1985

The Relation of Knowledge Development to Children's Basketball Performance.

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THE RELATION OF KNOWLEDGE DEVELOPMENT TO CHILDREN'S BASKETBALL PERFORMANCE

A Dissertation
Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The School of Health, Physical Education, Recreation, and Dance

by

Karen Elizabeth French
B. S. University of New Orleans, 1977
M. A. Sam Houston State University, 1981
August 1985

ACKNOWLEDGEMENTS

This project could not have been completed without the help and encouragement of many individuals. I would like to thank the coaches and players in the Biddy Basketball Program sponsored by the Denham Springs Recreation Department. I would especially like to thank Mr. Tony Dugas and Mr. Cecil LaBorde for their consideration and cooperation throughout the study.

I would also like to thank Dr. Lesley Ellis of the Livingston Parish School Board Office and the principles of the schools which participated in the study for their consideration and cooperation throughout the collection of the data.

I also want to thank Mr. Earl Brooks, principle of Goodpine Middle School, and Ms. Hazel Bell, physical education teacher, for their cooperation in collection of the reliability data and the control group data.

Many friends and fellow graduate students contributed their valuable time and effort in collection of the data. I would like to thank Rosalyn Edwards, Charlette Humphries, Sue McPherson, Madge Ashy, Amanda Palmer, Carol Wood, and Diana Daigle.

I would also like to thank committee members Dr. Amelia Lee, Dr. Jack Nelson, and Dr. Ray Buss for their helpful comments and recommendations in the preparation of earlier drafts of this paper.

I must make a special note of thanks to Dr. Richard Magill. Dick has invested much of his time and has given me so many opportunities to learn and develop my research skills.

I also want to thank Dr. Jerry R. Thomas, my major professor. Perhaps more than anything, Jerry had confidence in me and my abilities, often when I didn't. I can only say thank you for the many times you have dropped whatever you were doing to help me with a research problem. You have helped me become a better person and a scholar.

Most of the credit for any of my accomplishments must be directed to my parents, Mr. and Mrs. V. J. French. First, they have sacrificed time, headaches, and money to give me every opportunity to do and be whatever I wanted to be. More important though, they alone instilled the desire to learn, the desire to be the best that I could be in whatever endeavor I undertook. There is no way I can ever repay them for all they have given me. I can only say thank you for being the loving parents that you are.

FOREWORD

This manuscript is written in the format of the American Psychological Association. The body of the paper is presented in the format of submission for publication to scholarly journals. Additional information concerning measurement instruments and procedures, statistical procedures, tables, and studies reviewed for the three experiments are presented in the appendices.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

Table

Abstract

The purpose of this paper was to examine the relation of sport specific knowledge to the development of skilled basketball performance in children. Three experiments were conducted. The first experiment established the reliability and validity of instruments used to measure basketball knowledge, dribbling skill, shooting skill and individual components of offensive basketball performance--control, decisions, and execution. The second experiment compared expert and novice basketball players in two age leagues, an 8- to 10-year-old league and an 11- to 12-year-old league, on the individual components of performance and on measures of basketball knowledge, dribbling skill, and shooting skill. The cognitive decision making component maximally discriminated expert and novice basketball players and expert players of both age groups possessed more shooting skill and more basketball knowledge. Canonical analysis indicated that basketball knowledge was related to decision making skill in basketball, whereas dribbling and shooting skill were related to the motor components of control and execution. Experiment 3 examined the changes in the individual components of performance, basketball knowledge, dribbling skill, and shooting skill from the beginning of the season to the end of the season. Subjects improved in the cognitive decision making component of performance across the course of the season and basketball knowledge increased from the beginning to the end of the season. Only

basketball knowledge was a significant predictor of the decision making component at the end of the season. The overall results of Experiments 2 and 3 indicate that the development of the sport knowledge base plays a salient role in skilled sport performance of children. In particular, many of the deficits of young children in youth sports may be due to lack of sufficient sport knowledge which is necessary to make appropriate decisions within the context of sport.

Introduction

Much of the research in developmental learning has attributed the performance deficits of children to three areas: the capacity of working memory, the development and efficient use of mnemonic strategies, and lack of a sufficient knowledge base. Researchers in verbal learning as well as motor skills have spent considerable effort studying the former two (Chi, 1976; Flavell, 1970; Naus & Ornstein, 1983; Pascual-Leone & Smith, 1969; Thomas, 1980, 1984). Only recently have researchers in verbal learning examined the relation between the knowledge base and performance of children. Several studies (Chi, 1978; Chi & Koeske, 1983; Lindberg, 1980; Ornstein & Naus, 1984) suggest that the existence of domain related knowledge significantly improves the performance of children in memory tasks.

Chi (1978) was instrumental in demonstrating that lack of sufficient knowledge may explain many performance deficits of children. She compared the recall of plausible middle-game chess configurations by child experts and adult novices in chess. The child chess experts recalled significantly more chess configurations than adult novices. Lindberg (1980) reported similar findings for recall of information more familar to children than adults. These findings suggest that children can and do perform better than adults on memory tasks when the children possess more extensive knowledge than adults concerning the information to be remembered.

Lack of sufficient knowledge may also influence the performance of children in sports in which the highly skilled performer must possess a repetoire of cognitive decision making skills as well as motor skills. In order to accurately make appropriate decisions, sufficient sport specific knowledge must be developed. This includes knowledge of the rules, the goals and actions of the game, and offensive and defensive strategies. Many of the performance deficits of children may be due to lack of knowledge of what to do in situations within the context of the game. No empirical investigations have been conducted to examine the relation of sport specific knowledge and cognitive skills involved in the sport performance of children. Investigation of the relation of sport specific knowledge and sport performance is important for two reasons. First, the existence of sport specific knowledge may facilitate the performance of children in sport. This finding would have implications for frameworks of developmental learning. Second, the role of cognition in the development of skilled performance has received little attention. Furthermore, few studies have been conducted in a naturalistic environment which makes generalization of findings to real world situations difficult. The purpose of this paper is to examine the role of cognitive decision making skills and sport specific knowledge in the development of skilled performance of children in a given sport, basketball.

Although a few studies have examined the relation of knowledge to the performance of children in verbal memory tasks, a number of studies have compared the performance of adult experts and novices in a variety of knowledge domains. Generally, these studies have shown that experts possess greater amounts of knowledge, structure knowledge differently, and exhibit superior performance on a variety of tasks. Discussion of the literature on adults provides insight into the manner in which skilled performers of all ages structure knowledge and how they use this knowledge to facilitate performance.

Knowing more is conceptualized in semantic networks as having more nodes, more features defining each node, and more interrelating nodes (Chi & Glaser, 1980). Several studies in verbal learning have examined the semantic networks of experts and novices in a variety of knowledge domains, for example, dinosaurs, (Chi & Koeske, 1983), chess (Chase & Simon, 1973, Chi, 1978), psychological disturbances (Murphy & Wright, 1984), bridge (Charness, 1979), Go (Reitman, 1976), and baseball (Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979). In addition, two studies have examined the structure of game related information of expert sport participants (Allard, Graham & Paarsalu, 1980, basketball; Starkes & Deakin, 1984, field hockey). The results of these studies substantiate that experts have more concepts with more defining features within each concept. Furthermore, Murphy and Wright (1984) and Chiesi, Spilich, and Voss (1979, experiment 4) reported a high degree of consensus concerning the features generated for a given concept, which suggests that information is organized similarly by experts within a given domain. When asked to recall information from the knowledge domain, the expert has the distinct advantage of having access to more and better organized chunks of information which reduce the demands on short term memory and aid in retrieval of information from long term memory. Thus, the recall of domain related information is significantly better for experts than novices.

Chi, Feltovich, and Glaser (1981) and Adelson (1984) have shown that experts exhibit superior ability in problem solving tasks. In each study, verbal protocols obtained during problem solving situations provided evidence that experts represent problems in a different manner than novices. Both studies suggest that experts possess a greater amount of knowledge, form more abstract representations of problems, and restructure the existing knowledge so the solution to the problem is apparent.

Individuals with greater knowledge have also been reported to process input information within the knowledge domain in different ways. Chiesi, Spilich, and Voss (1979) and Spilich, Vesonder, Chiesi, and Voss (1979) examined the recall of new baseball related text. The results indicated that individuals with greater knowledge of baseball perform significantly better than individuals with less baseball knowledge in detecting changes in baseball descriptions, making judgments based on less information, recalling passages of scrambled text, keeping track of the order of events in the text, and recalling sentences when a context sentence was provided.

Several studies have also shown that adult expert sport participants process different cues than novices. Bard and Fleury (1981) found that experts were better able to predict the flight of a hockey puck. Furthermore, experts tended to use stick cues to make their predictions whereas novices were more likely to make their decisions after the puck was already in flight. Jones and Miles (1978) found that experts could make better predictions of the flight of a tennis ball than novices. Bard and Fleury (1976) presented subjects a series of slides depicting offensive and defensive configurations in basketball. The task required subjects to make decisions concerning whether to pass or shoot in the situation. Experts made decisions faster than novices and tended to fixate eye movements on pairs of offensive and defensive players whereas novices tended to ignore the positions of defensive players.

Although there are a limited number of studies which have examined the relation between knowledge and cognitive skills involved in sport performance, these studies support the findings of the verbal literature. Adult experts have superior recall of game structured information (Allard, Graham, & Paarsalu, 1980, basketball; Starkes & Deakin, 1984, field hockey), use different cues to make predictions of the flight of an object (Bard & Fleury, 1981, hockey puck; Jones & Miles, 1978, tennis ball; Starkes & Deakin, 1984, field hockey), and use different cues to make decisions within the context of a game situation (Bard & Fleury, 1976, basketball).

The existence of domain related knowledge has been found to enhance the performance of adults in verbal learning tasks and in cognitive tasks involved in sport performance. In addition, the knowledge base has been shown to explain many of the performance deficits of children in memory tasks. Lack of sport specific knowledge may also explain many of the performance deficits of young children in various sports.

When children enter into youth sport, they generally lack a sufficient knowledge base of sport specific information. This includes knowledge of the rules, the goals and actions of the game, and offensive and defensive strategies. Without such knowledge, the quality of decisions made within the context of the game greatly suffers. Often the decision concerning the appropriate action in a certain situation is as important as the execution of the motor skill to carry out the action. Many of the performance deficits seen in young children in various sports may be due to lack of knowledge of what to do in the context of a given sport situation.

Children often possess limited skill in specific sport skills. Therefore, the contribution of motor skill execution to skilled performance in sport cannot be ignored. Both the quality of decisions and the quality of skill execution determine successful performance in sport. However, different factors may contribute to the development of skilled performance in decision making ability which are not associated with skill execution and vice versa. Knowledge should influence decisions, whereas skill development should influence execution of motor skills during actual play. Both knowledge and skill should influence the development of overall skilled performance.

The purpose of this paper was to examine the contribution of basketball knowledge and specific basketball skills to the development of skilled decision making and motor skill execution components of overall performance of children in basketball. The first step in empirical investigation of these relations was to develop the instrumentation to measure the separate components of performance--decisions and motor skill execution. The manner in which this paper has attempted to separate the decision making and motor components of performance is to assume that offensive performance in basketball typically occurs in the following sequence: a player catches the ball, a decision is made concerning the appropriate action, and the execution of the skill is carried out. The decision component would involve the selection of the skill (i.e., hold the ball, pass, dribble, shoot), as well as where to pass or dribble, which teammate to pass to, what direction to dribble, when to shoot, when to stop dribbling, etc. With this operational definition of decisions, the quality of decisions can be inferred from the observation of children during actual game play. The quality of catching the basketball and the quality of execution of dribbling, passing, and shooting can also be observed. Although catching the basketball is in fact a motor execution, gaining control of the basketball will be considered as a separate component due to the sequence in which offensive actions typically take place in basketball.

In addition to the observation of actual game performance, instruments were also designed to measure basketball knowledge, dribbling skill, and shooting skill. Experiment 1 was designed to obtain reliability and validity of these instruments.

Before sport specific knowledge can be directly related to sport performance of children, it is important to establish that cognitive decision making skills are an important component of skilled performance in children. The actual game performance of a group of expert and novice basketball players of two age groups were observed in Experiment 2. If cognitive decision making skills are an important component of skilled performance, the decision component of perfromance should discriminate between expert and novice players of both age groups. The expert and novice players of both age groups were also measured on dribbling skill, shooting skill, and basketball knowledge. Based on the findings of Allard, Graham, and Paarsalu, (1980) and Starkes and Deakin, (1984), expert basketball players of both age groups should possess more basketball knowledge than novice players of both age groups. The relation between the factors of basketball knowledge, dribbling skill, and shooting skill and the individual components of performance was also examined. Basketball knowledge should be related to the decision making component of performance, whereas dribbling skill and shooting skill should be related to the motor components of performance--control of the ball and skill execution. The establishment of a relationship between sport specific knowledge and the decision component of performance would support the findings of Chi (1978) and Lindberg (1980) in the verbal literature.

Experiment 3 was designed to examine the changes in knowledge, skill, and actual game performance over the course of a basketball season. The improvement in the decision component of performance may occur at a faster rate across the course of the season than the improvement of skill execution since the acquisition and refinement of motor skills is a gradual process. Furthermore, the acquisition of sport specific knowledge may be more highly associated with this rapid improvement in performance rather than improvement in skill level.

Experiment 1

Method

Basketball Knowledge Test

A 50 item multiple choice test was constructed to assess basketball knowledge. The content of the test was judged by two experts in basketball and deemed as a valid measure of basketball knowledge. The reliability and concurrent validity of the test was determined by administering the test to a group of basketball players and nonplayers.

Subjects. Thirty-six students at Goodpine Middle School, Jena, Louisiana served as subjects. Twenty subjects played organized basketball on the school team. The remaining 16 subjects were randomly selected from physical education classes. The age of the subjects ranged from age 10 to 12. Each age level was equally represented in both the basketball player and nonplayer groups.

Procedures. The subjects were administered the knowledge test in a standard classroom. Each subject had a copy of the test; however, the experimenter read each question aloud to minimize the influence of reading ability. Subjects were instructed to listen to the entire question prior to selecting an answer. Once the entire question had been read, subjects were instructed to respond. This process continued until all 50 items had been completed.

Skill Tests

The speed spot shooting test and the control dribble test were chosen from the AAHPERD Basketball Skill Test (Hopkins, Shick, & Plack, 1984) to evaluate basketball skill. Both tests have been shown to be valid and reliable measures of basketball skill for age 11 through the college level using a standard size basketball and a standard size goal. The subjects of Experiment 2 and 3 participate in a league which used a junior size basketball and a lower goal. Thus, reliability estimates were obtained using the junior size basketball and the lower goal.

Two modifications were made in the speed spot shooting test to accomodate the memory deficits and limited ball handling skills of younger children. First, subjects were allowed to shoot up to four layups in succession. The original test prohibits successive layup shots. Second, subjects were not penalized credit for shots made after a ball handling error. In the original test, subjects do not receive credit for any successful shot after a ball handling error.

Subjects. Twenty fourth-grade and 20 sixth-grade students from Goodpine Middle School served as subjects. Subjects were randomly selected from physical education classes.

Procedures. The control dribble test and the modified speed spot shooting test were administered in a regular gymnasium using a junior size basketball and a portable goal adjusted to a height of 3 m (8 feet 6 inches). With the exception of the modifications of the speed spot shooting test previously noted, the procedures outlined in the AAHPERD Basketball Skill Test Manual (Hopkins, Shick, & Plack, 1984) were used to administer both tests. Both tests were administered a second time on the following day.

Observational Instrument

An observational instrument was designed to assess the performance of individual children during an actual game. Three categories of behaviors were coded -- control, decision, and execution. Control was operationally defined as gaining control by a successful catch of the basketball. Control was coded one for a successful catch and zero for an unsuccessful catch. Once a player is in possession of the basketball, a decision must be made regarding the appropriate action to be performed, either hold the ball, pass, dribble, or shoot. Furthermore, the player must decide such things as where to pass or dribble, who to pass the ball to, which direction to dribble, when to stop dribbling, etc. The quality of this decision was coded as one for an appropriate decision and zero for an inappropriate decision. The execution of an action was also coded. Successful execution of a pass, drive, or shot was coded as one, whereas unsuccessful execution was coded as zero. The number of successful catches of the basketball, number of appropriate decisions, and number of successful actions executed were divided by the number of opportunities to respond in each category. Therefore, percentages for successful control of the basketball, appropriate decisions, and successful execution of actions were determined for every individual.

Reliability. In order to establish inter-rater reliability for the coding instrument, four Biddy basketball games were videotaped. Players were randomly selected and their performance for a 5-minute time period was coded by two independent expert observers using the observational instrument. A minimum of 90% agreement was established as the criterion for each category of the instrument -- control of the basketball, appropriate decisions, successful execution.

Once the criterion of 90% agreement had been established, 10 children were selected at random and their performance for one quarter of playing time during two Biddy basketball games was coded on two different occasions. The results of the coding was used to obtain intra-rater reliability coefficients for each category of the observational instrument. The experimenter, who coded the video tapes, had over 12 years of experience in playing and coaching basketball.

Results and Discussion

Knowledge Test

A KR-20 was calculated on the scores obtained on the knowledge test. The results indicated the internal consistency of the test was .86. An item analysis was also conducted. The median of the index of difficulty was .54. Forty-eight of the 50 (96%) items had an index of difficulty greater than .20. The median for the index of discrimination was .39. Forty-three of the 50 (86%) items had an index of discrimination greater than .20.

A t-test was conducted between the percentage of correct responses for basketball players and nonplayers. The value for $t(34)$ was 4.71,

$p < .01$. The mean for players was 64.6% correct with a standard deviation of 12.0. The mean for nonplayers was 44.1% correct with a standard deviation of 13.7. The percent variance accounted for by the group difference was 38.8%.

The results indicated that the knowledge test was a reliable measure of basketball knowledge. Evidence for content validity was provided by the judgment of the test as a valid measure of basketball knowledge by two experts in basketball. The test also was shown to discriminate between basketball players and non-basketball players. Thus, the test may be considered valid in terms of construct validity.

Skill Tests

The scores of each skill test were analyzed separately for each grade level in a 20 x 2 (Subject x Day of Testing) analysis of variance. Intraclass correlation coefficients were calculated for each skill test for each grade level. The reliability estimates for the fourth grade boys on the control dribble test and the speed spot shooting tests were .92 and .95, respectively. The reliability estimates for the sixth grade boys was .88 for the control dribble test and .91 for the speed spot shooting test.

The original control dribble test and the speed spot shooting test have been shown to be reliable and valid measures of dribbling skill and shooting skill. Although a different size basketball and lower goal were used and minor changes were made in the speed spot shooting test, adequate estimates of reliablity were obtained for both skill tests. There is no reason to believe that the modifications of the skill tests substantially affects their validity. Thus, the control dribble test and modified speed spot shooting test used in this experiment may be considered as reliable and valid measures of dribbling and shooting skill.

Observational Instrument

The behaviors coded using the observational instrument were collapsed across games. Although one of the dependent variables of interest in Experiment 2 and Experiment 3 is the percentage of successful responses in each category of the observational instrument, using this measure to obtain reliability could mask measurement error. For example, the observer may code two out of three successful behaviors on one occasion. On the second observation of the same child's performance, the observer may have coded four out of six sucessful behaviors. Although these are different observations, using the percentage of successful responses to obtain reliability would result in an overestimate of the consistency of the observer. Thus, the total number of successful responses and the total number of opportunities to respond in each category were dependent measures. The number of opportunities to respond for each category were analyzed in a 10 x 2 (Subject x Time of Coding) analysis of variance. A similar analysis was conducted using the number of successful responses in each category. In addition, the total number of opportunities to respond and the total number of successful responses collapsed across categories were analyzed separately in a 10 x 2 (Subject x Time of Coding) ANOVA. A reliability estimate for each dependent measure in each category and the total collapsed across categories was obtained through intraclass correlation and were .99 in all analyses. Although these estimates are rather high, a substantial amount of training was conducted prior to estimating reliability.

Since two experts were found to obtain 90% agreement on the coding instrument, some evidence of validity of the instrument can be assumed. The percent agreement for the two independent observers and the high estimates of intra-rater reliability indicate that the observational instrument is a reliable measure of the components of offensive basketball performance.

