2011

View from the virtual pocket: using virtual simulation and video game technology to assess the situation awareness and decision making of NCAA quarterbacks

Burnie Bristow

Pepperdine University

Graduate School of Education and Psychology

VIEW FROM THE VIRTUAL POCKET:
USING VIRTUAL SIMULATION AND VIDEO GAME TECHNOLOGY TO ASSESS THE SITUATION AWARENESS AND DECISION MAKING OF NCAA QUARTERBACKS

A dissertation proposal submitted in partial satisfaction

of the requirements for the degree of

Doctor of Education in Learning Technologies

by

Burnie Bristow

April, 2011

Linda Polin, Ph.D. – Dissertation Chairperson

This dissertation is written by

Burnie Bristow

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

Dissertation Committee:

Linda Polin, Ph.D., Chairperson

Eric R. Hamilton, Ph.D.

Jack McManus, Ph.D.

TABLE OF CONTENTS

Page

Page

Page

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

Page

Page

DEDICATION

Dear God,

Thank you for breathing life into the heart and soul of a virtuous woman.
My Mom was my roadmap to YOU!

To: My Mom
Bertha L. Bristow
- My First and Greatest Teacher -

Your unconditional love, nurturing spirit and unwavering faith in my dreams and aspirations propelled me to grow into the crown of scholarship, manly deeds, and love for all mankind.

ACKNOWLEDGEMENTS

"Happy is the man who…gains understanding." Pr 3:13

As I close the book on this professional milestone and begin the next phase of my ideal life, I'm compelled to pay homage to scores of individuals that have impacted my life well beyond the completion of this manuscript. Please know that you will be receiving a personalized expression of my heartfelt gratitude.

Thus, I will reserve this section to acknowledge the unique contributions that fueled the development and completion of *View from the Virtual Pocket*.

Dissertation Committee:

To Dr. Linda Polin, the distinguished chair of my dissertation committee: You were the intellectual compass that inspired me to write the next chapter in my ideal life. *View from the Virtual Pocket* is a testament to your role in my professional, intellectual and spiritual transformation.

To Dr. Jack McManus: By honing and encouraging my desire to challenge what is known, you allowed me to call an audible in the stadium of naturalistic decision making.

To Dr. Eric Hamilton: Your insights into the link between the "naturalistic" experimental learning environment and the democratization of access to world class, world-wide learning provided me with important knowledge and essential connections.

Dissertation Support:

To Dr. Michelle Kowalsky, my secret weapon in this doctoral journey, many thanks to you -- my content, process, and emotional mentor. Thank you for (a) cultivating that "aha" moment! And for (b) helping me develop the scholarly voice required to turn an intriguing hypothesis into an intellectual touchdown.

To Dr. Curtis Odom and Kai Dupe, thanks for inspiring me to be the Best Man I can be.

To: Dr. Besenia Rodriquez, thanks for 40 acres of intellectual REALNESS!

To: Dr. Lani Fraizer, thanks for the nurturing of Dr. B. Inc.!

To my Pepperdine University colleagues in Cadre 11, First name Greatest, Last name Ever. Thanks for an amazing journey!

To my professors: Dr. Polin, Dr. McManus, Dr. Riel, Dr. Sparks, Dr. Madjidi, and Dr. Goodale…..thanks for breathing life into the words, "Freely ye received, freely give."

To My Study Participants:

I want to thank you for your time, your knowledge, your wisdom, your patience, and an unwavering commitment to this study.

XOS Digital

To Joe Schrimpl, Regional Sales Manager: Thank you for (a) championing the virtues of this study, for (b) believing that, for better or worse, I had the expertise and integrity to fairly represent the capabilities of PlayAction Simulator, and for (c) the countless hours and resources you gave in support of bringing the empirical investigation of the PlayAction simulator PC to fruition. Your background as an award-winning video coordinator served as scaffold between the situational analysis and the system design. But most of all, I will never forget your unwavering commitment to this study.

To Albert Tsai, Vice President: Thank you for having the courage to put your innovative invention under the scrutiny of an empirical investigation.

To John Scott, Senior Software Engineer: Thank you for countless hours of hard work and your infinite levels of patience. Thanks for sharing your knowledge of how Artificial Intelligence and Motion Capture Technology shapes the interaction between man and machine.

Football Experts

To the incomparable Darrel “Mouse” Davis: I have been a fan of yours all my life. Thank you for being so gracious with your time. Thanks for taking me under your wings and treating me like YOUR quarterback. Meeting you was the cerebral opportunity of a lifetime. This study is a salute to you, and to all the collegiate and professional teams employing the concept of multiple adjusting routes in the dynamic and time constrained domain of the quarterback.

To John Jenkins, NCAA, NFL, CFL, USFL: Thank you for unfettered access to your playbook, schemes and teaching methods. Your learning environment should be patented! Thanks for a marathon session on defensive coverages! You helped me to conceptualize multiple adjusting routes and shaped my thinking around the link between reinforcement learning and expert decision making in football. Most of all, you reminded me how much unadulterated FUN you can have in the Run and Shoot offense. Man, how I miss 700-yard passing games and 54-touchdown seasons! The NFL could certainly use an injection of your innovative ideas.

To Nick Rolovich, Offensive Coordinator, University of Hawaii: Thank you so much for your time and for the unparallel look inside the huddle of the Run and Shoot quarterback. You helped me eliminate all the wrong decisions so I could begin to locate the correct options. The rich and detailed analysis of my data collection was the result of our knowledge elicitation session. Mahalo nui loa!

To June Jones, Head Coach, Southern Methodist University: Thanks for an all-access pass to your football program.

To David Klingler, NCAA Record-setting Quarterback: You are the glue to this manuscript. Thanks for your profound explanation of "how" the innovative concepts of these great coaches are implemented on the field. The concept and process of the optimization of serially generated options is forever linked to "*how"* you attack defensive coverages. But equally important, thank you for reminding me of Faith, Family, Football!

To Dan Morrison, Quarterback Coach, Southern Methodist University: Thank you for your review of THREE iterations of Goal Directed Task Analysis! I wanted to provide attribution to you for your introduction to the concept of "unconscious competence" listed in the decision making model for quarterbacks. I'm grateful for your patience, indebted to you for your time, amazed and thankful for your insights into decision making expertise.

Up Close and Personal

To: My Dad: Burnie Bristow Sr.
Thanks for reminding me that success is uncommon, therefore not to be enjoyed by the common man.

To: My Sister: Brenda L. Savage
Thanks for letting me know we have a Guardian Angel!

To: My Brother: Bradford L. Bristow
Thanks for showing me the Genesis of a purposeful life!

To: Kim Rousseau
My love for you is indelibly etched in the Hall of Fame of my Heart.

To: The House of Alpha Phi Alpha, OOOOOOO Six! And the memory of Grambling State University Hall of Fame Football Coach, Eddie Robinson and Fritz Pollard, the NFL's 1st African-American Player and Coach, Omega Chapter.

Thanks to all my students with special mention to: The Honorable T.J. Best, Mishynn Squire, Lorena Nicotra, Tashera Bolds, Carlos Torres, Joel Alba, Jason Mitchell and Ivan King. Thanks for making me a "Who's Who in Learning Technologies."

To all my players, with special mention to: Stanley Jackson, T.J. Hill, Patrick Thompson, David Thompson, Shawn Seabrooks, Marcel Shipp, Kenny Thomas, Eddie Cotton, Bradford Bristow as player and coach, Rafael, and the entire 1999 Eastside High School Freshman Football Squad -- the greatest team that never was. You are why I love the game of Football and why I'm proud to be called "Coach."

