of Study: Expertise and Basketball Officiating

Introduction: You are invited to participate in a research project being conducted by Chad M. Sed, a doctoral student, in the Psychology Department at The University of Akron.

Purpose: The purpose of the study is to examine age and performance differences between expert and novice high school basketball officials. There will be approximately 80 basketball officials participating in the study.

Procedures: Participants will be asked to fill out a questionnaire that gives information on their basketball experience. Participants will be asked to complete a 50-question true/false test on the rules and mechanics of high school basketball officiating. The participants will be asked to recall and physically demonstrate all the hand signals used in high school basketball. Participants will be asked to view a DVD of 40 high school basketball scenarios, make a basketball call (specific kind of foul, violation, or no call), and give a brief explanation for the call. Participants will be asked to complete tests on fluid and crystallized abilities.

Risks and Discomforts: There are no known risks or discomforts associated with this study.

Right to refuse or withdraw: Your participation in this research is voluntary and you may refuse to participate, or may discontinue participation at any time, without penalty or loss of benefits to which you are otherwise entitled.

Confidentiality of records: All information collected from participants will be kept confidential. Each participant will be assigned a research number. The research number will be used in place of participant name on all forms except his/her signed consent form. The signed consent form will be kept separate from your data and nobody will be able to link your responses to you. Participants will not be individually identified in any publication or presentation of the research results. Only aggregated data will be used.
Who to contact with questions: If you have any questions about this study, you may call Chad M. Sed, MA, investigator, at (740) 772-1307 or Harvey L. Sterns, Ph.D., advisor/committee chairperson, at (330) 972-7243.

Acceptance & Signature: I have read the information above and all my questions have been answered. I voluntarily agree to participate in this study. I will receive a copy of this consent form for my information.

____________________     _____________
Signature                     Date
APPENDIX I

DVD SCENARIO ANSWER SHEET

ID# ________________

**ANSWER SHEET FOR DVD SCENARIOS**

Scenarios 1-4 are practice trials. Scenario 5 starts the testing. There are 2 second scenarios and 7 second scenarios to view. Please circle answer with an F if a foul was committed and report the type of foul. Circle answer with a V if a violation was committed and report the type of violation (if violation is out of bounds tell who gets ball possession). If you believe no foul or violation was committed please circle answer with a NC for no call.

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Please answer the questions I am going to ask you:

**Anticipation:** The first 2 scenarios are practice trials. Number 53 starts the testing. Again there are 2 and 7 second scenarios. First you will view the 2 or 7 second scenario, then briefly state what you think will happen next. For example:

53. pass to top of key—three point shot.
54. foul after basket.
55.
56.
57.
58.
59.
60.

Please answer the questions I am going to ask you:
APPENDIX J

PSYCHOMOTOR QUESTIONS

Retroactive Questions for Videos

1. As you view the videotapes plays what thoughts go through your mind?
   a. Other plays
   b. Similar plays or situations in other games
   c. Area of responsibility
   d. Referee offense or defense
   e. Position of partner on court
   f. Own position on court

2. As you blow the whistle and make the call what thoughts go through your mind?
   a. Raise hand
   b. Type of hand signal
   c. Type of call: violation or foul
   d. If foul—shooting or non-shooting; bonus situation or not
   e. Who committed the foul—number
   f. Who was fouled—number
   g. Reporting procedures
   h. Communication: partner, scorer’s table, coach(es), player(s), spectator(s)
   i. Position on court
   j. Ball inbound spot if violation
APPENDIX K

FACTORS AND LOADINGS

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Note:
*NC- No Call
** F- Foul
***V- Violation
APPENDIX L

JUSTIFICATION KNOWLEDGE (JK)

Justification Knowledge | Factor Loadings
-------------------------|-------------------

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