Experiment 2

The first step in an empirical investigation of the role of cognition in the development of expertise in a given sport is to establish that the quality of decisions is related to skilled performance. Since this relationship may not be independent of the motor components, control and skill execution, the first question addressed was which components of performance discriminate expert and novice children in basketball. If cognition plays an important role is skilled performance, the decision component of performance must discriminate between expert and novice basketball players. The subjects were also measured on basketball knowledge, dribbling skill, and shooting skill. Thus, the second question addressed was which of the factors of basketball knowledge, dribbling skill, and shooting skill discriminated expert players from novice players. Experts should possess more basketball knowledge and exhibit higher scores on each skill test. Since the relation of the components of performance and basketball knowledge, dribbling, and shooting skill to expertise may vary as a function of age, the progression of expertise was examined by comparing the components of performance and basketball knowledge, dribbling, and shooting skill using two different age groups of experts and novices.

The third question addressed was the interrelation of the components of performance and the factors of knowledge and skill. Knowledge should be related to the quality of decisions whereas dribbling and shooting skill should be related to control and skill execution components.

Since the multiple choice knowledge test is a measure of recognition memory, an open-ended basketball situation interview was designed to examine the differences between experts and novices in recall of basketball related information.

Method

Subjects

Boys participating in the Biddy basketball program in Denham Springs, Louisiana served as subjects. The program has two leagues, an 8- to 10-year-old league and an 11- to 12-year-old league. The 8- to 10-year-old league consisted of five teams with at least 12 players on each team. The 11- to 12-year-old league consisted of four teams with at least nine players on each team. The coaches of each team in each league were asked to identify the best players on their team (top one third) and the poorest players on their team (bottom one third). Thus, four players were identified as experts and four players were identified as novices on each team in the 8- to 10-year-old league. The three best players and the three poorest players on each team in the 11- to 12-year-old league were identified as experts and novices.

Due to lack of cooperation from some of the parents of identified experts and novices, the final sample size was limited to 34 subjects in the 8- to 10-year-old league (17 novice players and 17 expert players). Twenty-two subjects (11 novice and 11 expert players) were tested from the 11- to 12-year-old league. The total sample size was 56.

Measurement instruments

The measurement instruments included those described in Experiment 1 (i.e. the paper-and-pencil basketball knowledge test, the observational instrument, the control dribble test, and the speed spot shooting test) and a child questionnaire, a coaches' rating form, a coaches' questionnaire, and an open-ended basketball interview.

A coaches' rating form was designed to determine the ability rating of each player. Coaches were asked to identify the best players, the average players, and the lesser skilled players on their respective teams. In addition, a questionnaire was designed to assess the offensive and defensive strategies taught during the season by each coach. This information was used to develop the general questions on the basketball situation interview.

The child questionnaire was designed to assess information concerning each subjects' playing experience, the amount of time each subject practiced basketball, family members' playing experience in basketball, etc.

The open-ended basketball interview included five basketball game situations for which the subject was required to generate appropriate actions in the context of a game situation. Situation 1 required subjects to list offensive actions appropriate in a two on one fast break. Situation 2 required subjects to generate offensive actions appropriate in a three on two fast break. Situation 3 required subjects to generate defensive actions in a three on two fast break. In Situation 4, subjects were asked to recall as many offensive out-of-bounds plays as possible. Situation 5 required subjects to list as many alternatives as possible to score a field goal on offense. The quality of the responses for Situations 1, 2, and 3 was also coded as zero, one, or two depending on the subject's understanding of the situation. Quality was coded as zero if no correct answers were given, one if correct answers were given without demonstrating complete understanding of the situation, and two if the subject demonstrated complete understanding of the situation by explaining answers in the context of possible counteractions of the opposing offense or defense. The quality of the organization of the responses in situation 4 and 5 were coded as zero or one. The organization of out-of-bounds plays in Situation 4 and the organization of offensive alternatives in situation 5 were coded as zero if the subject's responses were based only upon simple passes rather than systematic movement of the players and the ball.

Procedures

The coaches' rating form and the coaches' questionnaire were distributed at the end of the season. All coaches completed and returned both forms.

The first two games of each team in each league were video taped using a JVC home video camera (model GX-N70U) and a Mitsubishi home video recorder (model HS-317UR). The novice players generally played one quarter during the game. The expert players usually played more than one quarter. Therefore, one quarter of playing time was coded using the observational coding instrument for each subject for each game. The quarters of playing time were randomly selected for the expert players. Quarters of playing time were randomly selected for the novice group whenever possible (when the novice players played more than one quarter).

One basketball expert coded the performance of each subject. Due to the arrangement of quarters of playing time for experts and novices during actual games, blind observation was impossible. A second independent observer without knowledge of group membership coded a sample of 10 subjects, 5 experts and 5 novices. The percentage of agreement of the two observers for the number of behaviors identified in each category was 90% or greater. The percentage agreement for the number of successful responses in each category was 90% or greater. The observation of the performance of experts and novices was not substantially biased due to knowledge of group membership since the percentage of agreement with a blind observer was greater than 90%.

The control dribble test and the speed spot shooting test were administered to each subject at the end of the season. Both tests were administered in a regular gymnasium during practice or following a game. The testing procedures outlined in Experiment 1 were used during the skill testing.

The paper-and-pencil basketball knowledge test was given to each subject at the end of the season at the school which they attended. In addition, the child questionnaire and the basketball situation interview was administered to each subject individually. The responses of each subject on the basketball situation interview were recorded on cassette tape for coding purposes.

Results

Characteristics of the experts and novices

No statistical analyses were conducted on the information from the child questionnaires. However, a summary of the characteristics of the experts and novices in each age group is presented in Table 1. Experts generally practiced basketball more hours per week, had participated in more sports, and had more years of experience playing basketball.

Insert Table 1 about here

Components of Performance

The experts of both ages had more opportunities to respond in control, decision, and execution than novices. However, there is no reason to believe that fewer opportunities to respond by novices would substantially bias the percentage of successful responses in control, decision, and execution.

To determine the relationship between expertise and age and the percentage of successful responses in each of the components of performance, a 2 x 2 (Age League x Expert-Novice) MANOVA was performed using the categories of the observational instrument as dependent variables. The MANOVA revealed a significant main effect for expert-novice, $F(3, 50) = 12.61$, $p < .01$. No other effects were significant, $Fs < 2.23$, $p > .05$. A forward selection stepwise discriminant analysis was used to followup the significant main effect for expert-novice. The alpha level for entry was set at .05. Decision was stepped in first, $F(1, 54) = 37.38$, $p < .01$. Control and execution did not meet the criterion for entering into the discrimination equation. Experts (M = 85%) made more correct decisions than novices (M = 51%). The mean percentage of successful responses for control, decision, and execution for experts and novices, each age league, and experts and novices in each age league are presented in Table 2.

Insert Table 2 about here

The percentage of successful responses for control, decision, and execution were also subdivided according to the type of skill which was executed. The mean percentages are presented in Table 3. There were many differences in the number of subjects who had the opportunity to execute a given skill. Thus, these results are described but not statistically analyzed. Generally, experts of both ages had higher percentages for control, decisions, and execution for dribbling, passing, and shooting performance. The percentages for decision and execution of dribbling and passing were similar for experts within an age group. However, the percentage for decisions was higher than the percentage for execution in shooting performance for experts of both age groups. The trend for shooting performance was similar for novices. A higher percentage was found for decisions than execution. An interesting observation is that 11-12 league novices actually made better shooting decisions than 8-10 league experts, however, the older novices were much poorer in shooting execution. Novices showed a different pattern for dribbling and passing. Execution percentages were higher than decision percentages for novices in dribbling and passing performance.

Insert Table 3 about here

Knowledge, dribbling, and shooting skill

A 2 x 2 (Age League X Expert-Novice) MANOVA was conducted on the scores of the knowledge test and both skill tests. The results of the MANOVA indicated significant main effects for age league, $F(3, 50) = 5.81$, $p < .01$, expert-novice, $F(3, 50) = 28.01$, $p < .01$, but no significant interaction $F(3, 50) = 0.27$, $p > .05$. These main effects were followed up by a stepdown procedure using a forward selection discriminant analysis. The alpha level used as a basis for stepping in variables was set at .05. The discriminant analysis for age league revealed that knowledge was stepped in first, $F(1, 54) = 8.31$, $p < .01$. Neither skill test was entered. Older children ($M = 79.5$) possessed more knowledge than younger children ($M = 64.9$). The discriminant analysis for expert-novice revealed shooting was stepped in first, $F(1, 54) = 61.40$, $p < .01$, knowledge second, $F(1, 53) = 5.51$, $p < .05$, but dribbling was not entered, $F(1, 52) = 0.70$, $p > .05$. Experts ($M = 47.2$) performed significantly better than novices ($M = 25.7$) in shooting skill. The adjusted means for knowledge showed that experts ($M = 77.1$) possess more basketball knowledge than novices ($M = 64.2$). The means for experts and novices, each age league, and experts and novices in each age league are presented in Table 4.

Insert Table 4 about here

Relationships between the components of performance and basketball knowledge, dribbling skill, and shooting skill

To determine the relationships between basketball knowledge, dribbling skill, and shooting skill and the components of performance, a canonical correlation was conducted using the basketball knowledge, dribbling skill, shooting skill as one set of variables and the components of performance as the second set of variables. The canonical correlation analysis revealed two significant functions. The canonical correlation for the first function was .72, $F(9, 121) = 8.37$, $p < .01$. The canonical correlation for the second function was .43, $F(4, 102) =$

4.05, $p < .05$. The standardized canonical coefficients for each function are presented in Table 5. The standardized canonical coefficients reveal that the first function represents a decision function whereas the second function represents an execution function. Separate univariate multiple regressions using the knowledge test, the control dribble test, and the speed spot shooting test to predict each component of performance were used to followup the canonical analysis. The univariate regressions showed a significant relationship for control, $F(3, 52) = 4.79$, $p < .01$, $R^2 = .20$, decisions, $F(3, 52) = 19.86$, $p < .01$, $R^2 = .53$, and execution, $F(3, 52) = 5.75$, $p < .01$, $R^2 = .25$. The standardized regression coefficients for each univariate regression are presented in Table 6. Dribbling had the largest standardized regression coefficient for control. Shooting skill and knowledge had the largest standardized regression coefficients for decisions. Dribbling skill and shooting skill had the largest standardized regression coefficients for execution.

Insert Tables 5 and 6 about here

Since these relationships may vary according to age and the level of expertise, a separate canonical correlation and separate multiple regressions using age, the level of expertise, basketball knowledge, dribbling skill, and shooting skill to predict each component of performance were conducted. The solutions of these analyses were not different from the analyses without age and level of expertise, thus, the simpler solutions without age and expert-novice as predictors were used.

Situation Interviews

The number of correct responses for Situations 1, 2, and 3 were summed to form a total number of correct responses. The total number of correct responses were analyzed in a 2 x 2 (Age Level x Expert-Novice) ANOVA. The main effects of age level, $F(1, 52) = 6.10$, $p < .02$, and expert-novice, $F(1, 52) = 26.86$, $p < .01$, were significant but not the interaction, $F(1, 52) = 1.64$, $p > .05$. Older players ($M = 5.5$) produced more correct answers than younger players ($M = 4.4$). Expert players ($M = 5.9$) gave more correct answers than novice players ($M = 3.8$). In addition, the quality of the answers given by experts was superior to novices. Novices were less likely to give correct answers by explaining that the actions depended on the actions of the opposing team. The mean and standard deviations for the number of correct responses for Situations 1-3, for each situation, and the quality of response for each situation for experts and novices are presented in Table 7.

Insert Table 7 about here

The number of out-of-bounds plays generated by experts and novices in Situation 4 ranged from three out-of-bounds plays to no out-of-bounds plays. The scores for experts and novices were analyzed in separate chi squares for age and expert-novice. The chi square for expert-novice was significant, $\chi^2(2, N = 56) = 19.22$, $p < .01$. Experts ($M = 1.3$) listed more out-of-bounds plays than novices (M = 0.3). The chi square test for age level was nonsignificant, $\chi^2(2, N = 56) = 5.70$, $p > .05$. The scores for experts and novices on the number of offensive alternatives to score a field goal in Situation 5 were normally distributed. Therefore, the scores for Situation 5 were analyzed in a 2 x 2 (Age Level x Expert-Novice) ANOVA. The main effect for expert-novice was significant, $F(1, 52) = 10.04$, $p < .01$. Experts (M = 5.1) generated more alternatives then novices (M = 3.8). All other effects were nonsignificant, all Fs < 0.15, $p > .05$. Experts also were judged to give a more organized answer for out-of-bounds plays and alternatives to score a field goal. The mean number of out-of-bounds plays and the mean number of alternatives for experts and novices and the mean quality of organization of the responses are also presented in Table 7.

Discussion

The results indicate that cognitive skills play a salient role in the development of basketball expertise in children. The percentage of appropriate decisions was found to be the component of performance which maximally discriminated between experts and novices. Experts were found to make better decisions within the context of basketball game situations than novices.

Experts were also shown to possess more basketball related knowledge and shooting skill than novices. The results of the canonical correlation analysis revealed that basketball knowledge was related to the quality of decisions, whereas dribbling and shooting skill were related to the motor components of performance, control and execution.

Thus, both cognitive and motor skills are important in the development of basketball expertise in children. The cognitive components, however, seem to play a more salient role in discriminating experts and novices in the early development of skilled basketball performance in children.

The results of the basketball situation interview provide information which is useful in describing the manner in which basketball knowledge may be related to decision making ability. Experts gave more correct answers to Situations 1, 2, and 3. Each situation represented a circumstance which commonly occurs during an actual game. Thus, experts seemed to know what responses were appropriate within the context of each situation. Furthermore, experts were more likely to discuss their answers by explaining what to do if the opposing team made a certain action. For example, experts were more likely to give the answers to Situation 1 by saying the decision to pass or shoot depends on who the defensive player guards. Few novices discussed answers by referring to possible actions of the opposing team in that situation. Situations 4 and 5 provide evidence that experts have more and better organized basketball information. Experts generated more out-of-bounds plays and more alternatives to score a field goal. The experts also generated more organized responses in these situations. Experts were more likely to recall out-of-bounds plays designed to score and which involved systematic movement of the ball and players on the court. Similar organization of ball and player movements were observed in experts alternatives to score a field goal. These findings support the findings of other studies that experts possess more game structured information

(Chase & Simon, 1973, Chi, 1978, Starkes & Deakin, 1984) and use different cues to make decisions than novices (Bard & Fleury, 1976).

The progress of the components of performance collapsed across the type of skill performed shows a similar trend to that found by Chi (1978). Older experts perform best followed by young experts, older novices, and young novices. This trend was found for control, decision, execution, knowledge, shooting skill, and dribbling skill. Thus, the development of skilled performance in basketball appears to be more influenced by the development of expertise than age.

However, the progression of the decision and execution components was different depending on the type of skill performed. Experts and novices had a similar pattern for shooting performance. Both groups had a higher percentage for decisions than execution. Novices had a lower percentage for decisions than execution in dribbling and passing performance, whereas the percentages for decisions and execution for experts were similar. There are slightly different interpretations for these results based on the task requirements of dribbling, shooting, and passing.

Dribbling performance requires an individual to make decisions while executing the skill. The performer must be able to monitor the environment while maintaining control of the dribble. The division of attention caused by performing two tasks at once creates more demands on working memory. This is particularly true when dribbling skill is low. A nice illustration of this problem is given by Leavitt (1979) with hockey skills. Thus, a portion of the deficit in dribbling decisions may be due to division of attention. However, there were a number of instances in which novices made poor decisions where no division of attention occurred such as dribbling away from the goal toward midcourt, dribbling into the backcourt. These types of decisions are clearly related to knowledge. In addition, many of the decisions for dribbling were made prior to initiation of dribbling, thus no attention was directed to performing the skill.

Passing is a relatively simple skill. Generally, most children have had experience in some form of passing skill with other objects which could be easily transferred to passing a basketball. Most of the performance deficits observed in novices were a result of a poor decision. Novices often passed to a teammate who was guarded closely. Therefore, the pass was intercepted by a defensive player. These deficits are likely due to lack of knowledge and lack of use of relevant cues such as defensive player positions.

Shooting performance is clearly a more difficult skill than either passing or dribbling. The percentages for shooting execution were much lower than the percentage of shooting decisions for both experts and novices. Thus, for complex skills requiring precise motor coordination, the quality of decisions appears to progress at a much faster rate than the quality of execution.

Experiment 3

Although the progression of expertise across age levels provides information concerning how the components of performance change with age and expertise, a within-subject design would allow assessment of the changes in performance of experts and novices during the course of a season.

The purpose of Experiment 3 was to determine which components of performance change across the course of a basketball season. In addition, this experiment evaluated the change in basketball knowledge, dribbling skill, and shooting skill of experts and novices across the basketball season. The third issue examined was the relation between changes in the components of performance and changes in basketball knowledge, dribbling skill, and shooting skill. The game performance of the 8- to 10-year-old subjects from Experiment 2 was observed at the beginning and at the end of the season. The subjects were also measured on the knowledge test and both skill tests at the beginning and at the end of the season. Because testing and maturational effects could influence the scores of the knowledge test and the skills tests, a control group was added to the design. The control group consisted of a group of children who did not participate in an organized basketball program.

Method

Subjects

Thirty-one players from five teams in the 8- to 10-year-old Biddy Basketball league who had participated in Experiment 2 served as subjects. Fourteen players were rated as novices and 17 players were rated as experts. Sixteen subjects who had never participated in an organized basketball program served as a control group. The control group was randomly selected from physical education classes at Goodpine

Middle School. The total sample size was 47. The age of all subjects ranged from 8 to 11 years.

Procedures

The subjects who participated in an organized basketball program were administered the basketball knowledge test, the control dribble test, and the speed spot shooting test at the beginning of the regular season and a second time at the end of the season. The time between the beginning of the season and the end of the season was approximately 7 weeks. The control group was administered the basketball knowledge test, the control dribble test, and the speed spot shooting test on two different occasions with 7 weeks between administrations.

In addition, the first and last two games of each basketball player was videotaped using a Mitsubishi home video recorder (model HS-317UR) and a JVC color video camera (model GX-N70U). The performance of the expert and novice players during one quarter of each the games was coded using the observational instrument described in Experiment 1. The novice players played only in the second quarter. The expert players played one or more quarters in either the first, third, or fourth quarters. Therefore, one quarter of playing time was randomly selected and coded as a measure of actual performance for the expert players.

Results

Components of Performance

A 2 x 2 (Expert-Novice x Pre-Post) MANOVA with repeated measures on the last factor was conducted using the categories of the observational instrument as dependent variables. Significant effects were found for expert-novice, $F(3, 27) = 8.42$, $p < .01$, and pre-post, $F(3, 27) = 8.45$, $p < .01$. The interaction was nonsignificant, $F(3, 27) = 0.74$, $p > .05$. Univariate ANOVAs revealed a significant main effect for expert-novice in control, $F(1, 29) = 12.69$, $p < .01$, decisions, $F(1, 29) = 18.31$, $p < .01$, and execution, $F(1, 29) = 6.06$, $p < .05$. Experts had a larger percentage of successful responses in each category of performance than novices. The mean percentage of successful responses for experts and novices are presented in Table 8. Univariate ANOVAs also revealed a significant pretest-posttest effect for control, $F(1, 29) = 10.31$, $p < .01$, and decision, $F(1, 29) = 15.70$, $p < .01$. Pre-post was nonsignificant for execution, $F(1, 29) = 0.72$, $p > .05$. Subjects had a higher percentage of successful control and decisions during their performance in the last two games of the season than the first two games. The mean percentage for each category on pretest and posttest measures are presented in Table 8.

Insert Table 8 about here

The pretest and posttest percentages for experts and novices in control, decisions, and execution during dribbling, passing, and shooting performance are presented in Table 9. Experts and novices improved in all components of performance for each skill with the exception of dribbling execution of novices. The percentages for experts in dribbling and passing decisions and executions were similar on both the pretest and posttest measures. Experts had a lower percentage for shooting execution than shooting decisions on both the pretest and posttest measures. Even though experts improved their percentages in decision and execution for dribbling, passing, and shooting on the posttest, the percentages for both components remained similar to each other on posttest measures. The percentages increased across the course of the season, however, the ratios did not change. Unlike the pretest measures, the decision component of novices on the posttest for dribbling performance was higher than the execution component. The trend for decisions to lag behind execution for novices in Experiment 2 was also present on the posttest measures for passing. Also the trend in Experiment 2 for the shooting decisions of novices to have a higher percentage than shooting execution was found.