To Michael Terrizzi, for allowing me to quarterback the Passaic County Tech Bulldogs.

To Donald Davis, for allowing me to install the Run and Shoot at Eastside High School.

To Manny Matsakis, Bob Jones, Mark Mickens and the Butler Bulldogs for showing me the TripleShoot Offense.

To the City of Paterson, New Jersey: If you call, I will answer.

To my children: With Love!

To countless family, friends and well wishers…My love, admiration and respect for you extend beyond the pages of this manuscript.

VITA

BURNIE BRISTOW
Paterson, NJ
bbristow@pepperdine.edu

EDUCATION AND CERTIFICATION

Doctoral Candidate, Ed.D. in Learning Technologies, Graduate School of Education and Psychology, Pepperdine University (anticipated degree posting, April 2011)

Dissertation Chair: Dr. Linda Polin, Ph.D.
Oral Comprehension Exam Chair: Dr. Kay Davis, Ed.D.
Written Comprehension Exam Chair: Dr. Jack McManus, Ph.D.

M.A., Educational Administration and Supervision, Montclair State University, 2002
Graduate Project: Coaching Coaches in the Triple Shoot Offense

Graduate Certificate: Educational Media and Tech., Montclair State University, 2003
Graduate Project: Computer Animated Playbook -- Triple Shoot Offense

B.S., Workforce Development Education, Southern Illinois University, 1991

National Board Certified Teacher of Educational Media and Technology, 2004-2014
Certification as New Jersey School Administrator
Certification as New Jersey School Principal
Certification as New Jersey School Supervisor
Certification as New Jersey School Business Administrator
Certification as New Jersey School Library Media Specialist
Certification as New Jersey Vocational-Technical Education Teacher

PROFESSIONAL EXPERIENCE

Assistant Principal, School of Performing Arts, Paterson, NJ (2010-2011)

Technology Director, P.A.N.T.H.E.R. Aviation and Space Science Academy, Paterson, NJ (2004-2010)

Adjunct Professor, School of Curriculum and Instruction, Montclair State University, Upper Montclair, NJ (2009-2010)

National Board for Professional Teaching Standards (NBPTS), Assessment Center Expert in Library Media; Scoring Validator for ECYA-LM, Dallas, TX (2006)

Educational Information & Resource Center (EIRC), Site Supervisor and Mentor, Statewide National Board Candidate Support, NJ (2006-2009)

Educational Media Coordinator, Newark Public Schools, Newark, NJ (2001-2004)

Computer Technology Teacher / Coordinator, Wake County Public Schools, Raleigh, NC (2000-2001)

Founding Coordinator, High Tech / MPACT Academy, Paterson, NJ (1999-2000)

Educational Media Specialist, Eastside High School, Paterson, NJ (1996-1999)

Football Coach, Eastside High School, Paterson, NJ (1997-2000)

Human Relations Officer, United States Navy, Special Appointment: Broadened Opportunity for Officer Selection and Training (BOOST)

FOOTBALL PLAYING EXPERIENCE

Passaic County Technical Institute, NJ, Quarterback/Wide Receiver

Kennedy High School, NJ, Wide Receiver/Kick Returner
All-Passaic Valley Conference; All Area Team

Iowa Wesleyan College, IA, Wide Receiver/Kick Returner
Scholarship Recipient

AWARDS AND HONORS

Passaic County's First National Board Certified Teacher

Featured in the 9th Edition of "*Who's Who Among America's Teachers*"

Successfully certified, mentored and nominated three Bill and Melinda Gates Scholars

NJ Senate and General Assembly Citation: "Unsung Hero Award"

Finalist for United States Navy Sailor of the Year
Naval Air Station, Jacksonville, Florida

Navy Good Conduct Medal and Navy Achievement Medal

Member of the last All Passaic Valley Conference Football Team

ABSTRACT

View from the Virtual Pocket is a proof of concept study in which a theoretical proposition about situation awareness in time constrained decision making is wedded to the affordances of a computer based simulation to ascertain if the real world decision making in the pocket of an NCAA quarterback can be modeled successfully for simulation based learning.

The researcher used the Situation Awareness Global Assessment Technique (SAGAT) for the purposes of (a) analyzing the situation awareness requirements for expert decision making and (b) to empirically assess the viability of using a computer based football simulator as a SAGAT simulation tool.

The highlight of this study is a Goal Directed Task Analysis developed in conjunction with some of the most recognized names in professional and collegiate football. The results of the (GDTA), a form of cognitive task analysis, defined the information requirements for expert quarterbacking and shed light on the enormous cognitive demands placed on the quarterback.

The researcher was able to create, categorize and program SAGAT queries from the Goal Directed Task Analysis into an innovative virtual reality simulator called the PlayAction Simulator PC. Once the queries were programmed and the plays were published, the Researcher evaluated the simulator's ability to (a) stop a simulated repetition at random points to ask probing questions aimed at evaluating a quarterback's SA and (b) create the ecological validity required to extapolate the informating needed to measure situation awarness in the domain of the quarterback.

The results of this inquiry (a) identified the goals of the quarterback, the decisions the quarterback has to make to achieve those goals and the information the quarterback needs to know in order to make accurate decisions, (b) validated the ability of the interactive virtual simulator to used as a SAGAT Simulation tool in the assessment of the quarterback's situation awareness.

Additionally, the Goal Directed Task Analysis led to the creation of the Decision Making Model 4 QB's. The model, a hybrid of the Endsley (2000a; 2000b) SA Model and the Klein (1998) RPD Model, represents a viable and testable description of the situation assessment process that quarterbacks use to formulate an aerial hypothesis. Inherent in this new model is a proposition about the role of unconscious competence in the optimization of serially generated options.

Chapter 1

Figure 1. Virtual football trainer. Reprinted from UM-VRL: Virtual Football Trainer, n.d. Retrieved October 9, 2009, from http://www-vrl.umich.edu/project/football/index.html. Copyright 2008 by Klaus-Peter Beier. Reprinted with permission.

> *"It might not be the real thing, but the Virtual Football Trainer comes pretty darn close," says the U-M player who inspired No. 7 to take the simulated snaps -- former Wolverine quarterback Tom Brady, who saw an early version of the program in 1999.* (Hoffman, 2001, p. 16)

Introduction

In the summer of 1999, engineers at the University of Michigan put a little-known back-up quarterback named Tom Brady in a computer automated virtual environment that housed a unique full-immersion virtual football trainer designed to improve the decision making ability of NCAA quarterbacks. Once inside the CAVE (Computer Animated Virtual Environment), Brady became fully immersed in an artificial, three-dimensional football world that was completely generated by a computer (Beier, 2001). Wearing lightweight stereo glasses, he was able to take snaps and read the reactions of the computer-generated avatars.

During the fall season of 1999, Brady was named team captain and his steady play on the field was rewarded by being named All-Big Ten (Honorable Mention). He capped off his stellar season with an overtime victory over Alabama in the Orange Bowl. In that game, Brady threw for 369 yards and four touchdowns. But few NFL scouts took notice.

Upon the completion of his collegiate career, Brady was not selected until the sixth round of the NFL draft. He was the 199th player selected, and the seventh quarterback selected. He was drafted behind the likes of Giovanni Carmazzi and Spergon Wynn! It goes without saying that Brady did little to impress NFL scouts with his ability, and displayed little potential to be a quarterback in the NFL. He began his rookie season as the number four quarterback on the New England Patriots' roster.

But, almost a decade after his view from the virtual pocket, Brady is widely regarded as one of the best quarterbacks of his era. He has played in four Super Bowls, winning three of them (XXXVI, XXXVIII, XXXIX). He has won two Super Bowl MVP awards (XXXVI and XXXVIII), has been invited to four Pro Bowls, and holds the NFL record for most touchdown passes in a single season!

Watching Brady shred NCAA and NFL defenses, one can't help but wonder about the connection between his uncanny decision making ability and the time he spent in the University of Michigan Computer Animated Virtual Environment (CAVE). How did Tom Brady -- operating in a high-stakes adversarial environment, under extreme time constraints, and on the biggest stage in professional sports, the Super Bowl -- display such unparalleled examples of expert decision making and performance? Was the virtual football trainer his secret weapon?

Context of the Study

To answer this question, this study used a Goal Directed Task Analysis, developed in conjunction with expert coaches and quarterbacks, to identify what great quarterbacks need to know to make great decisions. Armed with "what" they need to know, the researcher programmed a virtual football trainer, the PlayAction PC, in an attempt to create an ecologically valid environment to assess the quarterback's situation awareness. The researcher sought empirical evidence of how expert quarterbacks read and recognize complex NCAA defenses and parlay that knowledge into decisive and appropriate action. What are the situation awareness (hereafter, SA) requirements for the exemplary decision making displayed by NCAA record setting quarterbacks like David Klinger, Colt Brennen and Heisman Trophy winner Andre Ware? What do great quarterbacks know and see that average quarterbacks miss, and how do we design and use immersive virtual reality simulators as a tool to assess this situation awareness expertise or lack thereof?

The researcher's secret weapon in this endeavor is the aforementioned virtual reality football trainer called the PlayAction Simulator PC, developed by XOS Digital, a national leader in the sports technology industry. "Powered by EA SPORTS, …athletes can now practice using their teams' customized plays against realistic scout defenses in a three-dimensional, video-game-simulated environment. A quarterback using this new tool can practice reading a defense, picking up blitzes and making quick decisions on where to throw the ball, all based on the tendencies of the team he is going to play the upcoming weekend" (BusinessWire, 2007, p. 2).

Situation Awareness + Decision Making = Expert Performance?

Playing quarterback in the NCAA is a cognitively complex and demanding endeavor. It requires an ability to react quickly and make accurate decisions in an adversarial, dynamic, time-constrained environment. Hall of Fame quarterback Joe Montana claims that he knew by the second step where he was going to throw the football. That's right, two steps! According to Montana, "you should already know exactly where all your receivers will be. When you recognize the defense, you should know which of your guys will be open and which will be covered before the play really develops" (Montana & Weiner, 1998, p. 41). Despite the danger, time constraint and complexity of a NCAA or NFL defense Montana guesstimates that the great quarterback successfully executes an aerial hypothesis 95% of the time."

Dr. Gary Klein (1998), renowned scholar in time-constrained decision making, explains that these "experts see the things the rest of us cannot, and often experts do not realize that the rest of us are unable to detect what seems obvious to them" (p. 147). Klein (1998) believes that this situation awareness expertise, particularly the part that involves pattern matching and recognition of familiar and typical cases, can be trained. Klein states that "if you want people to size up situations quickly and accurately, you need to expand their experience base" (p. 42). He espouses training programs with exercises and realistic scenarios, so the person has a chance to size up numerous situations very quickly. He asserts that "a good simulation can sometimes provide more training value than direct experience. A good simulation lets you stop the action, back up to see what went on, and cram many trials together so a person can develop a sense of typicality" (p. 43).

Specifically, these programs can provide appropriate repetition for training.

> If the purpose is to train people in time-pressured decision making, we might require that the trainee make rapid responses rather that ponder all the implications. If we can present many situations an hour, several hours a day, for days or weeks, we should be able to improve the trainee's ability to detect familiar patterns. The design of the scenarios is critical, since the goal is to show many common cases to facilitate recognition of typicality along with different types of rare cases so trainees will be prepared for these as well. (Klein, 1998, p. 30)

When thinking of designing *typicality* in the pocket of an NCAA quarterback the systems designer must understand the temporal dynamics associated with quarterback play, and seek to understand how time constraints tax the decision making ability of quarterbacks and which may lead to errant passes, sacks and interceptions.

Recognition Primed Decision Model (RPD)

Klein provides empirical support for his position through the Recognition Primed Decision Model (RPD). Klein, Calderwood and Clinton-Cirocco (1986) formulated a Recognition-Primed Decision (RPD) model of how people are able to make decisions in naturalistic settings without having to compare options. "The function of the RPD model is to describe how people can use their experience to arrive at good decisions without having to compare the strengths and weaknesses of alternative courses of action. The RPD model suggests that people can use experience to size up a situation, providing them with the sense of typicality" (p. 287), here shown in Figure 2, i.e., recognition of goals, cues, expectancies, and course of action (Zsambok & Klein, 1997).

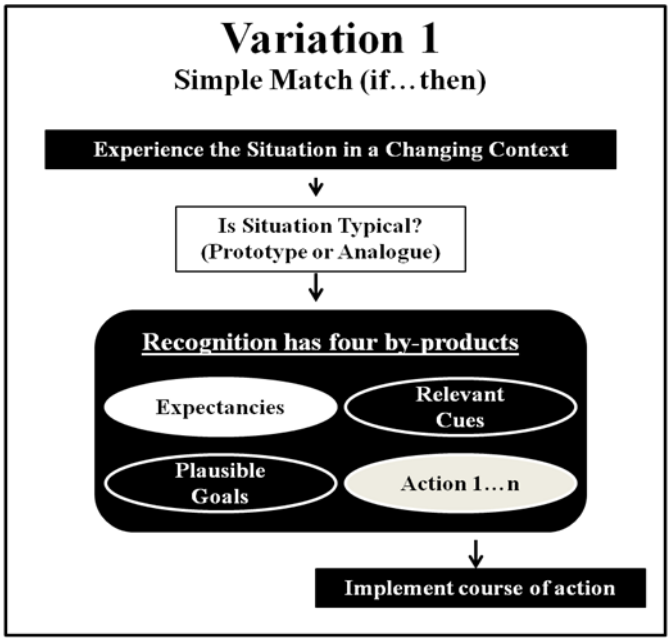


Figure 2. Klein's RPD model, variation 1. Adapted from Sources of Power. (p. 25), by G. Klein, 1998, Cambridge, MA: The MIT Press, Copyright 1998 by The MIT Press. Reprinted with permission.

The model was developed on the basis of field studies about the way experienced personnel (firefighters, medical emergency personnel, chess masters, military commanders) actually make decisions within time constraints, limited information and changing goals. In naturalistic environments with time constraints, changing conditions, and stress, recognition primed decisions (RPD's) are hypothesized to take place (Klein, Calderwood & MacGregor, 1989). "An RPD involves an assessment of the situation, recognition of events as typical, and a resultant course of action based on previous experience" (Holmquist & Goldberg, 2007, p. 2).

The RPD model provides a compelling description of expert decision making that seems to parallel the dynamic environment of a NCAA quarterback attempting to complete a forward pass. But the model does not address all of the concerns of naturalistic decision making. While the model addresses situation assessment and

recognition in the decision making process, it does not reflect memory or attention processes. For a more in-depth look at role of situation awareness in naturalistic decision making, the researcher turned to research being conducted Dr. Mica Endsley.