Insert Table 9 about here

Knowledge, dribbling, and shooting skill

A 3 x 2 (Group x Pre-Post) MANOVA with repeated measures on the last factor was performed using the knowledge test and both skill tests as dependent variables. The MANOVA revealed a significant main effect for group, $F(6, 84) = 13.17$, $p < .01$, pre-post, $F(1, 42) = 6.80$, $p < .01$, and a significant interaction, $F(6, 84) = 3.37$, $p < .01$. Univariate ANOVAs were used to followup the MANOVA. Univariate analyses revealed a significant group effect for knowledge, $F(2, 44) = 23.29$, $p < .01$, dribbling, $F(2, 44) = 19.96$, $p < .01$, and shooting, $F(2, 44) = 38.00$, $p < .01$. A significant main effect for pre-post was found only for the knowledge test, $F(1, 44) = 19.81$, $p < .01$. These results are superseded by presence of significant interactions for knowledge, $F(2, 44) = 5.41$, $p < .01$, and dribbling, $F(2, 44) = 4.71$, $p < .05$. The significant interaction for the knowledge test was caused by an increase in the scores of both the expert and novice players on the posttest while the scores of the nonplayer control group remained constant from pretest to posttest. The significant interaction for dribbling was primarily caused by slight improvement in dribbling speed by the control group whereas the performance of the expert and novice players remained relatively constant over time. The means and standard deviations for the knowledge test, the control dribble test, and the speed spot shooting test are presented in Table 10.

Insert Table 10 about here

Relationship between components of performance and basketball knowledge, dribbling skill, and shooting skill

Two separate canonical correlations were conducted. One canonical analysis examined the relationships between knowledge and both skill tests and the components of performance using the pretest measurements of these variables. The second canonical examined the relationships between knowledge and both skill tests and the components of performance using the posttest measurements. The results of the canonical correlation analysis of the pretest values on the knowledge test and both skill tests and the components of performance were similar to the results in Experiment 2. Two canonical functions were significant. The canonical correlation for the first function was .68, $F(9, 61) = 3.64$, $p < .01$. The canonical correlation for the second function was .56, $F(4, 52) = 3.02$, $p < .05$. The standardized canonical coefficients are presented in Table 11. The first function represents a decision making function, whereas the second function primarily represents an execution function, but with some importance attached to decisions (weighted negatively). Univariate multiple regressions using the knowledge test, the control dribble test, and the speed spot shooting test to predict each component of performance were significant for control, $F(3, 27) = 3.98$, $p < .01$, $R^2 = .31$, decision, $F(3, 27) = 7.19$, $p < .01$, $R^2 = .44$, and execution, $F(3, 27) = 3.05$, $p < .05$, $R^2 = .25$. The standardized regression coefficients for each univariate regression are presented in Table 12. Shooting skill had the largest standardized coefficient for control. Knowledge and shooting skill had the largest standardized regression coefficients for decisions. Dribbling and shooting skill had the largest standardized coefficients for execution.

Insert Tables 11 and 12 about here

The canonical correlation analysis of the posttest scores of the knowledge test, dribbling test, and shooting test and components of performance was nonsignificant, $p > .05$. Univariate regressions using the knowledge test, the control dribble test, and the speed spot shooting test to predict the posttest measures of control, decisions, and execution were conducted in order to evaluate why the relationship had become nonsignificant on the posttest. The univariate regression for decisions was the only one remaining significant, $\underline{F}(3, 27) = 5.58$, $\underline{p} < .01$. The univariate regressions for control and execution were nonsignificant. The standardized regression coefficients for the univariate regression for decisions are presented in Table 13. Knowledge is the only predictor that appears important based on the standardized coefficients. Pearson correlations and were calculated between decisions and the knowledge test, the dribbling test, and the shooting test and are reported in Table 13. The Pearson correlations show that knowledge, dribbling, and shooting had moderate correlations with the quality of decisions. Second order semi-partial correlations were calculated between decisions and each predictor by partialling out the relationships among the predictors. These semi-partial correlations are presented in Table 13. The semi-partial correlations show that knowledge has the highest relationship to the quality of decisions when the relationships are adjusted for the correlations between the other measurements (knowledge, dribbling, and shooting).

Insert Table 13 about here

The level of expertise may influence the results of the canonical analyses reported above. Separate canonical correlations using the pretest and posttest measures of the knowledge test, control dribble test, the speed spot shooting test, the level of expertise and the components of performance were conducted. The addition of the level of expertise did not change the solution of either analysis, thus, the simpler solution was used.

Discussion

The results of the analyses comparing the measurement of the components of performance collapsed across the type of skill indicate that the components which improved across the course of the season were control of the basketball and the quality of decisions made within the context of the game. Both experts and novices showed slight improvement in control but exhibited substantial improvement in the quality of decisions.

The results of the analyses comparing pretest and posttest measures of knowledge and both skill tests indicated that the knowledge base increased for experts and novices across the course of the season but there was little change in dribbling or shooting skill. Because the scores of the control group did not change from the pretest to the posttest on the basketball knowledge test, the increase in the scores for experts and novices can be related to learning rather than the effects of repeated testing.

The improvement in the performance of experts and novices was due primarily to the improvement in cognitive decisions making skills and acquisition of sport specific knowledge since the percentage of successful execution and the scores on both skill tests did not change over the course of the season.

The results of the canonical correlation analysis on the pretest measures of knowledge, dribbling, shooting, and the components of performance were similar to the results of Experiment 2. However, the canonical correlation analysis of the posttest measures of knowledge, dribbling, shooting, and the components of performance was nonsignificant, which indicates that the relationships between basketball knowledge, dribbling, shooting, and the components of performance changed across the course of the season. No relationship was found between dribbling and shooting skill and the motor components of performance, control and execution. However, knowledge remained a significant predictor of the quality of decisions. Because the scores of the knowledge test and the quality of decisions both improved across the course of the season, an increase in basketball knowledge was related to an increase in the quality of decisions made in the context of game situations.

The mean percentages for control, decision, and execution for dribbling, passing, and shooting provide further information concerning the progression of cognitive and motor components in the development of expertise. All components of performance for experts and novices improved across the course of the season for dribbling, passing, and shooting with the exception of novice dribbling execution. Novices execution of dribbling was lower on the posttest than the pretest.

The progression of decisions and execution across the course of the season revealed a similar trend to Experiment 2. The percentages for decision and execution for experts were similar on posttest measures of dribbling and passing. Both components improved but the ratio remained similar. Novices decisions in dribbling substantially improved, however, novice execution actually declined. The increase in the quality of dribbling decisions of novices is likely due to increases in knowledge rather than a reduction in interference from limited attentional capacity, since neither the execution component nor the control dribble test showed improvement on the posttest. Novices were learning where to dribble, when to dribble, and when to stop dribbling.

Similar to Experiment 2, the decision component for passing performance of novices continued to lag behind the execution component. This tends to support the conclusion in Experiment 2 that for relatively simple skills, decisions are more difficult than actual skill execution.

Experts and novices had higher percentages for shooting decisions than shooting execution on posttest measures of performance. These results support the conclusions of Experiment 2. The decision component progresses much faster than the execution component for complex skills. An interesting observation is that improvement in shooting execution occurred for experts and novices. However, both groups showed no improvement in shooting skill as measured by the skill test. Although a number of factors which were not measured could contribute to this improvement, the increase in the quality of shot selection decisions may have also contributed to the improvement in shooting execution.

General Discussion

The results of Experiments 2 and 3 have demonstrated that many of the performance deficits of children in basketball can be attributed to insufficient basketball knowledge and poor cognitive decision making skills. The primary component of performance which discriminated child expert basketball players from child novice basketball players in Experiment 2 was the ability to make better decisions within the context of actual game play. Experts also possessed more basketball knowledge than novices. Furthermore, basketball knowledge was a significant predictor of the quality of decisions made within the context of game situations.

The results of Experiment 3 indicated that the major improvement in performance could be attributed to an increase in the quality of decisions across the course of the basketball season. The knowledge base of experts and novices also increased across the course of the basketball season. The increase in the quality of decisions was related to the corresponding increase in basketball knowledge.

The findings of these experiments have several important implications for theoretical frameworks of the development of skilled behavior. First, the comparisons of experts and novices of two different age levels in Experiment 2 revealed no developmental trend. Experts of both ages exhibited superior performance. The scores for the components of performance, the knowledge test, dribbling and shooting skill revealed a trend similar to the findings of Chi (1978) and Lindberg (1980). Older experts performed best on all measurements followed by young experts, older novices, and young novices.

Although no attempt was made to examine the processes with which these skills were acquired, the child questionnaires indicated the same trend existed for the number of years experience playing basketball and the number of hours spent practicing basketball each week. Thus, greater opportunity to practice and learn the cognitive and motor skills necessary for successful performance in sport appears to be more important than the individual's age.

The second important finding of these experiments was a signficant relation between sport specific knowledge and the decision component of performance. Although the relation of knowledge to the quality of decisions is correlational in nature, a number of studies have either established a relation between knowledge and performance on a variety of tasks (Adelson, 1984; Chi, 1978; Chi, Feltovich, & Glaser, 1981; Chiesi, Spilich, & Voss, 1979; Lindberg, 1980; Spilich, Vesonder, Chiesi, & Voss, 1979), or have found differences in the structure of the knowledge base between experts and novices (Chase & Simon, 1973; Charness, 1979; Chi & Koeske, 1983). Thus, acquisition of domain related knowledge is responsible, in part, for the facilitation of performance on many tasks.

The results of Experiment 2 and 3 suggest two ways in which knowledge may affect the quality of decisions made in basketball. First, the results of Situations 4 and 5 of the basketball situation interview in Experiment 2 indicate that experts possess larger amounts of better organized information. Similar findings have been found in adult expert basketball players (Allard, Graham, & Paarsalu, 1980). The existence of more and better organized information increases the efficiency of the memory system (Chiesi, Spilich, & Voss, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979). The structure and organization of information allows the expert to have access to more information in short term memory at a given point in time. Thus, the capacity limitations of short term memory are reduced. Better organized information also facilitates the search and retrieval of information from long term memory. Because experts have more years of experience in playing basketball, the memory processes involved in manipulating the knowledge base should become more efficient with experience in using the information. Thus, the search and retrieval processes would take less time and become less variable.

Another way in which basketball knowledge could affect the quality of decisions in basketball is the manner in which input information is selectively processed. Since the knowledge test is a measure of recognition memory, experts could recognize the relevant information within a given question and match this information with the correct answer. The expert is better able to recognize the relevant information in a problem solving situation during game play and match this information with an appropriate decision. The results of Situations 1, 2, and 3 in Experiment 2 suggest that expert basketball players are also more likely to understand the importance of the actions of the opposing team in making appropriate decisions. Similar support was found by Bard and Fleury (1976) who found that experts fixated eye movements on pairs of offensive and defensive players whereas novices only concentrated on offensive players.

Experiment 3 also demonstrated that the major change in a child's performance across the course of a basketball season was an increase in the ability of make appropriate decisions during game play. Furthermore, the change in the quality of decisions was related to a corresponding increase in sport specific knowledge. Because there was no change in the execution component of performance or the scores of the dribbling and shooting tests, the cognitive skills involved in sport performance progressed at a faster rate than the execution of motor skills. Children were learning what to do in given basketball situations faster than they were acquiring the motor skills to carry out the actions. These results are not surprising given that acquisition of motor skills is a slow process requiring much practice over long periods of time to refine the movements associated with complex skills such as dribbling and shooting.

The results of these experiments have practical implications for teachers and youth sport coaches as well. Sport specific knowledge and their relation to cognitive decision making skills are important in the development of skilled performance. Teachers and coaches should plan their instruction to include time to develop sport specific knowledge and decision making skills. The knowledge base for a given sport would include knowledge of the rules, the goals and subgoals of the game, and offensive and defensive strategies. Children should also be exposed to many different situations which occur in the sport. Teachers or coaches should explain each situation, provide the child the relevant information neccessary to make successful decisions, and provide useful cues. Players must also be given the opportunity to practice these decision making skills.

Applications from research in this area can be served best by a sport specific approach since the fundamental sport specific knowledge and sport skills vary considerably from sport to sport. Further research is needed to examine the interrelations of sport specific knowledge, sport specific skills, and the components of performance in the development of skilled performance in other sports.

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Table 1

Descriptive statistics for the characteristics of the expert and novice basketball players by league.

11-12 Year Old League (n=11 per cell)

	Experts		Novices	
	M	SD	M	SD
Age in years	11.8	0.4	11.3	0.5
Years experience	2.9	0.9	1.2	1.0
Hours of practice[a]	3.9	0.3	3.2	1.1
Number of sports[b]	1.8	0.6	1.1	0.8
Practice with adults[c]	2.5	2.1	1.6	1.8
Practice with children[d]	2.3	2.1	2.6	1.7

8-10 Year Old League (n=17 per cell)

	Experts		Novices	
	M	SD	M	SD
Age in years	9.8	0.6	8.7	0.6
Years experience	1.4	0.7	0.5	0.8
Hours of practice	3.5	0.9	2.8	1.3
Number of sports	1.9	0.8	1.3	0.9
Practice with adults	2.5	1.7	2.8	1.6
Practice with children	1.6	2.1	1.9	1.8

[a] number of hours practice per week

[b] number of sports subject has previously played

[c] hours of practice with father or mother

[d] hours of practice with siblings

Table 2

Mean percentage of successful responses for control, decisions, and execution for experts and novices.

	Experts (n=28)		Novices (n=28)	
	M	SD	M	SD
Control	96	8	86	17
Decisions	85	9	51	28
Execution	76	12	63	30

	8-10 League (n=22)		11-12 League (n=34)	
	M	SD	M	SD
Control	88	16	96	9
Decision	65	27	74	26
Execution	68	26	73	17

8-10 League	Experts (n=17)		Novices (n=17)	
	M	SD	M	SD
Control	94	9	81	19
Decision	82	9	47	28
Execution	76	9	60	34
11-12 League	Experts (n=11)		Novices (n=11)	
Control	98	4	93	12
Decision	90	7	57	29
Execution	76	16	69	19

Table 3

Mean percentage of successful responses for experts and novices in each age league for control, decisions, and execution in dribbling, passing, and shooting performance.

8-10 League	Experts			Novices		
	M	SD	n	M	SD	n
Dribbling						
control	97	9	17	91	16	14
decision	85	18	17	44	34	14
execution	91	24	17	66	35	14
Passing						
control	61	46	10	69	39	12
decision	88	13	17	55	37	15
execution	89	13	17	82	36	15
Shooting						
control	90	29	12	83	25	8
decision	65	28	17	42	33	9
execution	23	20	17	1	5	9
11-12 League	Experts			Novices		
Dribbling	M	SD	n	M	SD	n
control	99	3	9	100	00	9
decision	81	31	9	36	37	9
execution	86	32	9	68	43	9

Table 3 continued.

Passing		Experts			Novices	
control	97	6	10	90	17	10
decision	95	4	11	67	37	11
execution	94	8	11	86	19	11
Shooting						
control	100	00	8	100	00	4
decision	90	14	11	74	25	6
execution	32	24	11	3	8	6

Table 4

Means for the knowledge test, the control dribble test, and the speed spot shooting test by age league, expert-novice, and age league by expert-novice.

	11-12 Year Olds (n=22)		8-10 Year Olds (n=34)	
	M	SD	M	SD
Knowledge[a]	79.5	15.5	64.9	20.0
Dribbling[b]	20.8	3.3	22.7	3.9
Shooting[c]	40.7	14.3	33.7	14.7

	Experts (n=28)		Novices (n=28)	
	M	SD	M	SD
Knowledge	83.1	15.2	58.1	15.1
Dribbling	19.4	1.8	24.4	3.6
Shooting	47.2	10.7	25.7	9.8

Table 4 continued.

	Experts		Novices	
	M	SD	M	SD
11-12 Year Old League (n=11 per cell)				
Knowledge	91.8	6.8	67.1	11.1
Dribbling	18.7	1.4	22.9	3.4
Shooting	50.7	8.8	30.7	11.5
8-10 Year Old League (n=17 per cell)				
Knowledge	77.5	16.5	52.4	14.7
Dribbling	20.0	1.8	25.4	3.5
Shooting	44.9	11.3	22.5	7.2

a percent correct

b seconds

c total points

Table 5

Standardized canonical correlation coefficients using the knowledge test, the control dribble test, the speed spot shooting test, and the control, decision, and execution components.

	Standardized Canonical Coefficients	
	Function 1	Function 2
Knowledge	0.431	-0.012
Dribbling	-0.420	1.401
Shooting	0.252	1.524
Control	0.304	-0.405
Decision	0.950	-0.030
Execution	-0.236	0.984

Table 6

Standardized regression coefficients for the univariate regression analyses using the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decision, and execution.

	Standardized Regression Coefficients		
	Control	Decision	Execution
Knowledge	0.0873	0.3280	0.0397
Dribbling	-0.4477	-0.0638	0.5242
Shooting	-0.0663	0.4124	0.7580

Table 7

Means and standard deviations for experts and novices on the basketball situation interview.

	Experts (n=28)		Novices (n=28)	
Situations	M	SD	M	SD
Total 1, 2, 3	5.9	1.5	3.8	1.7
1. Offense on a 2 on 1 fast break				
Number correct	1.8	Ø.4	1.6	Ø.5
Quality[a]	1.5	Ø.6	1.Ø	Ø.4
2. Offense on a 3 on 2 fast break				
Number correct	2.1	Ø.9	1.5	1.Ø
Quality[a]	1.2	Ø.5	Ø.7	Ø.5
3. Defense on a 3 on 2 fast break				
Number correct	1.9	Ø.8	Ø.7	Ø.7
Quality[a]	1.2	Ø.6	Ø.4	Ø.5
4. Number of out-of-bounds plays generated				
Number of plays	1.4	1.1	Ø.3	Ø.5
Quality[b]	Ø.7	Ø.5	Ø.2	Ø.4
5. Alternatives to score a field goal				
Number generated	5.1	1.7	3.8	1.4
Quality[b]	Ø.7	Ø.5	Ø.2	Ø.4

[a] Quality scored as Ø, 1, or 2

[b] Quality scored as Ø or 1

Table 8

Mean percentage of control, decision, and execution for each group (expert-novice) and for each time of measurement.

	Experts		Novices	
	M	SD	M	SD
Control	97	7	86	17
Decision	88	9	58	33
Execution	76	9	62	32

	Pretest		Posttest	
	M	SD	M	SD
Control	87	16	96	9
Decision	67	27	83	26
Execution	68	27	72	20

Table 9

Mean percentage of successful responses for control, decision, and execution for experts and novices in dribbling, passing, and shooting performance for each time of measurement.

	Pretest			Posttest		
Experts (n=17)	M	SD	n	M	SD	n
Dribbling						
control	96	9	17	100	00	17
decision	85	18	17	96	6	17
execution	91	24	17	90	13	17
Passing						
control	61	46	10	98	7	11
decision	88	13	17	93	9	17
execution	89	13	17	94	8	17
Shooting						
control	90	29	12	100	00	15
decision	65	28	17	95	9	17
execution	24	20	17	39	21	17
Novices (n=14)	Pretest				Posttest	
Dribbling						
control	91	17	12	93	13	11
decision	45	38	12	65	37	11
execution	66	35	11	59	35	11

Table 9 continued.

Passing						
control	59	41	9	93	15	9
decision	63	36	12	73	31	12
execution	78	39	12	90	17	12
Shooting						
control	78	27	6	100	00	3
decision	33	27	7	92	19	7
execution	2	5	7	28	48	7

Table 10

Pretest and posttest means for the knowledge test, the control dribble test, and the speed spot shooting test for each group.

	Pretest		Posttest	
	M	SD	M	SD
Experts (n=17)				
Knowledge[a]	66.6	13.5	77.5	16.5
Dribbling[b]	19.2	1.6	20.0	1.8
Shooting[c]	42.8	8.1	45.0	11.3
Novices (n=14)				
Knowledge	46.0	13.5	54.4	13.6
Dribbling	25.6	3.7	25.7	3.7
Shooting	18.9	9.7	22.4	7.6
Controls (n=16)				
Knowledge	42.1	12.5	42.1	13.5
Dribbling	26.1	4.7	24.5	3.3
Shooting	27.4	7.2	26.5	7.8

a percent correct

b seconds

c total points

Table 11

Standardized canonical correlation coefficients for the canonical analysis using the pretest scores on the knowledge test, the control dribble test, the speed spot shooting test and the components of control, decisions, and execution.

	Standardized Canonical Coefficients	
	Function 1	Function 2
Knowledge	0.279	0.085
Dribbling	-0.223	1.767
Shooting	0.569	1.562
Control	0.267	0.628
Decision	0.860	-0.911
Execution	-0.082	1.038

Table 12

Univariate standardized regression coefficients for the analysis using the pretest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

	Standardized Regression Coefficients		
	Control	Decision	Execution
Knowledge	-0.048	0.266	0.308
Dribbling	0.161	-0.161	0.706
Shooting	0.713	0.293	0.660

Table 13

Standardized regression coefficients, Pearson correlations, and semi-partial correlations for the prediction of decisions from the scores of the knowledge test, the control dribble test, and the speed spot shooting test.

	Standardized Coefficients	Pearson Correlations	Semi-partial Correlations
	Decision	Decision	Decision
Knowledge	0.436	0.599	0.289
Dribbling	-0.095	-0.526	-0.054
Shooting	0.146	0.495	0.094

Appendix A

Extended Review of Literature

The Relation of Knowledge Development to Children's Performance in Basketball

Much of the research in developmental learning has attributed the memory performance differences between children and adults to three areas: the capacity of working memory, the development and efficient use of mnemonic strategies, and an increase in the knowledge base. Researchers in verbal learning as well as motor skills have spent considerable efforts studying the former two (Chi, 1976; Flavell, 1970; Naus & Orstein, 1983; Pascual-Leone & Smith, 1969; Thomas, 1980, 1984). Only recently have researchers begun to examine the effects of the knowledge base on performance (Chi, 1980; Lindberg, 1980). Studies (Chi & Koeske, 1983; Orstein & Naus, 1982) suggest that the existence of domain related knowledge significantly improves the performance of children in memory tasks.

The knowledge base may also have effects on the performance of children in sport situations especially in highly structured goal oriented sports which require a repetoire of cognitive as well as motor skills. Furthermore, much of the improvement of young children across age and during the course of a given sport's season may be attributed to an increase in sport specific knowledge and cognitive skills required in the context of the given sport. Although the skill level of children in terms of actual physical skill indeed improves with age and across a given sport season, the child also improves the ability to make appropriate decisions within the context of the sport situation. This type of decision making requires a variety of knowledge, including knowledge about the game, its goals and actions, knowledge of monitoring skills, and knowledge of actions within the context of game situations. Although much of the research concerning the effects of the knowldege base has been carried out using verbal tasks, many of the findings have implications for sport skills.

Theoretical Orientation

Substantial evidence suggests that a considerable portion of the performance deficits of children can be attributed to ineffective processing of information. Although there are a number of information processing models cited in the literature, a common framework used in development memory is a multi-store model (Atkinson & Shriffrin, 1971; Thomas, 1980; Thomas, 1984). A similar feature of these models is the existence of three memory stores -- sensory register, short term memory, and long term memory.

Generally, most of the research in developmental learning has focused on the processing deficits associated with short term memory. The deficits of children have been attributed to increases in the capacity of short term memory with age (Pascual-Leone & Smith, 1969) or failure to produce and effectively use the control processes (i.e. rehearsal, encoding, grouping, organization, recoding, search, and retrieval) of short term memory (Chi, 1976; Thomas, 1980). Further discussion of these explanations is presented elsewhere (Chi, 1976; Flavell, 1970; Naus & Orstein, 1983; Pascual-Leone & Smith, 1969, Thomas, 1980, 1984).

Although several authors have emphasized the role of prerequisite knowledge as a foundation for learning complex skills (Gagne, 1968; Fisher, 1980; Bransford, Franks, Morris, & Stein, 1979), few studies have examined the relation between the information stored in long term memory and the performance of children. Chi (1978) was instrumental in demonstrating that lack of sufficient knowledge also affects the performance of children. Child experts and adult novices were compared on the recall of plausible middle-game chess configurations. The results indicated that child experts performed better than adult novices on the recall of chess positions. Similar findings were reported by Lindberg (1980). Thus, even though child experts within a given knowledge domain lack sophisticated mnemonic strategies for remembering, they can and do perform better than adults on memory tasks when they possess a greater amount of knowledge related to the task.

The Structure of Knowledge

Most of the inferences concerning the structure of the knowledge base have been drawn from studies which compare the performance of individuals with a high degree of domain specific knowledge (experts) and individuals possessing a limited amount of domain specific knowledge (novices). Although the majority of these investigations have been correlational in nature, they illustrate that experts possess a different type of representation of knowledge, process new domain information in a different manner, and approach problem solving differently than novices. Establishment of these relationships can guide further research concerning how knowledge is acquired and the processes necessary in the transition from novice to expert. Since children most frequently lack a high degree of knowledge, they may be considered novices under most circumstances. Thus, studies using adult subjects may be helpful in understanding the processes with which individuals of all ages progress in expertise.

Before discussing the findings of expert-novice differences in the structure and representation of the knowledge base, it is helpful from a conceptual viewpoint to distinguish different types of knowledge. Chi (1981) suggests three distinct types of knowledge; declarative, procedural, and strategic. Declarative knowledge involves factual information or lexical knowledge (Chi, 1981). Procedural knowledge is loosely defined as knowledge of "how to do something". Both declarative knowledge and procedural knowledge are domain specific. For example, in basketball, knowledge of the rules, the field, and different positions would correspond to declarative knowledge, whereas knowledge of the offensive and defensive strategies would correspond to procedural knowledge.

Strategic knowledge can be viewed as knowledge of general rules, such as mnemonic strategies, which are applicable across a wide variety of domains (Chi, 1981). For example, the process of rehearsal is useful to remember numbers and words, as well as possible actions which may occur during a forthcoming play in basketball.

Chi (1981) suggests that mnemonic strategies develop first as task specific strategies or procedural knowledge within a given knowledge domain. Only after much use are these strategies developed into general strategies which may be applied across knowledge domains. This progression of strategy development may explain the difficulty of children in transferring mnemonic strategies to different tasks.

Expert-novice differences in the structure of content. One of the ways to conceptualize the structure of the knowledge base is in the form of semantic networks (Chi, 1980). In such frameworks of memory, knowing more would generally be characterized by having more nodes, more features defining each node, and more interrelating nodes (Chi, 1980).

Several researchers have examined the semantic networks of experts and novices in a variety of knowledge domains, such as, dinosaurs, (Chi & Koeske, 1983), chess (Chi, 1978; Chase & Simon, 1973), baseball (Chiesi, Spilich, & Voss, 1979, Spilich, Vesonder, Chiesi, & Voss, 1979), and psychological disturbances, (Murphy & Wright, 1984). Not surprisingly, the results of these studies do substantiate that experts have more concepts with more defining features within each concept. In addition, Murphy and Wright (1984) found that experts have many features which are common to more than one concept within the knowledge domain.

Another characteristic found in the group of experts was a high degree of consensus concerning the features generated for a category or concept (Chiesi, Spilich, & Voss, 1979, experiment 4; Murphey & Wright, 1984). This seems to suggest that information is organized similarly by experts within a given domain.

Therefore, the structure of the knowledge base of the expert can be described as a dense semantic network containing many interrelated concepts and features. When asked to recall information from the knowledge base, the expert has a distinct advantage. The expert has access to more information through more and larger chunks which are highly organized and interrelated. Thus, the demands on or limitations of working memory are minimized. The experts also has the advantage of a large number of links interrelating each concept which increases the efficiency of search and retrieval of information from long term memory by establishing multiple pathways to the same information.

In addition to declarative knowledge within the semantic network, Chi (1980) suggests the knowledge base also contains procedural information. Chi, Feltovich, and Glaser (1981) and Adelson (1984) used a verbal protocol technique during problem solving to examine the procedural knowledge of experts and novices. The first noticeable difference between experts and novices was the representation of the problem to be solved. In both studies, experts formed a more abstract representation than novices. For example, experts solving physics problems represented the problems in terms of physical laws whereas the novice based their representation on the literal features of the problem (Chi, Feltovich, & Glaser, 1981). Adelson (1984) found expert computer programmers generally form abstract representations of what the program does, whereas novices formed more concrete representations of how the program functions. Both studies suggest that experts do possess a greater amount of procedural knowledge than do novices. Adelson (1984) further suggests that procedural knowledge cannot be inspected directly in some instances and must be inferred. Experts may represent information in such a manner that the details of the processes involved are hidden (Adelson, 1984). Thus, experts possess a rich semantic network of declarative and procedural knowledge which allows the expert to form an abstract plan for solving problems with greater ease than the novice even though the expert may be unaware of the detailed processes of how the procedural knowledge was used in the solution process.

Prior to relating these findings directly to specific sport situations, one other framework for examination of the structure of the knowledge base merits consideration.

Hierarchial organization based on goal structure. Chiesi, Spilich, and Voss (1979) and Spilich, Vesonder, Chiesi, and Voss (1979) conducted two studies which approach the structure of the knowledge base from a slightly different viewpoint. In their conceptual framework, the structure of the knowledge base for a given sport is organized in terms of the games goal structure, game states and actions, and information concerning the setting in which the game takes place.

Spilich, Vesonder, Chiesi, and Voss (1979) propose that the goal structure of baseball is hierarchially organized with the highest goal as winning the game. Furthermore, the most salient knowledge consists of knowing the means by which a game is won. Subgoals enable the individual or team to accomplish the primary goal. Thus, a second level of goal structure in baseball consists of scoring runs and preventing runs from being scored (Spilich et al., 1979). A third level of goal structure consists of advancing runners or preventing the advancement of runners or batters from reaching base (Spilich et al., 1979).

Spilich et al. (1979) also suggest that most games can be described in terms of sequences of game states and game actions. A game state is defined as the existing conditions in a game at any given point in time (i.e. two outs, runners on first and third). A game action is defined as an action or series of actions occurring during the course of the game which typically produces a change in a game state. For example, a hit typically results in at least one runner on base.

Chiesi et al. (1979) stress two points. First, since game actions produce changes in game states, game actions vary in importance. The salience of a specific game action is determined by the goal structure (Chiesi et al., 1979). Second, many game actions can only occur in specific game states. For example, a double play can only occur when there is at least one runner on base and less than two outs..

Within this conceptual framework, Chiesi et al. (1979) and Spilich et al. (1979) compared the processing of baseball information by individuals with a high degree of baseball knowledge and individuals with a limited amount of baseball knowledge. The high knowledge (HK) individuals organized the information differently than low knowledge (LK) individuals. First, HK individuals were able to generate more possible game actions for a given game state. Moreover, the game actions generated by HK individuals were predominantly related to higher order goals in the game hierarchy (Chiesi et al., 1979, experiment 3). Second, HK individuals recalled larger chunks of information for a particular game action. Generally, the chunks were organized as a given sequence of actions (Spilich et al., 1979). Third, setting information and game actions which were salient in the goal structure were recalled more frequently by HK individuals, whereas information and actions irrelevant to the goal structure were recalled more frequently by LK individuals (Spilich et al., 1979).

These findings support other verbal learning studies. The knowledge base of the HK individual contains more and larger chunks of information. The important finding is that HK individuals tend to organize information within the goal structure of the game with information higher in the goal structure recalled more readily.

A second important finding from Spilich et al. (1979) and Chiesi et al. (1979) concerns differences in the processing of input information by HK and LK individuals. First, HK individuals were more likely to detect changes in baseball descriptions than LK individuals. Furthermore, the difference between the HK and LK individuals increased as the importance of the change to the goal structure increased (Chiesi et al. 1979, experiment 1). Second, the HK individuals could recognize baseball descriptions based on less information than LK individuals. The HK individuals could intergrate information more readily and make judgments pertaining to the "whole" based on a fewer set of parts (Chiesi et al. 1979, experiment 2). Third, when given scrambled passages of baseball text, the recall of HK individuals was greater due to their ability to restructure the information into meaningful sequences of events (Chiesi et al. 1979, experiment 3). This contention is supported by Spilich et al. (1979) who found LK individuals have difficulty keeping track of the order of events. Fourth, HK individuals recall of target sentences did not significantly differ from LK individuals recall when no context sentences were provided. However, the recall of HK individuals was substantially greater than LK individuals when a context sentence was provided.

These results suggest that HK individuals tend to process input information relevant to the goal structure of the game. The HK individuals is able to monitor changes in game states and actions and selectively process information related to the goal structure.

Knowledge base and motor performance

Although most of the studies thus far have used verbal memory tasks, there is no reason to believe that fundamental differences exist in the structuring of information used to recall words or text information and game related information used to make decisions in sport. Thus, my contention is that the structure and organization of the knowledge base for a given sport is represented similarly to any other specific knowledge domain.

However, the definition of procedural knowledge in the verbal literature is rather loosely defined as knowledge of "how to do something". This definition causes confusion for sport performance. Starkes and Deakin (1984) have suggested that procedural knowledge involves how to perform actual motor skills. While this analogy may be warranted, a more restrictive definition of procedural knowledge is needed for the purpose of this paper. In this paper, the term knowledge will not include knowledge of how a motor skill is performed. Rather than confuse the reader, knowledge, both declarative and procedural, will be operationally defined as information about the rules of the game, the players, positions, goals and subgoals of the game, and offensive and defensive strategies.

The knowledge base may contribute to the performance of children and adults in two major areas. First, an individual who possesses a high degree of knowledge in a specific sport is better able to make an appropriate decision for a given situation within the context of the goal structure of the game. Second, an individual who has an extensive knowledge base can make better decisions based on less information and in less time than an individual with a low degree of knowledge. Both the quality of decisions and the speed with which the decision is made are major factors in determining success in many sport situations.

Two studies have compared the structure of game related information in expert sport participants (Allard, Graham, & Paarsalu, 1980; Starkes & Deakin, 1984). These studies support the findings of the verbal literature. Experts exhibit superior recall for game related information. Thus, expert sport participants have an extensive semantic network of knowledge. Furthermore, Chiesi, Spilich and Voss, (1979) and Spilich, Vesonder, Chiesi, and Voss (1979) found that the knowledge base of individuals is hierarchially organized in terms of the goal structure of a given sport. Thus, an expert player knows what information is relevant within a given situation. The relevant information for a given action is mapped onto the existing knowledge structure. Since the semantic network of the expert consists of more interrelated chunks of information, the search and retrieval of knowledge from long term memory is more efficient and isconducted in less time. Furthermore, the retrieval of large chunks of information reduces the demands on working memory so that an expert player has access to more knowledge at any given point in time. Therefore, the memory system functions more efficiently. The quality of decisions is improved and processing time for a decision is reduced.

A second way in which processing time is reduced by expert players is through the development and use of sport specific strategies to monitor changes in goal states and actions, plan for possible actions, and predict certain game actions. As evidenced by Chiesi et al. (1979), high knowledge individuals understand relationships between game states and actions within the goal structure of the game. Furthermore, they suggest the high knowledge individuals detect and monitor changes in game states and actions. High knowledge players, in addition, know that monitoring such changes are important to the achievement of the goal. For example, in basketball, actions within the context of the game are dependent on a number of things such as positions of the players, the score, the opposing teams offense and defense, etc. These variables must be monitored throughout the game and must be remembered in a given situation to generate the appropriate response.

Indeed there are many external memory aides to facilitate remembering such information, for example, the score board, time outs, labeling of plays. A common procedure in baseball is for a certain player to remind team members of these variables as well as verbally state the responses most appropriate if certain actions occur. This suggests strategies for monitoring changes in game states develop into planning strategies prior to the initiation of the action, at least in baseball. When possible responses are preplanned, the player need only respond to a given stimulus, the action. Thus, the number of choices is reduced and the decision to respond occurs more rapidly.

At this point, the distinction between discrete and continuous sport is important. Discrete sport can be defined as sports in which there is a pause between sequences of game actions, for example, baseball, football. In continuous sport there are few breaks in the sequences of actions, for example, basketball, soccer. Discrete sports allow time for planning responses prior to the initiation of actions. While there is no such break in action for preplanning in continuous sports, observation suggests that to some degree this type of monitoring and planning occurs in basketball as well. While monitoring occurs throughout the game as evidenced by the importance of a playmaking guard, the planning typically occurs during timeouts, breaks in action such as free throws or out-of-bounds, or through discussions between teammates during play.

Since expert players realize the importance of monitoring changes in game states and actions, they are more apt to develop strategies to monitor changes and plan future responses in advance. Moreover, the development of such sport specific strategies faciliates the internal representation of events and reduces the dependence on external memory aides.

The expert player, in addition, has the ability to predict game related actions based upon a small set of environmental cues. The expert uses specific cues in three major areas. First, the expert selects relevant cues from the situation and attach probabilities to possible game actions. For example, a right handed basketball player is more likely to dribble to the right. These types of anticipations can be developed from setting information about the players, the team, etc., or developed during the course of the game by observing and remembering the actions that are likely to be repeated.

Experts are also better able to predict the consequences of certain actions. For example, experts have been shown to exhibit superior performance in predicting the flight of a tennis ball (Jones & Miles, 1978) and a hockey puck (Bard & Fluery, 1981). Furthermore, Bard and Fleury (1981) found that experts tended to make predictions based on stick cues whereas novices tended to make decisions after the puck was already in flight.

A third way environmental cues may be used to facilitate performance is in determining appropriate responses in highly structured offensive and defensive strategies. Offensive and defensive plays are designed with specific concepts which increase the chances of scoring or prevent the other team from scoring. Examples of such concepts in offense include creating mismatches, isolating a player one-on-one, overloading a zone. Often these concepts transfer across sports, for example, the offensive concepts above are common to basketball and football. Thus, the offensive and defensive formations in sport are abstract and are likely to be represented in problem solving situations during the game as abstract concepts rather than details of who moves where. In addition, there are certain sequences of actions within any offensive play which are more crucial than others. Because some actions within the concept are more salient than others, the expert player focuses attention to the cues within these sequences. For example, most basketball offenses for zone defenses have an option within the play which is designed to move the ball faster than the defense can readjust to cover all offensive players. Thus, one particular player at a particular spot on the floor is left unguarded for the shot. During the sequence of the play a number of passes must be made between offensive players. However, each player must attend to only a very small number of cues to decide whether to pass the ball to a teammate. Generally, the cue is the position of the defensive player in the area of the teammate. There is evidence to suggest that expert and novice basketball players attend to different visual cues while solving basketball problems (Bard & Fleury, 1976). Experts tended to concentrate visual fixations on a pair of offensive and defensive players whereas novices tended to neglect the defensive player (Bard & Fleury, 1976).

Conclusions.

Although the have been several studies which have examined the effect of the knowledge base with adults, the number which have examined the phenomena with children have been extremely small. Furthermore, there have been even fewer studies which have examined the relationship between the knowledge base and motor performance. Thus, we know very little concerning the effects of the knowledge base upon performance in sports. Further research is needed to establish how a person becomes an expert in a given sport. It is important to understand the processes with which one aquires the knowledge and skills necessary to succeed in sport situations since children value the opportunity to participate in sport and enter into sport at very young ages. If we are to provide an atmosphere in which every child can ultimately attain some degree of competence, we must further understand the process by which one achieves competence. While the expert-novice paradigm offers one means to this end, more research must be done both within age levels and across age levels before we achieve an accurate picture of the development of competencies in verbal and motor skills.

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Appendix B

The Knowledge Test

Knowledge Test

The knowledge test was administered to 36 students at Goodpine Middle School in Jena, Louisiana. The students ranged from age 9 to age 12. Sixteen students were players on the Goodpine Middle School Basketball Team. Twenty students who did not participate in an organized basketball program were randomly selected from regular physical education classes.

The students were administered the 50 item multiple choice test in a regular classroom. All questions were read aloud to the subjects to minimize the effects of reading level, however, each subject also had a copy of the test.

A KR-20 was performed on the scores of the knowledge test. The results of the KR-20 analysis revealed the test to be internally consistent. The KR-20 was .86.

The mean correct responses on the test was 26.6 (out of 50) with a standard deviation of 8.2. The index of difficulty values and index of discrimination values are presented in in Table 14.

A t-test was conducted between the percentage of correct responses for basketball players and nonplayers. The value for $t(34)$ was 4.71, $p < .01$. The mean for players was 64.6% correct with a standard deviation of 12.0. The mean for nonplayers was 44.1% correct with a standard deviation of 13.7. The percent variance accounted for by the difference between groups was 38.8%.

The values for internal consistency indicates that the test is a reliable measure of basketball knowledge. The large difference between players and nonplayers provides some evidence of concurrent validity of the test.

Table 14. Index of difficulty and index of discrimination for the knowledge test.