Situation Awareness (SA) in Recognition Primed Decision Making (RPD)

Endsley (1997) explains that many human errors that are attributed to poor decision making, i.e., interceptions thrown by the quarterback, actually involve problems with the situational awareness portion of the decision making process, as opposed to the choice of action portion of the process. "In order to understand and positively impact decision making in real-world environments, it is necessary to understand the construct of situation awareness, its role in the decision making process, and the factors that impact it" (Endsley, 1997, p. 270). To this end, Endsley (1998) defines SA as the "perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (p. 97).

She distinguished the three levels of situation awareness as the detection of the environments relevant elements (Level 1 SA), the comprehension of the elements' meaning (Level 2 SA), and the projection of the elements' status into the future (Level 3 SA).

Endsley's Level 1 SA can be interpreted as perception of only the important cues, which is a crucial component of RPD. Level 2 SA would map more directly as the recognition of the situation itself, particularly as it leads to a determination of the most important cues, the relevant goals, and the reasonable actions. Endsley's Level 3 SA, the projection forward into the future, is represented within the RPD model as the expectancies generated once a situation is recognized as typical. "Therefore, the

processes described by Endsley appear to be relevant for describing some aspects of decision making" (Klein, 2000, p. 57).

An in-depth review of the literature finds that the RPD model is consistent with Endsley's SA model; but Endsley's model provides a framework for objectively measuring SA, as well as an empirically tested guide for designing systems that can enhance it.

Klein (2000) suggests that it may be fruitful to study SA in the context of decision making incidents (both actual and simulated). "The context affects the way the aspects of SA are defined. Instead of studying the question of what -- what is the content of a person's SA, we can study the question of how -- how the SA affects action. In doing so, we can identify some of the important aspects of SA -- those that impact judgments and decisions" (Klein, 2000, p. 55). In this proof of concept study, the researcher attempts to wed a theoretical proposition about situation awareness in time constrained decision making to the affordances of a computer based simulation to ascertain if the real world decision making in the pocket of an NCAA quarterback can be modeled successfully for simulation based learning.

Significance of the Study

This research represents the first systematic SA requirements analysis in the domain of football. These questions are important to the system designer seeking to apply SA-oriented design principles in the dynamic domain of sports, and to the athletic coach and player seeking to incorporate evidence based practice into their decision training regiments.

Designing systems to enhance SA in sport. Enhancing situation awareness (SA) is a major design goal for projects in many fields, including aviation, ground transportation, air traffic control, nuclear power, medicine, space, systems maintenance and now the wide world of sports. The present inquiry seeks, in part, to ascertain if many of the decision making errors that occur in dynamic, time constrained athletic endeavors are the result of failures in situation awareness. The researcher attempts to further ascertain if the creation of SA-oriented system designs in sport can reduce the incidence of such problems.

"The term situation awareness (SA) has received scant explicit recognition within the sports psychology literature, which is surprising given the task requirements of many sports" (James & Patrick, 2004, p. 297). "As new technologies develop, solid research on the best way to design their features to enhance SA and human performance (in sport) lags significantly behind" (Endsley, Bolté, & Jones, 2003, p. 223). Thus, little information exists in an integrated format to support the designer in creating systems that support SA in the domain of sports.

By conducting an empirical evaluation of the of the XOS Technologies PlayAction simulator's ability to support the situation awareness of collegiate quarterbacks, the study provides system designers in this domain with current and cutting edge research on the ability of this mediating artifact to measure and train the situation awareness required to effectuate sound decision making and expert performance in collegiate and professional sports, and extends the potential of this concept to other dynamic, fast paced, adversarial domains from the World Cup to the Stanley Cup. This technology sits at the core of the study, and if it rises to the level of proficiency being

developed and used in other domains, will represent a ground breaking application in the world of sports. But equally important, the sound metrics applied in this study can signal to designers those areas where the design may hinder or hurt situation awareness.

A prescriptive theory of SA. The existing theories of SA are largely descriptive rather than prescriptive. "That is, while we think we have some notion of the mechanisms at play in building and maintaining SA, we have very little ability to determine *a priori* what level of SA an operator will achieve with a given system design, or to predict the ways in which one system design will affect SA as compared to another" (Endsley, 2004, p. 328).

In this study the researcher hypothesizes that if the virtual simulator can provide the ecological validity required to measure situation awareness it can certainly be used as a tool to pre-test, train, and post-test a quarterback's situation awareness.

Situated theory of learning. Additionally, the current models are grounded in cognitive theories. This study will attempt to provide observations and recommendations for training mental models (a cognitive approach to learning) through the use of ecologically valid virtual simulators that provide the context, interaction and experiences needed to enhance situation awareness (in other words, a situated approach to learning).

Objectively measuring SA in sport. "The difficulties associated with assessing SA in sport are primarily concerned with deriving measures that retain ecological validity as well as capturing the diversity of the sporting situations" (James & Patrick, 2004, p. 312). The empirical investigation of the PlayAction Simulator's ability to create the ecological validity in the domain of the collegiate quarterback will provide a research-based, domain-relevant rationale for using this mediating artifact as a tool for training

SA, and allows the researcher to validly and reliably utilize SAGAT as a methodology to objectively measure SA.

Purpose of the Study

Using Situation Awareness in Recognition Primed Decision Making as a theoretical framework, the purposes of this study are (a) to analyze the situation awareness requirements for expert decision making in the domain of the collegiate quarterback who is operating in high stakes, time constrained situations that feature inadequate information, ill-defined goals, dynamic conditions and team coordination; (b) to create probes that measure the situation awareness requirements needed to execute a statistically significant aerial hypothesis; and (c) to empirically assess the viability of using virtual simulation as a SAGAT simulation tool in the domain of football.

"The real time action of sports, relying heavily on cues in the body movements and expressions of other players and motion vectors of the ball, is difficult to simulate realistically" (Endsley, 2004, p. 333). The mediating artifact at the core of this inquiry is XOS Digital's PlayAction Simulator PC. Using the situation awareness requirements necessary for expert college quarterbacks as the benchmark, the researcher conducted an empirical investigation of the PlayAction Simulator's ability to create the ecological validity needed measure situation awareness in the domain of the collegiate quarterback.

> Given the significant role of highly automatized motor movements in sport activities, many aspects of the game may not be available to conscious awareness. Yet, anecdotal information from expert players (e.g., sports interviews with professional athletes) also demonstrates a high level of cognitive awareness of certain strategic aspects of the game that also bear examination. It would be interesting to see if the higher levels of SA can also be tapped into in sports studies. (Endsley, 2004, p. 333)

Thus, the present study endeavors to investigate aspects of these queries in the domain of American football.

Research Questions

Is expertise in situation awareness the foundation for exemplary decision making in the domain of quarterbacking, and if so, can we use virtual simulation to measure it?

To understand the role of situation awareness in the decision making and performance of NCAA quarterbacks and to explore the potential of virtual simulation as a tool to measure and train situation awareness the following questions were explored: (a) What are the situation awareness requirements for expert decision making in the domain of the NCAA quarterback? (b) Do the affordances of virtual simulation provide the information required to effectively measure the situation awareness of NCAA quarterbacks?

To answer these questions the researcher examined the situation awareness requirements of the Run and Shoot quarterback through a series of analysis that included (a) semi-structured interviews and (b) goal directed task analysis (GDTA) developed in partnership with NCAA record setting offensive coaches and quarterbacks. The researcher used the results of the GDTA to create probes (questions) that were programmed into an innovative virtual simulator by XOS Digital, a leader in the sports technology industry. Using an XBox 360 wireless controller, the researcher sought to provide evidence that PlayAction Simulator PC provided the information necessary to answer the questions.

The resultant requirements, information and empirical evidence are now presented, along with a methodology for determining the SA requirements of collegiate quarterbacks.

Chapter 2

Introduction and Theoretical Framework

The purpose of this chapter is to provide a basic understanding of the theoretical underpinnings and research findings that describe the role of situation awareness in recognition primed decision making of collegiate quarterbacks. The intention is to (a) understand the goal directed tasks of a quarterback who is operating in a dynamic, time constrained, adversarial environment; (b) provide an empirical basis for what quarterbacks need to know to expertly execute an aerial hypothesis in this theatre of engagement; and (c) how to objectively measure this situation awareness and decision making expertise.

Thus, this chapter presents a review of the literature related to the theories of Recognition Primed Decision Making (RPD) particularly in adversarial situations, the role of Situation Awareness (SA) in Recognition Primed Decision Making, and the connection between Recognition Primed Decision Making, Situation Awareness and expertise in sport. Additionally, the researcher reviews advances in the use of virtual reality and simulation as a tool to analyze and measure sports performance. The literature review will be infused with published anecdotal accounts of situation awareness and decision making as described by expert NCAA and NFL quarterbacks and coaches.

RPD model in the domain of sports. Any review of the literature in this area necessitates a quest for research that defines and validates the type of decision making that mirrors that of an NCAA quarterback. This review seeks to understand studies or models which may detail the process and product involved in time constrained decision

making, the methods and procedures that objectively measure it, and finally, the factors of design systems that support real time decision making and performance.

In determining a theoretical scaffold for this study, Klein's (1998) recognition primed decision making model provided the most compelling description of expert decision making by NCAA quarterbacks in a naturalistic environment.

The RPD model (Klein, Calderwood, & Clinton-Cirocco, 1985) is an example of a naturalistic decision making model. It attempts to describe what people actually do under conditions of time pressure, ambiguous information, ill-defined goals, and changing conditions. It fits four criteria of naturalistic decision making research presented by Zsambok & Klein (1997): "(a) experienced agents, working in complex, uncertain conditions, who face (b) personal consequences for their actions. The model (c) tries to describe rather than prescribe, and (d) it addresses situation awareness and problem solving as part of the decision making process" (p. 23).

The RPD model was formulated to explain how experienced fireground commanders could use their expertise to perceive, understand and serially generate quality options rather than comparing all the options for purposes of finding the best choice. "They found that the fireground commanders rarely compared the merits of alternative actions. Rather, they were able to use their experience to identify a workable course of action as the first one they considered" (Klein, 1997b, p. 285). The study of these commanders presents conditions analogous to those of the present study.

Following this seminal study, the RPD model has been evaluated in a variety of domains such as military, medical, firefighting, and chess tournament play (see Klein, 1997b). These studies support the role of interaction and experience in the acquisition of

expertise, and the link between assessment and option generation in the process of time constrained decision making as shown in Figure 2 (recognition of goals, cues, expectancies, and course of action).

Klein found that this option generation is based on critical cues in the environment that are often missed by others. Klein (1998) explains that "experts see the things the rest of us cannot, and often experts do not realize that the rest of us are unable to detect what seems obvious to them" (p.147). "In the RPD model, experts are separated from non-experts by their ability to detect the most important cues without hesitation and in a way that leads to decisive and appropriate actions" (Vickers, 2007, p. 139).

Through an emphasis on expanding the experience base of the individual rather than an emphasis on rational decision making strategies, the model "presents guidance for training people to make better decisions and for designing equipment that will support decision making" (Klein, 1997a, p. 383).

Vickers (2007) reviews the RPD model through the domain of amateur and professional sports. She claims that many of the characteristics Klein lists describe expert decision making in sport. These characteristics include:

- *An experienced decision maker:* "The hallmark of Recognition Primed Decision Making is the study of how people use their experience to make decisions in field settings" (Klein, 1998, p.11). Expert quarterbacks "routinely solve complex problems and develop methods for making effective decisions on a consistent basis" (Vickers, 2007, p. 139).
- *Time pressure:* The perception / action cycle for NCAA quarterbacks is typically 3.2 seconds. "The correct decision results in success. Incorrect decisions lead to

defeat" (Vickers, 2007, p. 139). For example, Maryland Terrapins Head Coach Ralph Friedgen highlights the importance of expert decision making in the sport of football. Friedgen (2008a; 2008b) has a formula called the percentage-of-error, which includes the number of penalties, sacks, dropped balls and number of turnovers by players. He takes those counts and divides them by the number of plays they run in order to calculate this statistic. Friedgen (2008a) claims that when his teams perform with a percentage-of-error under 12 percent, they have never lost a game!

- *Decisions made in the face of inadequate information.* In football, "uncertainty rules the day and comes from opponents, teammates, weather, officials, fans, media and many other sources" (Vickers, 2007, p.139).
- *Procedures are both well defined and poorly defined.*
- *Cue learning is required and is the basis of good decision making*. "Cue learning refers to the need to perceive patterns and make distinctions" (Klein, 1999, p. 5). "Experts in all domains have learned what is important and what is of no consequence" (Vickers, 2007, p.139). Quarterback play is about how fast the player can react and how accurate his decision can be. Friedgen (2008a; 2008b) talked at length about the importance of quarterbacks being able to recognize certain aspects of the defense (cues) so they can anticipate and react and make proper decisions quickly.
- *The context of decision making changes constantly*. "A solution in one situation is not automatically the solution in the next. Sports, by nature, are fluid, dynamic and unpredictable. Even relatively common things, like changes in playing

venues, can have a great effect on how an athlete performs and therefore should never be underestimated" (Vickers, 2007, p.140). The context of decision making is dynamic in that there is no one right solution all the time. Quick detection, adaptability, and exploitation are the norm rather than the exception in terms of expert decision making in high-pressure settings.

In relation, "Klein's RPD model consists of three variations that function according to the complexity of the decision that have to be made" (Vickers, 2007, p. 140). Together these three variations permit an analysis of different types of decision making found in sport. In the following sections of the literature review, the different variations will be presented and applied to sport settings.

Figure 2 on page six provides a visual guide to the basic strategy of variation 1.

> "Decision makers recognize the situation as typical and familiar. They understand what types of goals make sense (so the priorities are set), which cues are important (so there is not an overload of information), what to expect next (so they can prepare themselves and notice surprises), and the typical ways of responding in a given situation. By recognizing a situation as typical, they also recognize a course of action likely to succeed. The recognition of goals, cues, expectancies, and actions is part of what it means to recognize a situation. That is, the decision makers do not start with the goals or expectancies and figure out the nature of the situation" (Klein, 1998, p. 24).

Variation 1 (*if…then*) is found in situations where the typical cues are present and where the task is of recognition followed by a known action. Within the game of football, this *if…then* simple match scenario is very common due to the repetitive nature of the skills and tactics performed in football. "Indeed, the purpose of extensive training is to make much of the unpredictable world of sort predictable, and therefore something that can be controlled more easily" (Vickers, 2007, p.140). "When it comes to reading defenses…you have to know where everybody is. All the time you know what is going

to happen and what is taking place. Vision helps, but that will do little good without the knowledge of the field" (Montana & Weiner, 1998, p. 71).

One of the tenets of this study is that it takes experience to build this kind of intuition. Klein asserts that "intuition depends on the use of experience to recognize key patterns that indicate the dynamics of the situation … intuition grows out of experience … In fact, the simple version, variation 1 of the RPD model is a model of intuition" (Klein, 1998, p. 34).