Item	Difficulty	Discrimin.	Item	Difficulty	Discrimin.
1.	.5555	.5757	25.	.6944	.6666
2.	.8611	.4166	26.	.3888	.3939
3.	.9166	.25	27.	.4444	.2121
4.	.6111	.2272	28.	.7222	.3181
5.	.8055	.5833	29.	.4444	.7348
6.	.3055	.3712	30.	.3888	.6515
7.	.5277	.2196	31.	.5555	.1363
8.	.3333	.2803	32.	.5555	-.1363
9.	.5277	.5681	33.	.5555	.2196
10.	.6944	.4015	34.	.7222	.4166
11.	.4722	.5606	35.	.5833	.75
12.	.4444	.6515	36.	.3888	.3863
13.	.6944	.5833	37.	.2222	-.0681
14.	.5277	.3030	38.	.3611	.3863
15.	.4722	.5757	39.	.3055	-.0530
16.	.6111	.3181	40.	.4166	.2954
17.	.6666	.3106	41.	.6944	.3257
18.	.1388	.00	42.	.6666	.75
19.	.4444	.4772	43.	.6111	.75
20.	.4444	.2196	44.	.4166	.3939
21.	.7777	.5833	45.	.2777	.4621
22.	.5833	.3106	46.	.3611	.3863
23.	.3611	.4621	47.	.75	.2424
24.	.8055	.3333	48.	.6666	.1439
			49.	.1388	-.0757
			50.	.6944	.4924

Basketball Knowledge Test

1. When you catch the basketball, which of the the following things can you do?
a. pass the ball to a teammate
b. shoot the ball
c. dribble the ball
d. all of the above

2. When you dribble the basketball, where should you look?
a. at the coach
b. at the ball
c. at the defensive players and your teammates
d. none of the above

3. How many points does a field goal count?
a. three points
b. one point
c. two points
d. none of the above

4. The main goal in basketball is;
a. to score more points than the other team
b. to score as many points as possible
c. to make most of your shots
d. none of the above

5. How many points does a free throw count?
a. three points
b. two points
c. one point
d. none of the above

6. When you are guarding a player who has the ball, where should you look?
a. at the ball
b. at the player's shoulders
c. at the player's waist
d. none of the above

7. Walking or traveling with the ball is;
a. taking one or more steps with the ball without dribbling
b. moving or switching your pivot foot
c. both a and b
d. none of the above

8. Double dribble is;
a. dribbling the ball with both hands
b. dribbling the ball, picking it up, then dribbling again before passing to a teammate
c. both a and b
d. none of the above

9. A player can <u>not</u> continue playing in the ball game after he has;
a. 4 fouls
b. 3 fouls
c. 6 fouls
d. 5 fouls

10. A man-to-man defense is a type of defense in which;
a. players guard areas of the court rather than one player
b. players guard one player on the other team
c. players guard two players on the other team
d. none of the above

11. The referee hands you the ball out-of-bounds. You can
a. dribble the ball in bounds
b. move 3 feet right or left as long as you stay out-of-bounds
c. <u>not</u> move your feet once the referee hands you the ball
d. none of the above

12. A good dribbler should learn to
a. see the whole basketball court while dribbling
b. protect the ball when closely guarded
c. dribble the ball with either hand
d. all of the above

13. When you pass the ball to a teammate who is closely guarded, you should
a. pass the ball directly to him
b. pass the ball to him on the side away from the defensive player
c. pass the ball near his feet
d. none of the above

14. When you are guarding a player dribbling the ball, you should
a. try to force the player to dribble with his weak hand
b. try to turn the player or make him change directions
c. both a and b
d. none of the above

15. When you are dribbling the ball, you can <u>not</u>;
a. palm the ball
b. carry the ball
c. kick the ball
d. all of the above

16. A player is fouled while he is shooting the ball. He did <u>not</u> make the shot. The player fouled gets
a. 1 free throw
b. 2 free throws
c. 3 free throws
d. no free throws

17. The best way to get more rebounds is to
a. block out or get between the player you are guarding and the goal
b. get directly under the basket
c. wait for the ball to come to you
d. none of the above

18. When the other team gets the ball out-of-bounds underneath its own basket, you and your teammates should;
a. guard your man loosely
b. guard the middle of the lane to prevent an easy layup
c. double team the man taking the ball out-of-bounds
d. none of the above

19. A player is fouled while he is shooting the ball. He makes the shot. How many free throws does he get to shoot?
a. 1 free throw
b. 2 free throws
c. 3 free throws
d. no free throws

20. When you take the ball out-of-bounds, how many seconds do you have to get the ball in bounds?
a. 10 seconds
b. 5 seconds
c. 3 seconds
d. 15 seconds

21. A player dribbles past half court. The player then passed the ball back across half court to a teammate. What would the referee call?
a. double dribble
b. walking
c. a foul
d. back court

22. How much time does a team have to get the ball past the center court line?
a. 3 seconds
b. 10 seconds
c. 5 seconds
d. 15 seconds

23. A player dribbling the ball should
a. protect the ball with the opposite arm and leg
b. protect the ball with your leg
c. protect the ball with your arm
d. none of the above

24. When a defensive player is guarding you with his hands above his head and shoulders, what kind of pass is best to use to pass to a teammate?
a. chest pass
b. baseball pass
c. bounce pass
d. none of the above

25. When closely guarded by a defensive player, you should
a. lower your dribble and your body
b. stand straight up
c. try to dribble as fast as you can
d. none of the above

26. A jump ball occurs when
a. two players on opposite teams tie the ball
b. two players on opposite teams hit the ball out-of-bounds at the same time
c. the referee does not know who hit the ball out-of-bounds
d. all of the above

27. What happens when a player misses the first shot on a one-and-one?
a. the player gets another shot
b. a jump ball is taken at center court
c. the ball is in play and players can rebound the ball
d. the other team gets the ball out-of-bounds

28. A teammate has stopped dribbling the ball and is guarded closely. You should
a. break for the basket
b. set a screen for your teammate
c. move toward the teammate with the ball so he can pass to you easier
d. none of the above

29. On defense, a team should
a. get as many rebounds as they can
b. make the other team turnover the ball
c. make the other team take bad shots
d. all of the above

30. A team can prevent a fast break by
a. hustling down court
b. preventing a pass to a man down court
c. both a and b
d. none of the above

31. A team can move the ball.down court faster by
a. dribbling the ball quickly
b. passing the ball quickly
c. running down court
d. none of the above

32. The best way to break a full court zone press is to
a. dribble the ball down court
b. dribble the ball to the side line then pass the ball
c. pass the ball down the court quickly
d. none of the above

33. A screen or pick occurs
a. when an offensive player runs along the baseline
b. when a defensive player runs in front of the goal
c. when an offensive player stands stationary and blocks the defensive player guarding a teammate
d. none of the above

34. When the player you are guarding has stopped dribbling, you should
a. back up toward the basket
b. slap at the ball
c. guard the player closer and keep your hands up
d. help a teammate guard their man

35. A charging foul occurs when
a. an offensive player with the ball runs over a defensive player
b. a defensive player slaps the wrist of a player shooting the ball
c. an offensive player trips a teammate
d. none of the above

36. You are shooting a free throw. Which team lines up in the 2 spaces closest to the basket?
a. 2 players on your team
b. 2 players on the other team
c. 1 player from each team
d. none of the above

37. When a player sets a screen or pick, he should
a. roll to the basket with the front part of his body facing the teammate with the ball
b. roll to the basket with his back to the teammate with the ball
c. make sure he sticks his knee out so he blocks the defensive player
d. none of the above

38. An offensive player with the ball on a 2 on 1 fast break should
a. pass the ball to his teammate
b. shoot the ball himself
c. make the defensive man guard either his teammate or himself then decide to pass the ball off to his teammate or shoot
d. none of the above

39. On defense, if you are screened by an offensive player, you should
a. go in front of the player screening you
b. switch offensive players with a teammate
c. run toward the goal to rebound
d. either a or b are correct

40. The player you are guarding has the ball and has not dribbled yet. You should
a. stand further away from the player in case he should try to drive around you
b. stand as close to the player as you can
c. watch the players head and eyes
d. none of the above

41. When you are receiving a pass from a teammate, you should
a. wait for the ball to come to you
b. meet the ball or move toward the ball when it is passed to you
c. always jump in the air to catch it
d. none of the above

42. At the end of the game, the score is tied. Which of the following happens?
a. the teams flip a coin to decide the winner
b. the teams shoot a free throw to decide the winner
c. an overtime period is played
d. play continues and the first team to score a basket wins the game

43. When you are passing the ball to a teammate who is running down the court, you should
a. pass the ball directly to him
b. pass the ball slightly in front of the player or lead the player
c. pass the ball as high as you can
d. none of the above

44. Ten seconds are left in the game. Your team has the ball out-of-bounds. When does the clock start?
a. when the referee gives you the ball
b. when a player in bounds touches the ball
c. when the ball passes over the out-of-bounds line
d. none of the above

45. When you are playing defense, you should
a. try <u>not</u> to cross your feet
b. try to stay low in defensive position
c. try to keep your hands up
d. all of the above

46. On offense a team should
a. try to take as many shots as they can
b. try to shoot as close to the basket as they can
c. try to get as many offensive rebounds as they can
d. all of the above

47. A good offensive move is to
a. stand still with the ball
b. dribble towards a defensive player
c. fake one way and drive the other way
d. bring the ball down to waist level after a rebound

48. When you are shooting a layup on the right side of the basket, you should
a. aim for the box on the backboard
b. aim for the rim of the basket
c. both a and b
d. none of the above

49. When you are shooting a free throw, you should aim for
a. the front rim of the basket
b. the backboard
c. both a and b
d. none of the above

5Ø. How many seconds can an offensive player stay in the lane?
a. 3 seconds
b. 5 seconds
c. as many as you want
d. none of the above

Appendix C

The Control Dribble Test and the Speed Spot Shooting Test

Skill Tests for Dribbling and Shooting

The skill tests used in the study were the control dribble test and the speed spot shooting test of the AAHPERD Basketball Skill Test Manual. Both tests have been shown to be valid and reliable from grade 5 through college age level when administered using a standard basketball and standard basketball goal (Hopkins, Shick, & Plack, 1984).

Control dribble test.

The procedures outlined in the AAHPERD Basketball Skill Test Manual (Hopkins, Shick, & Plack, 1984) were used to administer the control dribble test. A smaller size basketball (Biddy size or intermediate size basketball) was used during testing rather than a regulation size basketball.

An obstacle course marked by six cones was set up with the same dimensions as the free throw lane of a regulation basketball court (12 feet by 19 feet rectagular). Four cones were positioned in the four corners of the rectangle. One cone was positioned in the center of the rectangle. Another cone was used to mark the start and was placed directly in line with the center cone. The subject's task was to dribble in a specified pattern between the cones as fast as possible. In order to facillitate memory of the correct pattern during testing, the pattern was taped on the floor. Subjects could then follow the tape to remember the correct pattern. Three trials were given. The first trial was considered practice. The last two trials were recorded and the subject's final score was the sum of the last two trials.

The experimenter walked through the pattern to ensure all subject's understood the pattern which they would dribble. Subjects were instructed to dribble through the pattern of cones as fast as they possibly could. The subject was permitted to use either hand during the testing. The experimenter gave a verbal "ready" signal, followed by "go". Time to complete the dribbling course was measured by a standard stop watch. If a subject lost control of the ball during the trial, the trial was repeated. Double dribble and walking during a trial was recorded by the experimenter. No time penalty was assessed for double dribble or walking.

Code Sheet for the Control Dribble Test

Name ______________ Team ______________

pre ______ ______ ______

______ ______ ______ Total ______

dd 1 2 3 4 5 6 7 8 9 10
walk 1 2 3 4 5 6 7 8 9 10

post ______ ______ ______

______ ______ ______ Total ______

dd 1 2 3 4 5 6 7 8 9 10
walk 1 2 3 4 5 6 7 8 9 10

reliability ______ ______ ______

______ ______ ______ Total ______

dd 1 2 3 4 5 6 7 8 9 10
walk 1 2 3 4 5 6 7 8 9 10

Speed Spot Shooting Test.

The procedures outlined in the AAHPERD Basketball Skill Test Manual (Hpokins, Shick, & Plack, 1984) were used with certain modifications. The equipment was a Biddy size basketball, a standard goal lowered to 8 feet 6 inches in height, a stop watch, and tape for floor markings. The five tape markers were placed 9 feet from the center of the basket. Two tape markers were placed on opposite sides of the basket along the baseline. Two tape markers were placed on opposite sides of the basket at 45 degree angles to the basket. One tape marker was placed directly facing the center of the basket or backboard.

The subject was given 3 trials of 60 seconds each. The first trial was considered practice. The last two trials were recorded. The subject's task was to make as many baskets from behind the tape markings as possible within 60 seconds. The subject was instructed to shoot at least one time from each tape marking during each trial or the trial would be repeated. The subject was also informed they could receive credit for a maximum of four layup shots during a trial. Subject's were instructed to shoot, rebound the ball as quickly as possibly, dribble to the next spot, and shoot again.

Two points were awarded for each successful shot, including layups. One point was awarded for an unsuccessful shot which hits the front of the rim or hits the rim after rebounding from the backboard. The total points for each shot were added for each trial. The final score is the total of the last two trials.

The speed shot test originally had a penalty for ball handling infractions such as double dribble or walking. Shots following a ball handling infraction were scored as zero. Young children generally have limited ball handling skills. If one wants to measure basketball shooting skill in young children, it appears unwise to confound the measurement of shooting skill with ball handling skill. For this reason, baskets made after ball handling infractions were scored as any other shot. Double dribble and walking were recorded on each trial, but no penalty was assessed.

The AAHPERD basketball skill manual also specifies that two layup shots could not be taken in succession. Young children have trouble remembering how many layup shots they have taken. Thus, subjects were allowed to take layup shots in succession. The experimenter reminded subjects when they had forgotten to shoot from a particular spot. The experimenter also reminded subjects to shoot their quota of layups and how many layup shots they had attempted. These procedures were necessary to ensure that subjects at all age levels were not operating at a disadvantage due to poor use of memory monitoring skills.

Code Sheet for the Speed Shot Test

Name______________________ Team_________________________

Shooting test - key Ø missed shot, 1 hit the rim, 2 basket made

A___________________________

B___________________________

C___________________________

D___________________________

E___________________________

LAYUP_______________________

1 2 3 4

dd 1 2 3 4 5 6 7 8 9 1Ø

walk 1 2 3 4 5 6 7 8 9 1Ø Total

A___________________________

B___________________________

C___________________________

D___________________________

E___________________________

LAYUP_______________________

1 2 3 4

dd 1 2 3 4 5 6 7 8 9 1Ø

walk 1 2 3 4 5 6 7 8 9 1Ø Total

A___________________________

B___________________________

C___________________________

D___________________________

E___________________________

LAYUP_______________________

1 2 3 4

dd 1 2 3 4 5 6 7 8 9 1Ø

walk 1 2 3 4 5 6 7 8 9 1Ø Total

Reliability of the Skill Tests

Since the reliability of control dribble test and the speed shot test has not been established using the smaller basketball, a lower goal, and the modified procedures used in this study, reliability estimates were calculated for the tests.

Twenty fourth-grade students and 20 sixth-grade students at Goodpine Middle School in Jena, Louisiana, served as subjects. Four students of each grade level were randomly selected from five different physical education classes. The subjects were administered both the control dribble test and the speed shot test during their physical education class. Both tests were administered to the subjects a second time the following day.

The scores of each test were analyzed separately for each grade level in a 20 x 2 (subjects x day of testing) ANOVA. Intraclass correlation coefficients were calculated for each test for each grade level. The ANOVA table and calculation of reliability estimates is presented for each test by grade level in Table 15 and 16.

Table 15. ANOVA table for the control dribble and the speed shot test for grade 4.

Grade 4

Dribble

Source	df	SS	MS	F
Subjects	19	363.247	19.12	12.27**
Day of testing	1	1.17	1.17	.76ns
Error	19	29.60	1.558	
Total	39	394.01		

$$R = \frac{MSsubjects - MSwithin}{MSsubjects} \quad \text{where } MSwithin = \frac{SSday + SSerror}{dfday + dferror}$$

$$MSwithin = \frac{29.60 + 1.17}{19 + 1} = \frac{30.77}{20} = 1.5385$$

$$R = \frac{19.12 - 1.5385}{19.12} = \frac{17.58}{19.12} = .919$$

Shooting

Source	df	SS	MS	F
Subject	19	2648.475	139.39	32.35**
Day	1	30.625	30.625	7.11*
Error	19	81.875	4.30	
Total	39	2760.975		

$$MSwithin = \frac{30.625 + 81.875}{1 + 19} = \frac{112.5}{20} = 5.625$$

$$R = \frac{139.39 - 5.625}{139.39} = \frac{133.765}{139.39} = .95$$

** $p > .01$ * $p > .05$

Table 16. ANOVA table for the control dribble and the speed shot for grade 6.

Grade 6
Dribble

Source	df	SS	MS	F
Subjects	19	127.26	6.6979	8.40**
Day	1	.756	.756	.95 ns
Error	19	15.1436	.7970	
Total	39	143.1596		

$$R = \frac{MSsubjects - MSwithin}{MSsubjects} \qquad \text{where } MSwithin = \frac{SSday + SSerror}{dfday + dferror}$$

$$MSwithin = \frac{.756 + 15.1436}{1 + 19} = \frac{15.8996}{20} = .795$$

$$R = \frac{6.698 - .795}{6.698} = \frac{5.90}{6.698} = .88$$

Shooting

Source	df	SS	MS	F
Subjects	19	1860.6	95.82	12.60 **
Day	1	22.5	22.5	2.96 n.s.
Error	19	144.5	7.605	
Total	39	1987.6		

$$MSwithin = \frac{22.5 + 144.5}{1 + 19} = \frac{167}{20} = 8.35$$

$$R = \frac{95.82 - 8.35}{95.82} = \frac{87.47}{95.82} = .91$$

**p < .01

Appendix D

Coding of Game Performance

Coding of Game Performance

An observational instrument was designed to measure the performance of each subject during actual game play. The instrument was designed to measure three major areas of performance, control of the basketball, decision making ability, and execution of skills. Although these categories were the primary measures of interest, turnovers and rebounds were also recorded.

Control, Decision, Execution

Basketball players must make many decisions during the course of an actual game. Often the quality of these decisions is as important as the skill with which a decision is carried out. This portion of the coding instrument was designed to estimate the percentage of time a player controlled the basketball, made an appropriate decision concerning play, and executed the decision successfully.

The observations coded were limited to offensive decisions, specifically possession of the ball. When a player gains possession of the ball, a decision must be made concerning a given action, either hold the ball, dribble the ball, pass the ball, or shoot the ball. Once a decision is made, the player must execute the action appropriately. Thus, three types of action were coded regarding offensive play. First, did the player gain and maintain control of the basketball. Second, did the player make the appropriate decision within the context of the given situation. Third, did the player execute the decision successfully.

Decision rules for coding control, decision, and execution

Control. The category, control of the basketball, was coded as one for a successful catch of the basketball and zero for an unsuccessful catch. Actions such as dropping the ball while attempting to catch it or fumbling with the ball were judged as unsuccessful catches and coded as zero.

Decision. A decision was operationally defined as the selection of an offensive action when a player is in possession of the ball. The possible responses which a player may choose to execute are either hold the ball, dribble the ball, pass the ball, or shoot the ball. The coding rules are discussed below.

Shooting.

Coded as one -

1. any shot taken within a 15 foot radius of the basket when the player has an open shot

Coded as zero -

1. a shot taken outside a 15 foot radius of the goal

2. a shot taken off balance without control being due to physical contact with a defensive player

3. a shot taken when the defensive player has a distinct advantage such as height (blocked shot) or position (charging)

4. not attempting a shot when the player is open and within a 15 foot radius of the goal

Passing

Coded as one -

1. any pass made to a teammate who is open, the defensive player guarding the teammate is not in the passing lane between the two players

Coded as zero -

1. a pass made to a player who is guarded closely by a defender, the defensive player is positioned in the passing lane

2. a pass made to an area of the court where no teammate is positioned

Dribbling

Coded as one -

1. a successful drive around a defensive player, the offensive player must have positioned his head and shoulders past the defender (avoiding charging) to be judged as successful

2. advancing the ball upcourt when not closely guarded

3. direction of dribble - a change of direction to dribble away from defenders or to an open area of the court

Coded as zero -

1. Double dribble in the case where the player stops his dribble, picks the ball up, and dribbles again before passing the ball to a teammate

2. trying to drive around a defender who has position (charging), the offensive player does not have the head and shoulders past the defensive player

3. dribbling into a double team and allowing the defensive players to trap

4. dribbling the ball out-of-bounds

5. dribbling the ball away from the goal, dribbling for the sake of dribbling rather than advancing the ball or attacking the defense

Holding the ball

Coded as one -

1. a player holding the ball for more than 5 seconds was coded as one only when the offensive team is attempting to stall the game or take the final shot at the end of the quarter

Coded as zero -

1. when a player holds the ball longer than 5 seconds when closely guarded

2. when a player holds the ball when dribbling or passing the ball would be a more appropriate decision. Often young players hold the ball because they don't know what to do. As a result, often a defensive player will tie the ball in these instances.