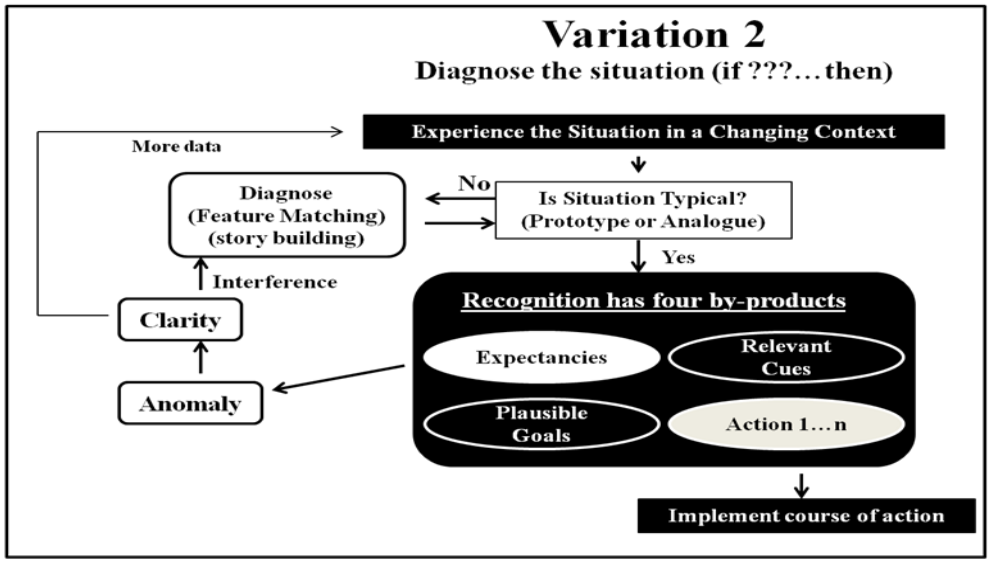


Figure 3. Klein's RPD model, variation 2. Adapted from Sources of Power. (p. 25), by G. Klein, 1998, Cambridge, MA: The MIT Press, Copyright 1998 by The MIT Press. Reprinted with permission.

Some situations are more complex, as shown by variations 2 and 3 in Figure 3 and Figure 4. "Variation 2 occurs when the decision maker may have to devote more attention to diagnosing the situation, since the information may not clearly match a typical case or may map onto more than one typical case. The decision maker may need to gather more information in order to make a diagnosis. Another complication is that the

decision maker may have misinterpreted the situation but does not realize it until some expectancy has been violated" (Klein, 1998, p. 26).

When the performer realizes he has misinterpreted the situation, he has to acquire new or useful information but still make familiar movements. The situation is unfamiliar and contains elements that must be figured out or diagnosed. Variation 2 *(if…???)* is needed when, for example, the opposition uses a new play, when an official make an unusual call, when the weather becomes challenging, yet this variation is where the same skills and tactics are routinely adapted to handle the new information. In these types of cases, performers have to assess each situation, interpret the available information, and then perform a well-known action.

Montana takes us inside the helmet of a NCAA quarterback as he describes the classic (*if...???*) scenario:

> *You feel the ball slam against your right hand, laces right along your fingers. Your left hand clamps shut on it while you grip it with your right hand. You pivot on your left foot and step back with your right. Both hands are on the ball, you're holding it near your chest, elbows tucked in, and you're looking straight downfield.*
>
> *Your pre-snap cues had signaled an all-out blitz, but it's a three-man rush, with eight dropping into coverage. Out of the corner of your eye you're watching the left cornerback. He's running with your primary receiver.*
>
> *You crossover with the left, step with the right, you check the safeties. The free safety is cheating a few steps toward you split-end who is running a deep pattern toward the end zone. The strong safety is staying at home, deep right. The right corner is running with your split-end, too. Are they double covering the split-end?*
>
> *You crossover with your left foot, Two inside linebackers are covering the short areas. You check your third receiver on the progression: your halfback on a comeback route. Will he break off his pattern and find the "seam" between the two linebackers?*
>
> *You plant with the right. Your front hand pushers the ball back into throwing position. Your arm is cocked. . ."* (Montana & Weiner, 1997, p. 43)

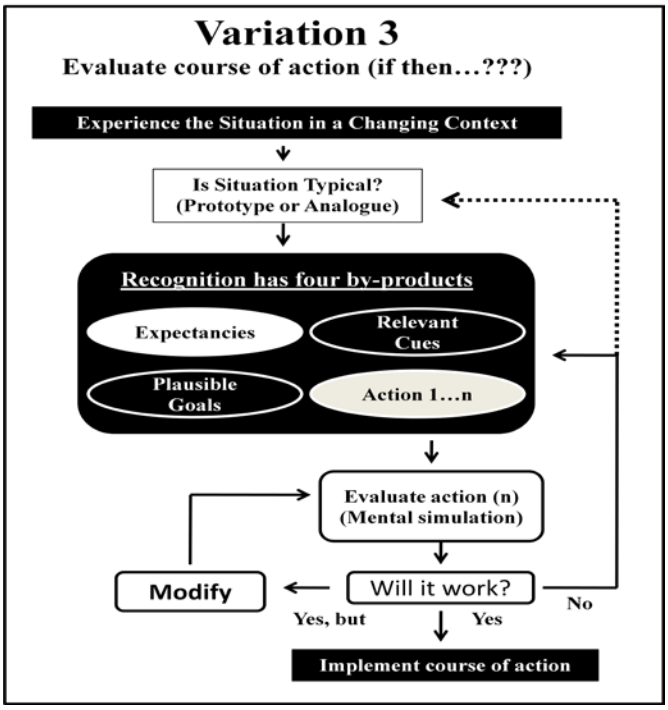


Figure 4. Klein's RPD model, variation 3. Adapted from Sources of Power. (p. 25), by G. Klein, 1998, Cambridge, MA: The MIT Press, Copyright 1998 by The MIT Press. Reprinted with permission.

The third variation of the RPD model requires taking in familiar information that is then used to produce a novel action. Here, the information that is available is familiar and adequate; however, the action taken is atypical. Variation 3 introduces mental simulation, which Klein (1999) calls the basis for evaluating courses of action.

> "Mental simulation serves several functions in non-routine decision making. It helps to explain the cues and information we have received so that we can figure out how to interpret a situation and diagnose a problem. It helps us to generate expectancies by providing a preview of events as they might unfold and by letting us run through a course of action in our minds so we can prepare for it. And it lets us evaluate a course of action by searching for pitfalls so we can decide whether to adopt it, change it, or look further" (Klein, 1999, p .89).

Dubbed the "Picasso of Pigskin Perfection" for his renowned improvisational skills (Willes, 2008), future Hall of Famer Brett Favre demonstrates a classic example of variation 3. In a 2008 NCAA playoff game against the Seattle Seahawks, Favre has

correctly read the defense but the heavy pass rush by the Seattle Seahawk defense has caused him to vacate the friendly confines of his pass pocket. As Favre narrowly escapes the clutches of the on-coming defenders, he begins to stumble and fumble forward on the snow-capped Lambeau Field. The only way Favre could complete this pass was to throw an unorthodox underhanded pass to tight end Donald Lee. On the very next play, the Green Bay Packers scored with 26 seconds left on the clock before half-time (Willes, 2008, p. 23).

RPD in adversarial conditions. "Decision making in combat is all about intuition and gut reaction," explains Lieutenant General David Petraeus (Wolgast, 2005, p. 1). Given the competitive environment of professional sports, the researcher is particularly interested in empirical support for the RPD model in adversarial conditions under extreme time constraints.

Major John Schmitt, of the U. S. Marine Corps Reserves, has pointed out that the RPD model asserts that people tend to choose the first reasonable action they consider. Yet in dealing with an adversary who might anticipate your tendencies, this strategy can get the decision maker into trouble. It leads him to take typical, and therefore predictable, actions. Schmitt's dilemma is that most officers will not put themselves in the position of their adversary, but if one is unlucky to come across an officer who does, such as a Hannibal or a Robert E. Lee, then his recognition primed decision making may get him into trouble (see Klein, 1999, p. 303).

In the NFL or the NCAA, one may replace Hannibal and Lee with the great defensive minds of World Champion Coaches like Tony Dungy (Indianapolis Colts) and Bill Belichick (New England Patriots) and NCAA Champion Pete Carroll formerly of the

USC Trojans. These "ministers of defense" spend hours studying the tendencies of high scoring offenses. "Defenses want you to beat them with what you don't do well. They want you to play left handed. If you are a passing team and that's all you do, they will make you run the ball. If you are a running team and that's all you can do they'll make you pass the ball" (Friedgen, 2008b, p. 66). Klein (1999) asserts that the RPD strategy is still an accurate description of what people do, but Klein acknowledges that "it has this drawback in adversarial situations that call for deception and not typical predictable action" (p. 23).

Klein (1999) also explains that his "suspicion is that....during the evaluation of a plan by mental simulation, the skilled *decision maker* will use a sense of predictability to notice that the adversary can easily anticipate their moves, and they will take the necessary precautions" (p. 304).

Boon Kee Soh (2007) addresses Klein's suspicion in a dissertation that "set out to understand the decision processes used by decision makers in adversarial environment by setting up an adversarial decision making microworld, as an experimental platform, using a real time strategy (RTS) game called Rise of Nations (RON)" (p. 23).

Using a "quarterback planning an offensive drive during a football match" as one example of people making decisions in adversarial environments, Soh set out to answer questions about the decision processes (such as RPD, concurrent or comparison processes) used in adversarial decision making and how cognitive differences may affect decision processes. His objective was to contribute to the validation of recognition-primed decision (RPD) model in a simulated adversarial environment. The researcher was particularly interested in two of the hypotheses which Soh used to address the

objective of the study: (a) All participants will use more RPD processes than normative concurrent processes. This is based on the assumption that the RPD model is valid in the adversarial decision task. If RPD model is valid, then it will be expected that participants will use more RPD processes; and (b) Experienced participants will exhibit a higher proportion of RPD processes than novice participants (between expertise groups and between the trial sessions). The RPD model is based on the recognition process of the decision makers to make quick decisions by recognizing situations rather than using concurrent comparisons of choices. "The study proposed that more experienced decision makers will be able to make more recognition of the processes compared to novice decision makers" (Soh, 2007, p. 75).

Sixteen total participants, eight experts in real-time strategy games (seven males, one female) and eight novices in real-time strategy games (seven males and one female) were recruited to take part in the Soh study. Expertise was determined through a subjective questionnaire. The validation involved the elicitation of the cognitive processes used by participants using process tracing methods. The adversarial environment consisted of a real-time strategy game involving two players playing against each other. The game scenario was a modified version of the computer video game *Rise of Nations* (RON) by Microsoft Game Studios. Participants' working memory and attention capacity were measured to determine if these two cognitive constructs affected the decision making process. The participants played RON against a human opponent (experimenter) as the decision task.

Using a research design that consisted of observations and interviews of participants, it was observed that PRD processes consisted of almost half (48%) of the

total decision processes used by the participants compared to 20% of concurrent process and the expert group had a higher mean percentage of RPD processes (*M*=47.85, *SD*=17.74) than the novices (*M*=40.54, *SD*=20.91) in the study (Soh, 2007, p.133). But Soh's findings do warrant a closer investigation.

Experience and time constraints play a critical role in recognition primed decision making. A Naval fighter pilot engaged in a "dog" fight with an adversary, a chess player playing in "blitz" conditions, or an NCAA quarterback facing an all-out blitz, are competing in theatres of great time pressure. The singular evaluation that uses mental simulation tries to find the first workable option, not necessarily the best. Without time constraints a decision maker will and in some cases should seek to optimize, finding the best course of action. Unfortunately, the researcher does not provide a window into the time constraints inherent in the RON video game.

Additionally, Klein's (1999) research has found that novices are less likely to use RPD decision making. Soh's use of a subjective questionnaire could have severely skewed the results of his study. Experience is a critical factor in analyzing expert decision making. Without an objective criteria, it is impossible to know if the interviewee is more than just a self-professed expert, and thus potentially less likely to have the experience needed to effectively use recognition primed decision making in the simulated adversary environment.

One assertion of the RPD model is that time pressure need not cripple the performance of decision makers who have considerable expertise, because they use pattern matching. One study that explored recognitional decision making in an adversary environment is an inquiry by Calderwood, Klein and Crandall (1988) into the effect of

time pressure on skill and move quality in chess. The researchers attempted to answer a simple but compelling question: how good are skilled decision makers under conditions such as time pressure? In contrast to Soh's study, one of the strengths of this study was the objective criteria for the selection of participants. Six male chess players were recruited from chess clubs based on their USCF tournament ratings. Three were class B and three were rated master. Players are rated based on a system of comparing tournament records (Elo, 1978) that is updated monthly by the United States Chess Federation (USCF). "Based on their performance in tournaments, chess players are given point ratings that are calibrated so that a player whose strength is 200 points higher than another should beat that other player 75 percent of the time. Chess players are rated as international grand masters (above 2,500 points), masters (2,200-2,500), experts (2,000-2,200), class A players (1,800-2,000), class B players (1,600-1,800) class C (1,400-1,600) and class D players (below 1,400) respectively" (Klein, 1999, p. 161). For this study, they compared class B players to masters. Another parallel of this study to the current study's inquiry is that "unlike many studies comparing skill levels, even the weaker players (class B) represent a level of skill well above novice" (Calderwood et al., 1988, p. 484). In blitz play, each player had only 5 minutes of total playing time (averaging 6 minutes per move).

> The most important finding of this study is in the participants' high quality of moves, even under blitz conditions. The time pressure did not slow the masters down. Six seconds a move, one after another, facing a strong opponent resulted in the move quality hardly changing at all. When research talks of naturalistic decision making, this is what is meant. There is no time to generate lots of options and compare them; there is barely enough time to pick up the piece, move it, release it, and hit the clock. (Klein, 1999, p. 163)

Under the blitz conditions, the masters held their own, whereas the class B players dropped sharply. This shift was statistically significant (Klein, 1999, p. 163). Calderwood et al. (1988) found that masters were able to maintain their relatively higher move quality in the speeded condition while simultaneously generating a substantially greater number of moves, responding to more complex situations, and minimizing poorer moves.

Similarly, Joe Montana, using the acumen of chess masters as an analogy to explain situational awareness, i.e., knowledge of the field, states, “It’s not that their brain can process all that information that quickly, it’s that they recognize the board… and they know how to beat it. They’ve played so many games; they’ve seen it all before” (Montana & Weiner, 1998, p. 23).

Studies done by Holding and Reynolds (1982) and Charness (1989) seem to confirm Montana’s explanation. Their findings showed that chess players look more moves into the future than less skilled players do. Klein asserts that this is not the product of higher intelligence or better memory, but rather the product of experience that allows the expert to better trace a sequence of moves further ahead.

Interestingly, in the Calderwood et al. (1988) study, by not having the class B players compete against the master level player, the authors failed to get a glimpse of the difference in situational awareness among the participants and how that difference may or may not have affected their performance.

Lastly, while the study gave us a clearer window into how time constraints affect the performance of the expert versus the near-expert player, it did not address the decision making processes used by the participants especially in the blitz conditions.