Execution

Shooting

Coded as one -

1. a successful field goal

Coded as zero -

1. a missed field goal

2. a blocked shot

Passing

Coded as one -

1. a successful pass to a teammate

Coded as zero -

1. a bad pass - too high, out-of-bounds, at the teammates feet, behind the teammate

Dribbling

Coded as one -

1. a successful drive

2. successfully advancing the ball up court

Coded as zero -

1. loss of control of the ball

2. double dribble (using both hands to dribble)

3. having the ball stolen while dribbling

<u>Turnovers</u>

The following turnovers were recorded; double dribble, walking, 3 seconds in the lane, holding the ball 5 seconds, 10 seconds to advance the ball past half court, back court, and a bad pass. The total number of turnovers was used as a dependent measure.

<u>Rebounds</u>

The total number of rebounds were recorded.

<u>Code sheets</u>

The performance of each subject was coded using the previously listed procedural guidelines. The behaviors of each individual were recorded on a code sheet for every game. A sample code sheet is presented on the following page.

Code Sheet for Films

Name________________ Game________________

Team________________ Position________________

Playing time ________

Passing, shooting, or dribbling

control
decision
execution

control
decision
execution

control
decision
execution

control
decision
execution

Turnovers - recorded as the total number
double dribble
bad pass
walking
3 seconds
back court
ten seconds

free throws
rebounds

Reliability of the Coding Instrument

The objectivity of the coding instrument was established by obtaining 90% agreement of two independent coders for each category of the coding instrument. Both coders had extensive experience playing and coaching basketball.

An estimate of the internal consistency of the investigator coding performance using the observation instrument was obtained by coding the performance of 10 players in the 8-10 year old league during one quarter of playing time in two games on two different occasions. Both the number of opportunities to respond and the number of successful actions were important variables. The coder must be consistent in identifying the same number of behaviors and in judging the quality of these behaviors. Therefore, the consistency of each variable was established for control, decisions, and execution. These estimates of reliability for each category of the observation instrument were determined by a 10 X 2 (subject X time of coding) analysis of variance and calculation of intraclass correlation. The calculation of reliability estimates and the ANOVA tables are presented on subsequent pages of this appendix.

Table 17. ANOVA tables and calculation of reliability estimates for the control category of the observational instrument.

Number of successful responses coded

Source	df	SS	MS	F
Between subjects	9	1544.80	171.64	151.45**
Time of coding	1	1.80	1.80	1.59ns
Error	9	10.20	1.13	
Total	19	1556.80		

MSwithin = 1.13

$$R = \frac{171.64 - 1.13}{171.64} = \frac{170.51}{171.64} = .99$$

Number of opportunities to respond

Source	df	SS	MS	F
Between subjects	9	1549.80	172.20	151.94**
Time of coding	1	1.80	1.80	1.59ns
Error	9	10.20	1.13	
Total	19	1561.80		

MSwithin = 1.13

$$R = \frac{172.2 - 1.13}{172.2} = \frac{171.07}{172.20} = .99$$

**$p < .01$

Table 18. ANOVA tables and calculation of the reliability estimates for the decision category of the observational coding instrument.

Number of succesful responses

Source	df	SS	MS	F
Between subjects	9	4718.45	524.27	245.11**
Time of coding	1	1.25	1.25	.58ns
Error	9	19.25	2.13	
Total	19	4738.95		

MSwithin = 2.13

$$R = \frac{524.27 - 2.13}{524.27} = \frac{522.14}{524.27} = .99$$

Number of opportunities to respond

Source	df	SS	MS	F
Between subjects	9	4912.80	545.87	372.18**
Time of coding	1	1.80	1.80	1.23ns
Error	9	13.20	1.47	
Total	19	4927.80		

MSwithin = 1.47

$$R = \frac{545.87 - 1.47}{545.87} = \frac{544.40}{545.87} = .99$$

**$p < .01$

Table 19. ANOVA tables and calculation of reliability estimates for the execution category of the observational coding instrument.

Number of successful responses

Source	df	SS	MS	F
Between subjects	9	3507.05	389.67	205.69**
Time of coding	1	.45	.45	.24ns
Error	9	17.05	1.89	
Total	19	3524.55		

MSwithin = 1.89

$$R = \frac{389.67 - 1.89}{389.67} = \frac{387.78}{389.67} = .99$$

Number of opportunities to respond

Source	df	SS	MS	F
Between subjects	9	4835.05	537.23	178.74**
Time of coding	1	.45	.45	.15ns
Error	9	27.05	3.00	
Total	19	4862.55		

MSwithin = 3.00

$$R = \frac{537.23 - 3.00}{537.23} = \frac{534.23}{537.23} = .99$$

** $p < .01$

Table 20. ANOVA table and calculation of reliability estimates for the total number of successful responses and total number of opportunities to respond on the observational instrument.

Total number of successful responses

Source	df	SS	MS	F
Between subjects	9	27378.20	3042.02	220.44**
Time of coding	1	9.80	9.80	0.71
Error	9	124.20	13.80	
Total	19	27512.20		

MSwithin= 13.8

$$R = \frac{3042.02 - 13.8}{3042.02} = \frac{3028.22}{3042.02} = .99$$

Total number of opportunities to respond

Source	df	SS	MS	F
Between subjects	9	31670.05	3518.89	241.30**
Time of coding	1	11.25	11.25	0.77
Error	9	131.25	14.58	
Total	19	31812.55		

MSwithin=14.58

$$R = \frac{3518.89 - 14.58}{3518.89} = \frac{3504.31}{3518.89} = .99$$

**$p < .01$

Appendix E

Questionnaires

Questionnaires

Two questionnaires, one for the child and one for the parents, were designed to assess the child experience in basketball and the social influences which might influence the child's skill acquisition in basketball. In addition, a questionnaire was also designed to measure each coaches background in basketball, experience in coaching children, and the instruction they provided to their team. A sample of each of these questionnaires is presented on subsequent pages.

Child Questionnaire

Name____________________________ Age____________________

School you attend ___________________________ Grade _______

1. How many years have you been playing organized basketball, not including this year? __________

2. Circle the position you usually play:

   guard forward center

3. If you play another position sometimes, which is it?

   guard forward center

4. Besides regular team practice and games in the Biddy Basketball program, how many hours do you play or practice basketball each week?

one two three more than three

5. Do you play organized basketball in a school program?______ If yes, what school?______________________

6. Do you play any other organized sports? yes no

   If yes, what? ____

For the next two questions, circle the best answer.

1. Do any of the grownups in your family play or practice basketball with you?

   hardly ever sometimes every week 2-4 times per week every day

2. Do any of the other kids in your family play or practice basketball with you?

hardly ever sometimes every week 2-4 times per week every day

Are they a brother or sister? brother sister both brother and sister

The parental questionnaires were distributed to the parents by each coach at the beginning of the season. The return rate was low. The experimenter, therefore, attempted to talk to as many parents as possible at their child's basketball game. Although a few questionnaires were obtained, the return rate was still very low. Thus, a copy of the parental questionnaire was mailed to each parent along with a self-addressed envelop. After all attempts the return rate was only 57%.

The number of parental questionnaires obtained was 12 for the young novices, 10 for young experts, six for older experts, and four for older novices. Since the return rate was low and the representation for experts and novices in each age level was poor, these results should be viewed with caution. In addition, few responses were obtained for the older children. Therefore, the results will be reported by expert and novice groupings collapsed across age levels.

The mean scores for Likert scaled questions concerning how often the child practiced with their father, mother, or other children are presented in Table 21. A larger score indicates more practice. In addition, the percentage of fathers and mothers who had previously participated in an organized basketball program are also presented in Table 22.

The questionnaire also contained several other Likert scaled items. Parents were asked how often they watched basketball on television and discussed the game with their children. The scores indicated that parents discussed basketball programs often with their children. The mean was 3.6 for experts and 3.1 for novices. Parents were also asked how important is it that your child becomes a skilled basketball player. The results for experts and novices were similar. The mean was 2.6 for experts and 2.7 for novices.

Table 21. Means for experts and novices for the frequency of practice with fathers, mothers, and other children.

	Expert (n=14)		Novice (n=18)	
	M[a]	SD	M[a]	SD
Practice with father	2.2	1.5	2.4	1.4
Practice with mother	2.6	1.8	1.8	1.1
Practice with other children	2.9	1.9	1.8	1.5

[a] Likert scaled - a larger number indicates more often

Table 22. Percentage of fathers and mothers of experts and novices who have previously participated in an organized basketball program.

	Experts (n=14)		Novices (n=18)	
	Percentage	Number	Percentage	Number
Fathers	77.0	11	67.0	12
Mothers	50.0	7	16.7	3

Parent Questionnaire

Child's name ____________________

Date of birth ____________________

In the questions below, Mother and Father may refer to stepparents if they are part of the child's household, rather than the natural mother or father. If either parent does not reside within the household, please indicated which parent does reside within the household ____________.

1. How many years (in numbers) has your child played organized

basketball excluding this year? ____________

a. Are there other children in your family who play or have played organized basketball? If so, please list the sex and age of the child? The child's name is not necessary.

____

____

____

2. Do you practice basketball with your child? How much? Circle the

number that best describes your answer.

1 is hardly ever (less than once every 2 weeks); 2 is sometimes (less than once per week); 3 is about once per week; 4 is 2-4 times per week; 5 is nearly every day

Mother: 1 2 3 4 5

Father: 1 2 3 4 5

3. Do any other adults or older children practice basketball with him or her? If so, who (relationship) and how much? Circle the number that best describes how often.

person's relationship to child ____________________

1 2 3 4 5

person's relationship to child ____________________

1 2 3 4 5

4. How much experience do you have as a basketball player? (Circle all answers that apply.)

Mother: youth league high school team college team college intramurals adult recreation league (If you played adult rec, have you played since you passed age 25?_____ Are you playing this year? yes no)

Father: youth league high school team college team college intramurals adult recreation league (If you played adult rec, have you played since you passed age 25? _____ Are you playing this year? yes no)

5. Do you watch basketball on television or go to games with your child?

______

If yes, do you talk to your child about the game?

seldom 1 2 3 4 5 often

6. How important is it to you that your child be a skilled player?

very 1 2 3 4 5 not much

Which parent filled out this form?______________________

Thank you very much!! I really appreciate your time and effort!

Coaches Questionnaire

The purpose of the questionnaire for coaches was primarily to gain general information to develop the basketball situation interview. For example, the coaches were asked to diagram the offense they used for a 2-1-2 zone defense. Most coaches used a similar offensive play. The outline of these diagrams was used to design the basic offensive set used in Situation 5 of the basketball situation interview.

However, a summary of the biographical data obtained from these questionnaires is provided. Six of the nine coaches had obtained at least an undergraduate degree from a college or university. Of these six, four were physical education majors and one was an elementary education major. Thus, the majority of coaches had profession training in the instruction of children. All coaches had previous experience in coaching.

Generally, the coaches taught similar offensive and defensive strategies. However, the instruction of the older children was generally more technically advanced. All coaches taught an offense for a 2-1-2 zone defense. All coaches taught and primarily used a 2-1-2 defense. One of the coaches of the older league taught fundamental man-to-man defense, however, his team played a 2-1-2 zone the majority of the time.

All coaches used some type of out-of-bounds play. The majority of coaches taught an out-of-bounds play specifically designed to score. The majority of coaches also taught some type of full court pressure defense. Primarily, a zone press was used.

Although there may have been differences in the quality of instruction provided by each coach, coaches were not included in the experimental design of the study. The effects of coaching instruction of the older children was confounded. Generally, the older children had previously participated in the younger league. Therefore, the older children had been coached by one coach in the younger league and one coach in the older league. There was no way to determine whether the influence of coaching was due to the coach the player had this year or the coach the player had in the previous years he had participated. Thus, a statistical test would not be meaningful.

Coaches Questionnaire

Background information - playing and coaching experience

1. Did you play organized basketball? ______ Indicate the number of years you played by the level of competition listed below.

high school ____________
college ____________

2. How many years have you been coaching in the Biddy Basketball Program? ______ Have you coached at the junior high or high school level? ______
If so, what level and how many years have you coached?

____

Please list any other sports that you have coached, school sponsored or recreation.

____

3. Please indicate your highest level of education. If you have a college degree, please list your major.

high school degree__________________
college degree and major__________________________
master's degree ________________________________

In this section, I am trying to get an idea of the offensive and defensive strategies that the kids on your team have been taught. I am not trying to judge your knowledge or ability as a coach. I have been quite impressed with all the coaches and the job you have done with the kids. The following questions will help me design a questionnaire to find out what the kids know about basketball.
Check all the answers which are appropriate.

1. What defenses did your team use during the season?

man-to-man______
2-1-2 zone______
1-3-1 zone______
1-2-2 zone______
box and one ______
other_________________

2. Did you use a pressing defense?_________ If so, what type?
If you used a half court press, please write half court by the type of press, otherwise I will assume it is a full court defense.

1-2-1-1 or diamond zone press____________
man-to-man ___________________
2-2-1 zone press ______________________
other ________________________________

3. Did you use an offense to break a full court pressing defense? _______ Did you try to get one ball handler to dribble through the press?__________ Did you use an offense to pass the ball up court against the press?_____________.

4. Did you use any out-of-bounds plays?__________ If so, check what situations you used an out-of-bounds play?

underneath your team's own basket (to score) ____________
against a pressing defense to get the ball in bounds __________

5. If you played a man-to-man defense, how did you teach your team to defend a screen and roll?

a. the man being screened must fight over the top of the screen and avoid switching if possible _________________________
b. switch whenever you are screened _____________________
c. a combination of the two above (fight over the top, switch only when you have to) __________________________

6. Most of the teams used some type of half court offense. Would you please diagram the offensive play that your team used most frequently against a 2-1-2 zone defense? There are two sheets attached which have blank half court diagrams.

Please indicate movement of the players with a straight line, passes with a dotted line, and dribbling with a wavy line. It is not necessary to diagram all the possible options off the offense. I just need to get an idea of where the players move through the entire play and where the ball moves throughout the entire play.
I can figure out all the options if I know where the players go and the passing sequences. Thank you for your cooperation. You have all been most kind and I appreciate it greatly!

Appendix F

The Basketball Situation Interview

Basketball Interview

An open ended basketball interview was constructed to measure each player's ability to recall possible alternative actions in the context of game situations. Each subject was interviewed individually. Each interview was taped on cassette tape for subsequent coding of responses. The structure of the interview as well as the illustrations presented to each subject are presented in this appendix. The guidelines for coding the responses of each individual are also presented.

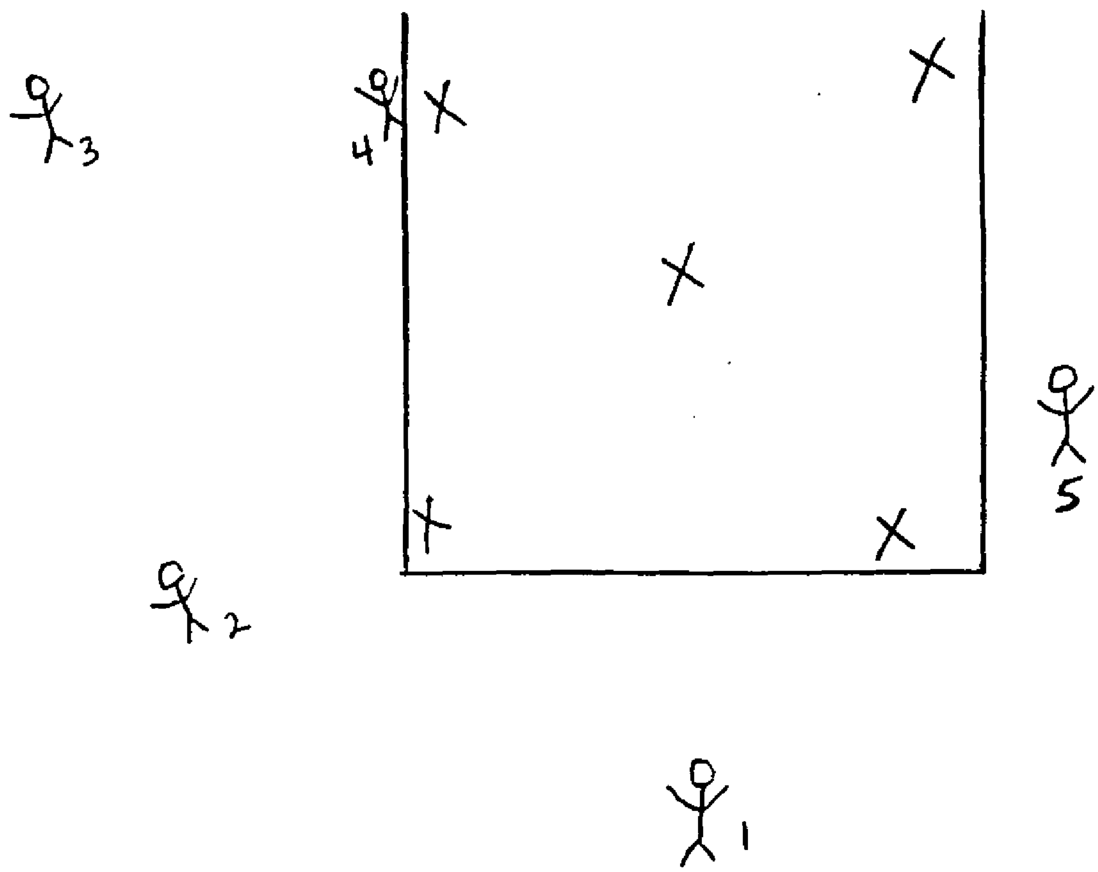
Basketball Situations

In the following basketball situations, imagine yourself actually playing in a basketball game. I will give you a picture of the players in an actual game situation. What I want you to do is tell me all the things that you or the other players on your team could do in that particular situation.

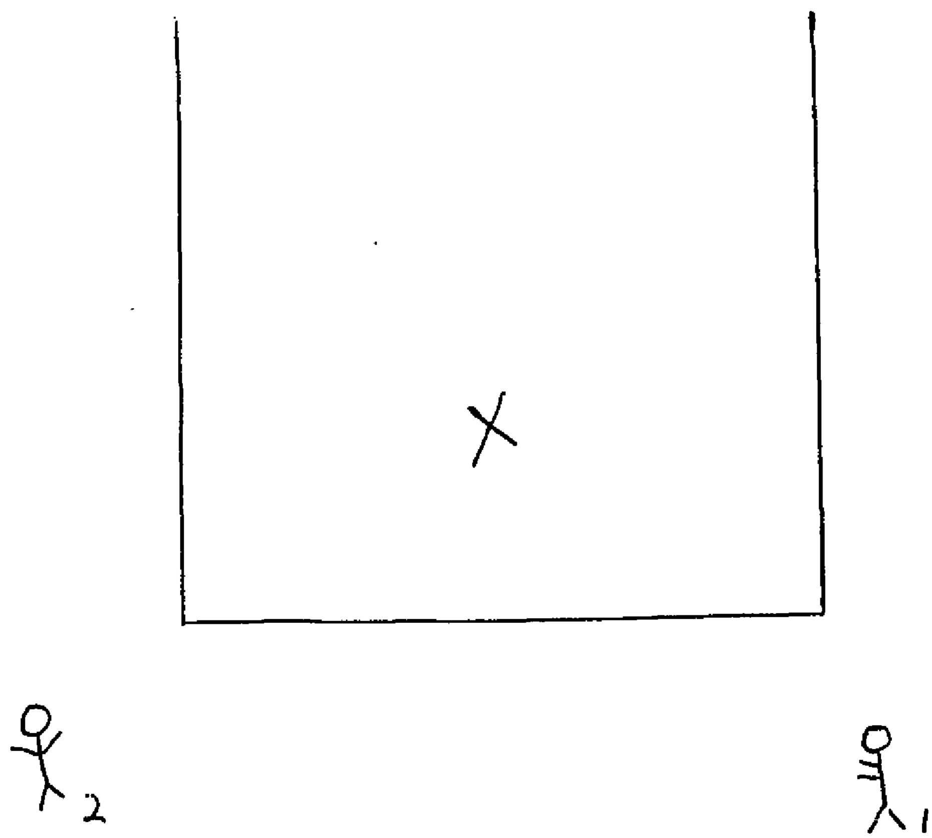
For example, you are playing a forward position in a 2-1-2 defense. If I ask where you would move in an actual game, there is more than one answer depending on the situation and where the ball is on the court. Here are two possible answers. There are other answers; these are only two.

1. If the ball is in the corner on your side (player#3), you would guard player#3, the man with the ball.
2. If player#2 has the ball and the player#4 is on your side of the court underneath the basket, you would stay in front of player#4 to protect against a pass to player#4 who could shoot a layup.

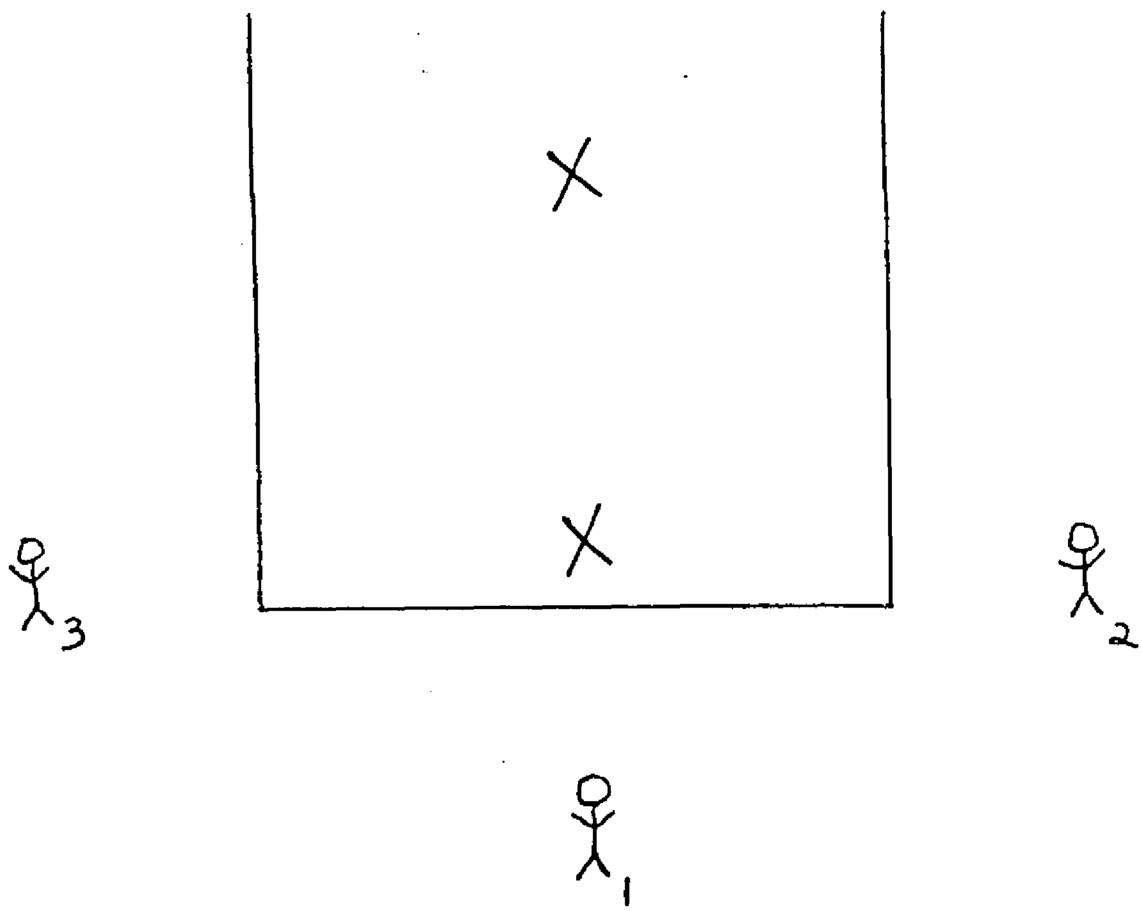
Can you give me some other possible answers. GOOD.



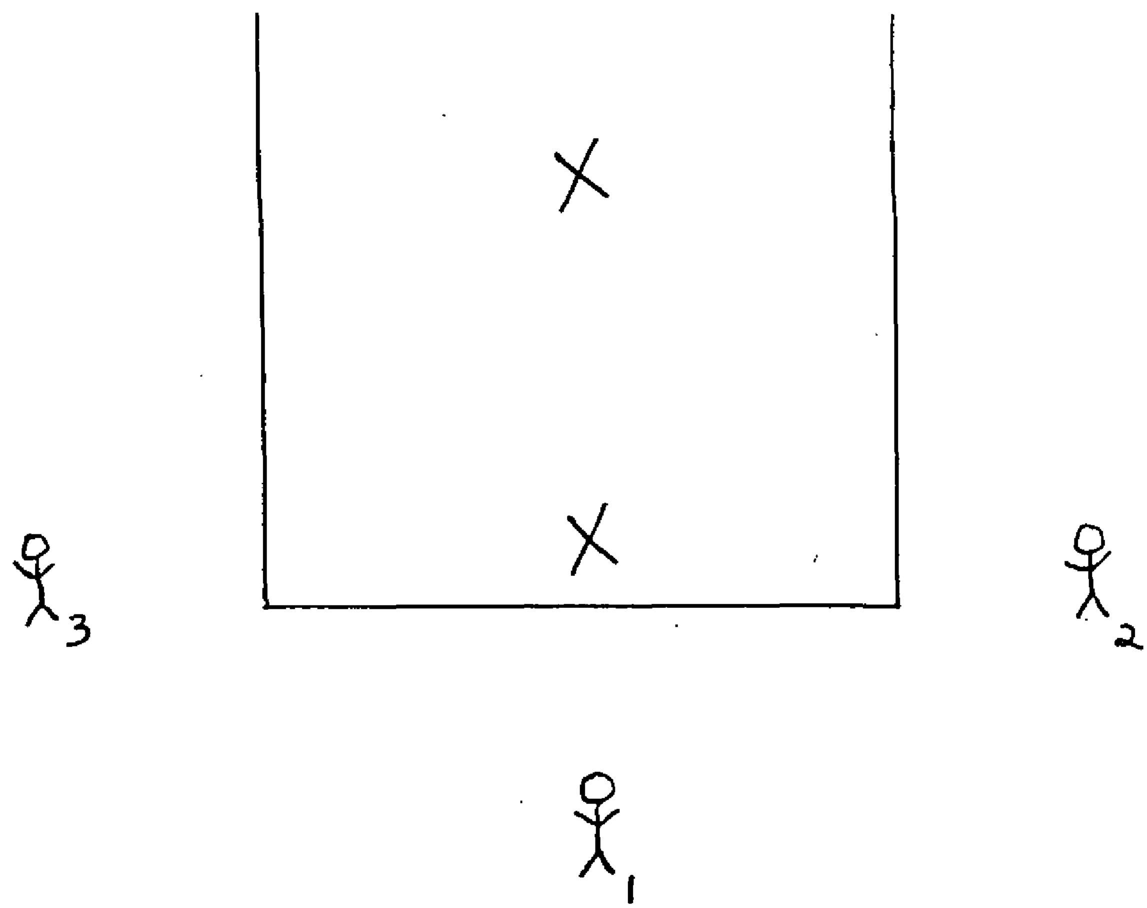
1. You have the basketball (player#1). You and a teammate are on a 2 on 1 fast break. There is one defensive player (the X). List all the things you and your teammate could do in order to score a layup.



2. You and 2 of your teammates are on a 3 on 2 fast break. You have the basketball and are dribbling down the middle of the court (player#1). There are two players (the Xs) on the other team guarding you and your teammates. List all the things you and your teammates could do in order to score a layup.

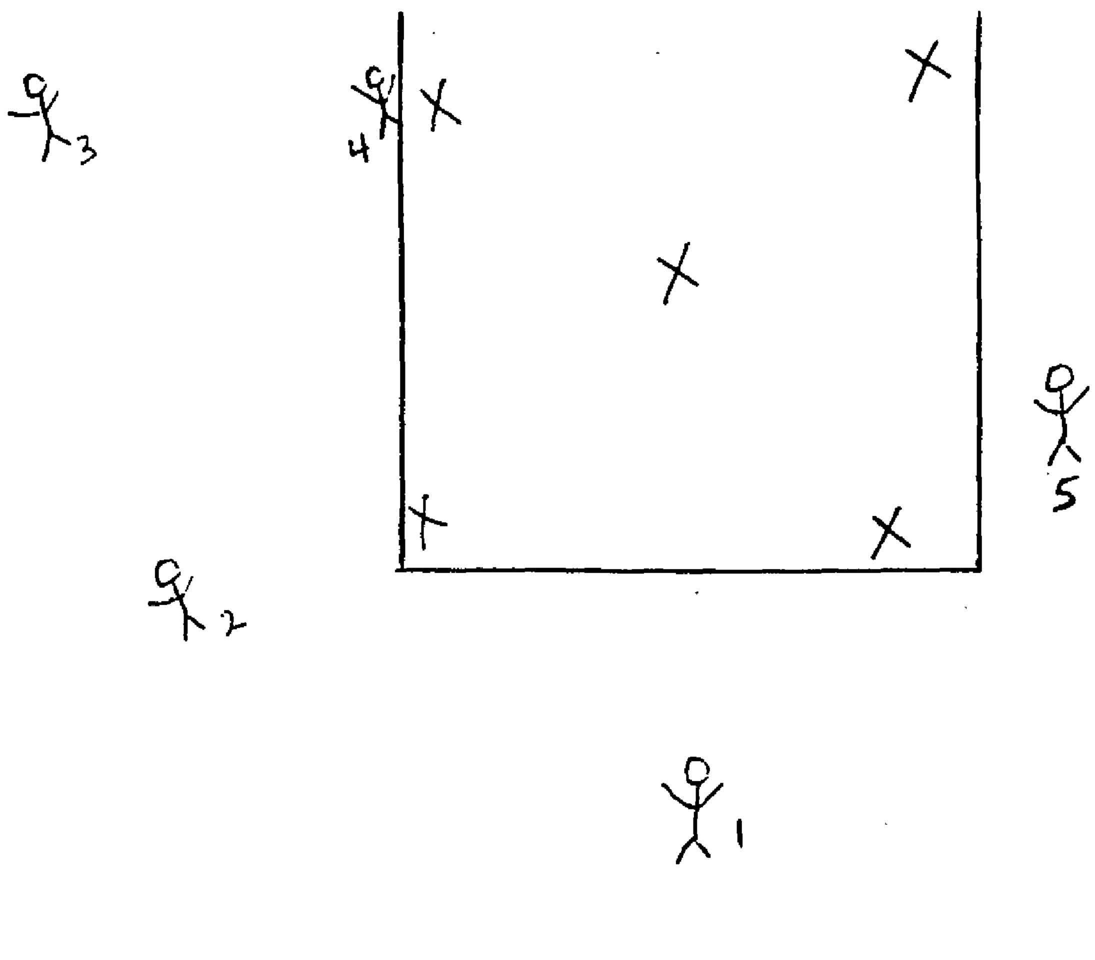


3. You and a teammate are on defense (the Xs). Three players on the other team are trying to fast break. Tell me what you and your teammate could do to try and prevent the other team from scoring a layup.



4. The score of the game is close. Your team has the ball out-of-bounds underneath its own basket. The other team is guarding you very tightly. List all the things you and your teammates can do to get the ball in bounds.

5. Your team has the ball on offense. The players on your team are in the positions given in the picture. List all the things you and your teammates can do to score a basket.



1. In #5 you told me several things you could do to score. Here is a picture of an offense similar to the one you used on your team.

a. if you are player#2 how would you know when to pass the ball to player #4

  1. when would you <u>not</u> pass the ball to player #4

b. if you are player#3 how would you know when to pass the ball to player#2

  1. when would you not pass to player#2

2. Your Biddy team had an offense for a 2-1-2 zone defense. How did you remember,

a. where you were suppose to go?
b. what to do? when to pass the ball?
c. can you tell me what you thought about when you were running down the court before you were going to play offense?

4. How much did your skills in passing, shooting, and dribbling improve over the basketball season? ____________

improved a lot
improved somewhat
improved very little
no improvement

5. How much did you learn about the rules of basketball, new offensive and defensive plays? ____________

learned a lot
learned somewhat
learned very little
learned nothing at all

6. How much did you learn about what to do in certain situations in a game, such as when and where to pass the ball, when to shoot, when to dribble up court? ______________

learned a lot
learned somewhat
learned very little
learned nothing at all

Code sheet for interviews

Name ____________________ Rating ____________________

Situation #1
% correct _____
quality _____

Situation #2
% correct _____
quality _____

Situation #3
% correct _____
quality _____

Situation #4
# of out-of-bounds plays _____
organization _____

Situation #5
alternatives _____
organization _____

Question #1
a.
b.

Question #2
strategy ____

Question #3
context __________
relates cues to actions ________________

Guidelines for Coding Interviews

Situations one, two, and three involve circumstances in which there are correct answers for the appropriate game actions. Thus, the number of correct answers was coded for each subject. In addition, the quality of the answer was coded as zero for poor quality, one for average quality, and two for high quality. Coding the quality of the response was necessary because subjects could give one or more correct responses without complete understanding of the situation. Further details of the coding procedure are given below.

Situation 1

There are two correct answers. Player #1 may shoot the ball himself or pass the ball to player #2. The key to the decision depends on which offensive player the defensive player chooses to guard. Quality was judged as zero if no correct answers were given; one if correct answers were given without stating the actions were dependent on the action of the defensive player, and two if the correct answers were given within the context of the defensive player's actions.

Situation 2

There are four correct answers. Player #1 must make the front defensive player (X1) commit to guard player #1. Player #1 can then pass the ball to player #2 or player #3 depending on which of the players (#2 or #3) the back defensive man (X2) guards. A fourth option is player #1 may pass the ball to player #2 or #3. If the back defensive man (X2) picks up the player who receives the pass and the front defensive player is slow in sliding back to the middle of the lane once player #1 passes the ball, the player who receives the pass from player#1 can then pass the ball to the other player (player #2 or #3) across the lane. Thus, the options depend on the play of both defensive player's actions. The quality of the response was coded as zero if no correct answers were given; one if correct answers were given without mentioning defensive play; and two if correct answers were given in the context of defensive players actions.

Situation 3

There are three correct answers to situation 3. The front defense player should force player#1 to stop dribbling. The back defensive player should guard the man (player #2 or #3) who receives the first pass from player #1. As soon as player#1 passes the ball to player#2 or #3, the front defensive player should immediately drop back to guard the player (#2 or #3) who did not receive the first pass from player #1. From a defensive view point, the shot which the offense should be forced to take is a shot by player #1 near the free throw line rather than a layup. Quality of the response was coded zero if no correct answers were given; one if correct answers were given without complete understanding of the situation, and two if correct answers were explained in the context of defensive actions to counteract offensive strategies.

Situation 4

The total number of out-of-bounds plays and the organization of the plays was recorded. An out-of-bounds play was operationally defined as an organized pattern of movement and positioning of offensive players designed to either score or in bound the ball to an open man. Answers which involved only simple passes to one player were not considered valid out-of-bounds plays. Such answers were coded as zero in terms of organization. Valid out-of-bounds plays were coded one in terms of organization.

Situation 5

The total number of alternatives and the organization of the alternatives given by each subject were recorded. Organization was coded one if the subject's alternatives involved systematic movement of the offensive players and the ball. Organization was also coded as one if the subject's answer included sequences of offensive strategies such as screen and roll, or give and go. Organization was coded as zero if the pattern of the alternatives given by the subject involved simple passes followed by a shot without systematic movement of the players.

Question 1

Correct answers to 1.a. and 1.b. were coded as one. Incorrect answers were coded as zero.

1.a. The correct answer to 1.a. is player #2 may pass the ball to player #4 when the defensive player guarding him is not preventing the pass. He should not pass the ball to player #4 when player #4 is closely guarded.

1.b. The correct answer to 1.b. is player #2 may pass the ball to player #2 when the guard on the same side of the court in a 2-1-2 is not in the passing lane preventing the pass to player #2.

Question #2

The type of strategy used to remember the offensive plays was recorded. If no strategy was used, question #2 was coded as zero.

Appendix G

Additional Tables for Experiment Two

Table 23. Summary of the positions played by experts and novices.

8-1Ø League	Experts	Novices
Position	Number	Number
Guard	1Ø	1Ø
Forward	4	4
Center	3	3
Total	17	17
11-12 League		
Position	Number	Number
Guard	7	7
Forward	3	1
Center	1	3
Total	11	11

Table 24. Means for the opportunities to respond on the categories of control, decisions, and execution for experts and novices in each age league.

	Experts		Novices	
	M	SD	M	SD
Control	17.00	9.23	6.23	2.80
Decision	28.71	14.42	8.64	4.85
Execution	27.68	14.26	7.71	4.79
	8-10 League		11-12 League	
	M	SD	M	SD
Control	10.29	7.28	13.82	10.20
Decision	17.59	13.65	20.36	16.38
Execution	16.20	13.45	20.00	16.22
8-10 League				
	Experts		Novices	
	M	SD	M	SD
Control	14.94	7.75	5.65	1.90
Decision	26.88	13.51	8.29	4.28
Execution	25.52	13.15	6.88	3.88
11-12 League				
Control	20.18	10.77	7.45	3.64
Decision	31.55	15.97	9.18	5.79
Execution	31.00	15.87	9.00	5.89

Table 25. MANOVA table for age level, group (expert-novice), and age level x group using control, decisions, and execution as dependent variables.

Effect - Age Level

Statistic	df	*F*
Hotelling-Lawley Trace	3, 50	2.22 ns
Pillai's Trace	3, 50	2.22 ns
Wilks' Criterion	3, 50	2.22 ns
Roy's Maximum Root	1, 52	6.92 upper bound

Effect - Group (expert-novice)

Statistic	df	*F*
Hotelling-Lawley Trace	3, 50	12.61**
Pillai's Trace	3, 50	12.61**
Wilks' Criterion	3, 50	12.61**
Roy's Maximum Root	1, 52	39.33 upper bound

Effect - Age Level x Group

Statistic	df	*F*
Hotelling-Lawley Trace	3, 50	0.56 ns
Pillai's Trace	3, 50	0.56 ns
Wilks' Criterion	3, 50	0.56 ns
Roy's Maximum Root	1, 52	1.76 upper bound

** $p<.01$

Table 26. MANOVA table for age level, group, and age x group with the knowledge test, the control dribble test, and the speed spot shooting test as dependent variables.

Effect - Age League

Statistic	df	*F*
Hotelling-Lawley Trace	3, 50	5.81 **
Pillai's Trace	3, 50	5.81 **
Wilk's Criterion	3, 50	5.81 **
Roy's Maximum Root	1, 52	18.13 upper bound

Effect - Group (expert-novice)

Statistic	df	*F*
Hotelling-Lawley Trace	3, 50	28.01 **
Pillai's Trace	3, 50	28.01 **
Wilk's Criterion	3, 50	28.01 **
Roy's Maximum Root	1, 52	87.41 upper bound

Effect - Age League x Group

Statistic	df	*F*
Hotelling-Lawley Trace	3, 50	0.27 ns
Pillai's Trace	3, 50	0.27 ns
Wilks' Criterion	3, 50	0.27 ns
Roy's Maximum Root	1, 52	0.84 upper bound

** $p<.01$

Table 27. Summary for the forward selection stepwise discriminant analysis with the knowledge test, the control dribble test, and the speed spot shooting test used to predict age league.

Step	Variable Entered	Partial R^2	*F*	Wilks' Criterion	Squared Canonical Correlation
1	Knowledge	.13	8.31**	.867	.133

** $p<.01$

Variables not entered in step 1

	Shooting	.0002	0.012 ns
	Dribbling	.0009	0.046 ns

Means for the knowledge test

	Mean
8-10	64.94
11-12	79.45

Table 28. Summary table for the forward selection discriminant analysis using the knowledge test, the control dribble test, and the speed spot shooting test to predict group (expert-novice).

Step	Variable Entered	Partial R^2	*F*	Wilks'	Squared Canonical Correlation
1	Shooting	.532	61.41**	.468	.532
2	Knowledge	.094	5.51*	.424	.576

Variables not entered

	Dribbling	.013	0.701ns

**$p < .01$

*$p < .05$

Table 29. Summary table for the forward selection discriminant analysis using control, decisions, and execution to predict expert-novice.

Step	Variable Entered	Partial R^2	*F*	Wilks' Lambda	Squared Canonical Correlation
1	Decision	.4Ø9	37.39**	.591	.4Ø9
Variables not entered					
	Control	.Ø29	1.6Øns		
	Execution	.ØØ2	Ø.11ns		

**p < .Ø1

Table 3Ø. Summary for the canonical correlation analysis using the knowledge test, the control dribble test, and the speed spot shooting test to predict the components of performance; control, decisions, and execution.

Function	Canonical Correlation	Variance	_F_
1	.724	1.4Ø	8.36**
2	.428	.33	4.Ø5**

Multivariate Tests and _F_ Approximations

Statistic	Value	df	_F_
Wilks' Lambda	Ø.31Ø	9, 121	8.366**
Pillai's Trace	Ø.841	9, 156	6.753**
Hotelling-Lawley Trace	1.742	9,146	9.42**
Roy's Greatest Root	1.4Ø2	3, 52	24.31 upper bound

Table 31. Standardized canonical correlation coefficients for the canonical analysis using the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Standardized Canonical Coefficients

	Function 1	Function 2
Knowledge	0.431	-0.012
Dribbling	-0.420	1.401
Shooting	0.252	1.524
Control	0.304	-0.405
Decisions	0.950	-0.030
Execution	-0.236	0.984

Table 32. Summary of univariate regression analyses using the knowledge test, the control dribble test, and the speed spot shooting test to predict each separate component of performance.

Squared Multiple Correlations and F Tests

Dependent Variable	R^2	Unbiased R^2	F
Control	.20166	.176957	4.793**
Decision	.53399	.507115	19.863**
Execution	.24900	.212030	5.747**

**p<.01

Standardized Regression Coefficients

	Control	Decision	Execution
Knowledge	0.0873	0.3280	0.0397
Dribbling	-0.4477	-0.0638	0.5242
Execution	-0.0663	0.4124	0.7580

Raw Regression Coefficients

	Control	Decision	Execution
Knowledge	0.00063	0.00448	0.00047
Dribbling	-0.01673	-0.00452	0.03236
Shooting	-0.00062	0.00742	0.01188
Intercept	1.25627	0.19447	-0.48073

Table 33. Standard errors of the raw univariate regression coefficients and t-tests for each regression coefficient for the followup regressions using the knowledge test, the control dribble test, and the speed spot shooting test to predict each component of performance.

Standard errors of the raw regressions coefficients

	Control	Decision	Execution
Knowledge	.001342	.001966	.002171
Dribbling	.008120	.011890	.013136
Shooting	.001876	.002748	.003036
Intercept	.268146	.392646	.433776

t statisitics for the raw regression coefficients

	Control	Decision	Execution
Knowledge	0.467	2.278*	0.217
Dribbling	-2.060*	-0.381	2.464*
Shooting	-0.335	2.703**	3.914**
Intercept	4.685**	0.495	-1.108

*$p<.05$

**$p<.01$

Table 34. Canonical correlation analysis using age, expert-novice, the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Function	Canonical Correlation	Variance Ratio	*F*
1	.77	1.48	5.00**
2	.50	0.34	2.16*

Multivariate Test Statistics and *F* Approximations

Statistic	Value	df	*F*
Wilks' Lambda	0.2903	15, 132	5.00**
Pillai's Trace	0.8846	15, 150	4.18**
Hotelling-Lawley	1.8599	15, 140	5.78**
Roy's Greatest Root	1.487	5, 50	14.87 upper bound

Table 35. Standardized canonical coefficients for the canonical analysis using age, expert-novice, the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Standardized Canonical Coefficients

	Function 1	Function 2
Age	-0.021	-0.032
Expert-Novice	0.232	0.156
Knowledge	0.382	-0.045
Dribbling	-0.368	1.424
Shooting	0.162	1.438
Control	0.289	-0.422
Decision	0.955	-0.039
Execution	-0.221	0.981

Table 36. Univariate regressions using age, expert-novice, the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Variable	R^2	Unbiased R^2	*F*
Control	.23	.16	3.02*
Decision	.55	.52	12.37**
Execution	.26	.19	3.44**

**p<.01

*p<.05

Standardized Regression Coefficients

	Control	Decision	Execution
Age	0.1640	-0.0549	0.0518
Expert-Novice	0.1033	0.1870	0.1319
Knowledge	0.0003	0.3063	-0.0105
Dribbling	-0.4137	-0.0458	0.5482
Shooting	-0.1490	0.3350	0.6848

Table 37. The mean percentage of successful responses in each age level for dribbling, passing, and shooting performance on the observational instrument.

	8-10			11-12		
	M	SD	N	M	SD	N
Dribbling						
control	94	13	31	99	2	18
decisions	67	33	31	58	40	18
execution	80	31	30	77	37	18
Passing						
control	66	42	22	93	13	20
decision	73	31	32	81	29	22
execution	86	26	32	90	15	22
Shooting						
control	88	27	20	100	00	12
decision	58	31	26	84	19	17
execution	16	19	26	21	23	17

Table 38. Mean percentage of successful responses on the observational instrument for experts and novices for dribbling, passing, and shooting performance.

	Experts			Novices		
	M	SD	N	M	SD	N
Dribbling						
control	97	7	26	94	13	23
decision	84	23	26	41	34	23
execution	89	27	26	66	37	22
Passing						
control	79	36	20	79	32	22
decision	90	11	28	60	37	26
execution	91	12	28	84	30	26
Shooting						
control	94	22	20	89	22	12
decision	75	26	28	55	33	15
execution	26	22	28	2	6	15

Table 39. ANOVA table for the total number of correct answers to Situations 1, 2, and 3.

Source	df	SS	MS	F
Age League	1	14.52	14.52	6.10*
Expert-Novice	1	63.90	63.90	26.86**
Interaction	1	3.90	3.90	1.64ns
Error	52	123.72	2.38	
Total	55	206.04		

**p<.01

*p<.05

Table 40. ANOVA table for Situation 5 on the basketball situation interview.

Source	df	SS	MS	F
Age League	1	0.36	0.36	0.14 ns
Expert-Novice	1	25.13	25.13	10.04**
Interaction	1	0.13	0.13	0.05 ns
Error	52	130.19	2.50	
Total	55	155.81		

**p<.01

Table 41. Means for the 8-1Ø and the 11-12 League on the basketball situation interview.

	8-1Ø (n=34)		11-12 (n=22)	
Situation	M	SD	M	SD
Total 1, 2, 3	4.41	1.76	5.45	2.Ø1
1. Offense on a 2 on 1 fast break				
Number correct	1.67	Ø.47	1.81	Ø.39
Quality[a]	1.11	Ø.59	1.54	Ø.5Ø
2. Offense on a 3 on 2 fast break				
Number correct	1.67	1.Ø6	1.95	Ø.95
Quality[a]	Ø.88	Ø.53	1.Ø4	Ø.57
3. Defense on a 3 on 2 fast break				
Number correct	1.Ø6	Ø.91	1.68	Ø.99
Quality[a]	Ø.64	Ø.54	1.ØØ	Ø.75
4. Number of out-of-bounds plays generated				
Number of plays	Ø.55	Ø.74	1.31	1.24
Quality[b]	Ø.32	Ø.47	Ø.68	Ø.48
5. Alternatives to score a field goal				
Number generated	4.38	1.92	4.54	1.29
Quality[b]	Ø.38	Ø.49	Ø.59	Ø.5Ø

[a] Quality judged as Ø, 1, or 2

[b] Quality judged as Ø or 1

Table 42. Means for experts and novices in the 11-12 League on the basketball situation interview.

11-12 League (n=11 per cell)

Situation	Experts		Novices	
	M	SD	M	SD
Total 1, 2, 3	6.81	1.07	4.09	1.81
1. Offense on a 2 on 1 fast break				
Number correct	1.90	0.30	1.73	0.46
Quality[a]	1.90	0.30	1.18	0.40
2. Offense on a 3 on 2 fast break				
Number correct	2.45	0.52	1.45	1.03
Quality[a]	1.36	0.50	0.73	0.47
3. Defense on a 3 on 2 fast break				
Number correct	2.45	0.53	0.91	0.70
Quality[a]	1.54	0.52	0.45	0.52
4. Number of out-of-bounds plays generated				
Number of plays	2.27	1.00	0.56	0.50
Quality[b]	1.00	0.00	0.36	0.50
5. Alternatives to score a field goal				
Number	5.18	1.40	3.90	0.83
Quality[b]	0.91	0.30	0.27	0.47

[a] Quality scored as 0, 1, or 2

[b] Quality scored as 0 or 1

Table 43. Means for experts and novices in the 8-10 League on the basketball situation interview.

8-10 League

Situation	Experts		Novices	
	M	SD	M	SD
Total 1, 2, 3	5.23	1.43	3.58	1.69
1. Offense on 2 on 1 fast break				
Number correct	1.76	.44	1.58	.51
Quality[a]	1.29	.69	1.59	.51
2. Offense on 3 on 2 fast break				
Number correct	1.88	1.05	1.47	1.06
Quality[a]	1.06	.56	.70	.47
3. Defense on 3 on 2 fastbreak				
Number correct	1.58	.79	.52	.71
Quality[a]	.94	.43	.35	.49
4. Number of out-of-bounds plays				
Number of plays	.88	.78	.24	.56
Quality[b]	.53	.51	.12	.33
5. Number of alternatives to score a field goal				
Number	5.11	1.86	3.64	1.72
Quality[b]	.58	.50	.17	.39

[a] Quality scored as 0, 1, or 2

[b] Quality scored as 0 or 1

Appendix H

Additional Tables for Experiment 3

Table 44. Mean number of opportunities to respond for control, decisions, and execution for experts and novice on pretest and posttest measures of performance.

	Pretest		Posttest	
Expert	M	SD	M	SD
Control	14.94	7.75	5.64	1.95
Decision	26.88	13.51	8.21	4.59
Execution	25.53	13.15	7.00	4.18
Novice				
Control	16.00	6.86	5.36	3.13
Decision	25.24	11.33	8.21	5.73
Execution	25.23	11.33	7.93	5.43

Table 45. MANOVA table for group (expert-novice), time of testing (pre-post), and group x time of testing using control, decisions, and execution subcategories of the observational instrument as dependent variables.

Effect - Group (expert-novice)

Statistic	df	F
Hotelling-Lawley Trace	3, 27	8.42**
Pillai's Trace	3, 27	8.42**
Wilks' Criterion	3, 27	8.42**
Roy's Maximum Root	1, 29	27.13 upper bound

Effect - Time of testing

Statistic	df	F
Hotelling-Lawley Trace	3, 27	8.45**
Pillai's Trace	3, 27	8.45**
Wilks' Criterion	3, 27	8.45**
Roy's Maximum Root	1, 29	27.24 upper bound

Effect - Group x Time of testing

Statistic	df	F
Hotelling-Lawley Trace	3, 27	0.74 ns
Pillai's Trace	3, 27	0.74 ns
Wilks' Criterion	3, 27	0.74 ns
Roy's Maximum Root	1, 29	2.40 upper bound

**$p < .01$

Table 46. Univariate ANOVA tables for group, time of testing, and group x time of testing using control, decisions, and execution as dependent variables.

Control

Source	df	SS	MS	F
Group	1	0.1870	0.1870	12.69**
Subject(Group)	29	0.4275	0.1474	
Time of testing	1	0.1395	0.1395	10.31**
Group x Time	1	0.0259	0.0259	1.92 ns
Error	29	0.3925	0.0135	
Total	61	1.1724		

Decision

Source	df	SS	MS	F
Group	1	1.3304	1.3304	18.31**
Subject(Group)	29	2.1078	0.0716	
Time of testing	1	0.4070	0.4070	15.70**
Group x Time	1	0.0197	0.0197	0.76 ns
Error	29	0.7515	0.0259	
Total	62	4.5967		

Table 46. continued.

Execution

Source	df	SS	MS	F
Group	1	Ø.3111	Ø.3111	6.Ø6*
Subject(Group)	29	1.4894	Ø.Ø513	
Time of testing	1	Ø.Ø384	Ø.Ø384	Ø.72 ns
Group x Time	1	Ø.Ø217	Ø.Ø217	Ø.41 ns
Error	29	1.5381	Ø.Ø53Ø	
Total	61	3.3987		

**p<.Ø1

*p<.Ø5

Table 47. Mean percentage for experts and novices for the pretest and posttest scores for control, decision, and execution.

	Pretest		Posttest	
	M	SD	M	SD
Experts (n=17)				
Control	94	9	99	2
Decision	81	9	94	5
Execution	76	9	77	9
Novices (n=14)				
Control	78	19	93	12
Decision	48	30	69	34
Execution	58	36	67	28

Table 48. MANOVA table for group, time of testing, and group x time of testing using the knowledge test, the control dribble test, and the speed spot shooting test as dependent variables.

Effect - Group (expert, novice, control group)

Statistic	df	*F*
Hotelling-Lawley Trace	6, 82	14.75**
Pillai's Trace	6, 86	11.62**
Wilks' Criterion	6, 84	13.17**
Roy's Maximum Root	2, 44	40.19 upper bound

Effect - Time of testing

Statistic	df	*F*
Hotelling-Lawley Trace	3, 42	6.80**
Pillai's Trace	3, 42	6.80**
Wilks' Criterion	3, 42	6.80**
Roy's Maximum Root	1, 44	21.37 upper bound

Effect - Group x Time of testing

Statistic	df	*F*
Hotelling-Lawley Trace	6, 82	3.64**
Pillai's Trace	6, 86	3.08**
Wilks' Criterion	6, 84	3.37**
Roy's Maximum Root	2, 44	11.47 upper bound

$^{**}p < .01$

Table 49. Univariate ANOVAs for group, time of testing, and group x time of testing using the knowledge test, the control dribble test, and the speed spot shooting test as dependent variables.

Knowledge

Source	df	SS	MS	F
Group	2	15827.61	7913.805	23.29**
Subject(Group)	44	14954.10	339.866	
Time	1	973.24	973.24	19.81**
Group x Time	2	531.67	265.835	5.41**
Error	44	2161.18	49.12	
Total	93	34357.80		

Shooting

Source	df	SS	MS	F
Group	2	9120.03	4560.02	38.00**
Subject(Group)	44	5280.24	120.00	
Time	1	56.60	56.60	1.68 ns
Group x Time	2	74.40	37.2	1.10 ns
Error	44	1486.47	33.78	
Total	93	16013.24		

Table 49. continued.

Dribbling

Source	df	SS	MS	F
Group	2	748.61	374.31	19.96**
Subject(Group)	44	825.05	18.75	
Time	1	1.40	1.40	0.53 ns
Group x Time	2	25.05	12.53	4.71*
Error	44	117.00	2.66	
Total	93	1717.11		

**$p<.01$

*$p<.05$

Table 50. Canonical Correlation using the pretest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Function	Canonical Correlation	R^2	Variance Ratio	*F*
1	.68	.47	.88	3.64**
2	.56	.31	.44	3.02*

Multivariate Test Statistics and *F* Approximations

Statistic	Value	df	*F*
Wilks' Lambda	0.3505	9, 61	3.65**
Pillai's Trace	0.8239	9, 81	3.40**
Hotelling-Lawley	1.3746	9, 71	3.61**
Roy's Greatest Root	0.8783	3, 27	7.90 upper bound

Standardized Canonical Coeffecients

	Function 1	Function 2
Knowledge	0.279	0.085
Dribbling	-0.223	1.767
Shooting	0.569	1.562
Control	0.267	0.628
Decision	0.860	-0.911
Execution	-0.082	1.038

Table 51. Univariate regressions using the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Variable	R^2	Unbiased R^2	*F*
Control	.307	.243	3.98*
Decision	.444	.399	7.19**
Execution	.253	.181	3.05*

**p<.01

*p<.05

Standardized Regression Coefficients

	Control	Decision	Execution
Knowledge	-0.048	0.266	0.308
Dribbling	0.161	-0.161	0.706
Shooting	0.713	0.293	0.660

Table 52. Canonical Correlation using the posttest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict the posttest scores of control, decisions, and execution.

Function	Canonical Correlation	Canonical R^2	Variance Ratio	*F*
1	.656	.431	.757	1.82 ns

Multivariate Test Statistics and *F* Approximations

Statistic	Value	df	*F*
Wilks' Lambda	0.559	9, 60	1.82 ns
Pillai's Trace	0.447	9, 81	1.57 ns
Hotelling-Lawley	0.773	9, 71	2.03*
Roy's Greatest Root	0.757	3, 27	6.81 upper bound

Table 53. Univariate regressions using the posttest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Variable	R^2	Unbiased R^2	*F*
Control	.125	.031	1.29 ns
Decision	.383	.330	5.58**
Execution	.046	-.064	0.43 ns

**p<.01

	Standardized Regression Coefficients for Decision
Knowledge	0.436
Dribbling	-0.095
Shooting	0.146

	Pearson r Decision	Semi-partial Correlations Decision
Knowledge	.599	.289
Dribbling	-.526	-.054
Shooting	.495	.094

Table 54. Canonical correlation using expert-novice, the pretest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict the pretest measures of control, decisions, and execution.

Function	Canonical Correlation	Variance Ratio	*F*
1	.70	.98	2.95**
2	.58	.51	2.27*

Multivariate Test Statistics and *F* Approximations

Statistics	Value	df	*F*
Wilk's Lambda	0.3107	12, 63	2.95**
Pillai's Trace	0.9032	12, 78	2.80**
Hotelling-Lawley	1.5676	12, 68	2.96**
Roy's Greatest Root	0.9846	4, 26	6.40 upper bound

Standardized Canonical Coefficients

	Function 1	Function 2
Expert-Novice	0.4792	0.4884
Knowledge	0.3611	0.1251
Dribbling	0.1957	1.8823
Shooting	0.4384	1.0092
Control	0.3020	0.4768
Decision	0.7257	-0.9967
Execution	0.1344	1.0773

Table 55. Univariate regressions using expert-novice, the pretest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict control, decisions, and execution.

Variable	R^2	Unbiased R^2	*F*
Control	.31	.22	2.95*
Decision	.47	.41	5.89**
Execution	.33	.24	3.21*

*p<.05

**p<.01

Standardized Regression Coefficients

	Control	Decision	Execution
Expert-Novice	0.1312	0.3180	0.4990
Knowledge	-0.0340	0.2984	0.3587
Dribbling	0.2044	-0.0564	0.8706
Shooting	0.6328	0.0968	0.3528

Table 56. Canonical correlation analysis using expert-novice, the posttest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict the posttest measures of control, decisions, and execution.

Function	Canonical Correlation	Variance Ratio	*F*
1	.67	.83	1.46 ns

Multivariate Test Statistics and *F* Approximations

Statistics	Value	df	*F*
Wilks' Lambda	Ø.5257	12, 63	1.46 ns
Pillai's Trace	Ø.4923	12, 78	1.27 ns
Hotelling-Lawley	Ø.8676	12, 68	1.64 ns
Roy's Greatest Root	Ø.8262	4, 26	5.37 upper bound

Table 57. Univariate regressions using expert-novice, the posttest scores of the knowledge test, the control dribble test, and the speed spot shooting test to predict the posttest measures of control, decisions, and execution.

Variable	R^2	Unbiased R^2	F
Control	.16	.04	1.30 ns
Decision	.39	.31	4.16**
Execution	.07	-.07	0.49 ns

Standardized Regression Coefficients

	Decision
Expert-Novice	0.1428
Knowledge	0.4231
Dribbling	-0.0536
Shooting	0.0761

Table 58. Mean percentage for control, decisions, and execution for dribbling, passing, and shooting for experts and novices.

	Expert			Novice		
	M	SD	N	M	SD	N
Dribbling						
control	98	6	34	92	15	23
decision	91	15	34	54	37	23
execution	91	19	34	62	34	22
Passing						
control	80	36	21	75	34	18
decision	91	12	34	68	33	24
execution	92	11	34	84	30	24
Shooting						
control	95	19	27	85	24	9
decision	80	25	34	63	38	14
execution	31	21	34	15	36	14

Table 59. Pre and posttest mean percentage for control, decision, and execution for dribbling, passing, and shooting.

	Pretest			Posttest		
	M	SD	N	M	SD	N
Dribbling						
control	94	13	29	97	8	28
decision	69	34	29	84	28	28
execution	81	31	28	78	28	28
Passing						
control	60	42	19	95	11	20
decision	77	28	29	85	23	29
execution	84	27	29	92	13	29
Shooting						
control	86	28	18	100	00	18
decision	56	31	24	95	12	24
execution	17	20	24	35	30	24

Vita

Karen Elizabeth French was born on June 23, 1955 in Alexandria, Louisiana, but spent most of her childhood in Jena, Louisiana. She attended Jena High School and graduated as a member of the 1973 graduating class. Karen earned her undergraduate degree in physical education at the University of New Orleans in 1977.

From January 1978 to August 1978 she pursued a master of arts degree in physical education at Sam Houston State University in Huntsville, Texas. In August 1978, she accepted a teaching and coaching position at Westlake High School in Westlake, Louisiana. She served as a physical education teacher and coach for girls basketball, softball, and track for three years. She returned to graduate school in the summer of 1981 and completed the requirements for a Masters of Arts in physical education from Sam Houston State University in Huntsville, Texas.

In the fall of 1981, she entered the doctoral program at Louisiana State University. While completing the requirements for the doctoral degree, she was a teaching and research assistant in the School of HPRD. After completing the requirements for the doctor of philosophy degree, Karen will serve as an assistant professor in physical education at the University of South Carolina.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Karen Elizabeth French

Major Field: Physical Education (Motor Development)

Title of Dissertation: The Relation of Knowledge Development to Children's Basketball Performance

Approved:

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Major Professor and Chairman

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Date of Examination:

July 17, 1985