Most notably missing was an analysis of a strategy called singular evaluation. "Singular evaluation means evaluating each option on its own merits, even if we cycle through several possibilities" (Klein, 1999, p. 20). Klein (1999) artfully distinguished between comparative and singular evaluation. "When you order from a menu, you probably compare the different items to find the one you want the most. You are performing a comparative evaluation because you are trying to see if one item seems tastier than the others. In contrast, if you are in an unfamiliar neighborhood and you notice your car is low on gasoline, you start searching for service stations and stop at the first reasonable place you find. You do not need the best service station in town" (p. 20).

The difference between singular and comparative evaluation is linked to the research of Nobel Prize winner Herbert Simon.

> Simon (1957) identified a decision strategy he called satisficing: selecting the first option that works. Satisficing is different from optimizing, which means trying to come up with the best strategy. Optimizing is hard and it takes a long time. Satisficing is more efficient. The singular evaluation strategy is based on satisficing. Simon used the concept of satisficing to describe the decision behavior of businesspeople. The strategy makes even more sense for expert decision makers operating under extreme time constraints. (Klein, 1999, p. 20)

Another study (Klein, Wolf, Militello, & Zsambok, 1995) examined a more detailed question, designed to test the RPD model itself. "The model claims that skilled decision makers can generate feasible courses of action as the first ones they consider, so there is no need to generate lots of options. Can skilled decision makers do this? If not, then the rationale for the RPD model disappears" (Klein, 1999, p. 164).

Klein et al. (1995) hypothesized "that skilled decision makers generate satisfactory options as the first ones they consider, thereby avoiding the need to perform extensive generation and evaluation" (p. 63). Thus, the purpose of the Klein et al. (1995)

study was to build on our understanding of the option generation process by examining whether subjects are able to generate feasible options as the first ones considered.

The researchers in that study claim that "a simple means by which we can determine whether subjects are generating reasonable options early in the sequence is to compare the quality of these options against the quality of a complete set of options for some finite problem space" (Klein et al., 1995, p. 64). Thus their major hypothesis is that subjects will generate options in an ordered fashion based on move quality, not randomly.

The position of the researchers was that if options are randomly generated then, on average, the first option an individual formulates should be better than the tenth, or the twentieth that comes to mind. If there is an ordered generation of options, then the initial ones should be the strongest, and the last ones should be the weakest. They posit that subjects will use a serial evaluation strategy thereby limiting the size of the set to a small number of reasonable options.

Sixteen subjects (all males) participated in the Klein et al. (1995) study. They were divided into two groups of skill level based on the United States Chess Federation (USCF) rating system. Eight individuals were rated between 1150 and 1600 (class C) and were placed in the medium skill level group. Another group of eight individuals with a rating of 1700-2150 (class A) were placed in the high skill level group.

In the experiment, the researchers presented some mid-game positions to players and asked them to think aloud while they studied each one, up to the point where they had selected a move. The participants were asked to share their thinking process aloud, especially the first move they considered. This was the same experimental method

de Groot (1978) used in his research; the major difference being that de Groot's study used objective data ratings for all the legal moves.

The objectivity for each move came by way of a chess master who selected four board positions, from mid-game or early end-game positions and had a panel of chess masters rate the moves made by the participants.

A chi-square analysis of both subjective move quality (as provided by the participants) and objective move quality (based on the analysis of panel of chess grand masters), supported the hypothesis that the moves were not being randomly selected. Additionally, the participants rated 75% of their first move as 3 or above, showing that the participants were fairly satisfied with the initial moves they considered. The grand masters concurred, rating 64% of the first moves as accepted. "Had the players in the experiment been sampling randomly from the possible legal moves, they would have had the same ratio: about one sixth of their first moves would have received points" (Klein, 1999, p. 167).

In chess, it is important to find the best move, not just a good one, so players do continue to search for the best options, yet the researchers found that for the most part, they settled on the first option they had thought of, even after considering some others. Interestingly, in this study even the weaker players generated reasonable options as the first ones they thought of.

Klein (1998) acknowledges two major objections to this experiment. The first is that the findings are obvious. Everyone knows people can generate feasible options as the first they consider. The second objection is that the players may have thought of really bad moves that they never told the researchers, to which Klein counters that these

findings are not so obvious to professional trainers, who teach problem solving skills by insisting that people generate large sets of options to do a good job. He asserts that if the results were so obvious, the instructors in these courses would not be presenting their seminars! As to the second objection, he acknowledges that the think-aloud method was subjective and that it could affect his findings. The researcher of the present study argues that the objective criteria provided by the grand masters supported those subjective findings, but Klein delves deeper into the objection by asking us to seriously consider what it means to accept the contention that people might generate a full set of options at each choice point. He asserts that if one has to generate all of the different actions available to him subconsciously each time he leads to a choice point, then he will not have time to make many decisions each day.

Raab, de Oliveira, and Heinen (2009) support Klein's assertions by arguing that people perceive their possibilities for action and generated options without "extensive and costly cognitive processes" (p.49). Espousing an ecological perspective, the authors offer the following explanation, "people perceive options in the relationship between themselves and relevant environmental information" (p. 49). They add that although people can normally perceive their options directly from the environment, there are instances where options are not directly available but instead need to be generated. When information is scarce, unspecific, or unfamiliar, people still use the available information to generate valid and appropriate options from which to choose.

While the data supported the hypothesis put forth by the researchers -- namely that although chess players seek to find the best option, the first options generated are quality moves for both experienced and novice players, and that the moves are not

randomly selected -- the study fell short of answering the singular evaluation question for chess players in time constrained "blitz" conditions. The study addressed the quality of moves in time constrained conditions; an important addition would have been to address how often singular or comparative evaluation strategies were used in these same conditions.

Situation awareness and the RPD model. Klein explains that the RPD model offers an account of situation awareness. It presents several aspects of situation awareness that emerge once a person recognizes a situation. These are the relevant cures that need to be monitored, the plausible goals to pursue and actions to consider, as well as the expectancies.

For the first variation, the recognition of the situation is sufficient to evoke a course of action. The second variation requires effort to determine how to interpret the situation in order to know how to proceed. In the third variation, the SA generates a course of action that is evaluated; sometimes the evaluation will identify aspects of the situation that result in a better understanding of the dynamics.

Inherent in Klein's explanation of situation awareness is an emphasis on a person's ability to understand a context rather than just the ability to accurately recall disconnected data elements. But, "it is important to note that the RPD model does not address all of the concerns of naturalistic decision making. While the model addresses situation assessment and recognition in the decision making, it does not cover issues of managing workload and attention" (Klein, 1999, p. 102). For a more in-depth look at role of situation awareness in naturalistic decision making, the researcher turned to research being conducted Dr. Mica Endsley.

Endsley's situation awareness model. Endsley's (1995) model of Situation Awareness is the most widely known account of SA and bears a strong resemblance to the RPD model. Endsley (1988) defines situation awareness as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of the status in the near future" (p. 97).

Similar to RPD, this model conceptualizes decision making as a recognition and reasoning process of serially matching situation with appropriate action (Lipshitz & Ben Shaul, 1997, p. 296). However, Endsley's model includes the "two hypothetical constructs that do not appear in the RPD, memory and attention" (Klein, 1997b, p.287).

Endsley (2000a) distinguished the three levels of situation awareness as the detection of the environment's relevant elements (Level 1 SA), the comprehension of the elements' meaning (Level 2 SA), and the projection of the elements' status into the future (Level 3 SA).

Level 1 SA: Perception. Level 1 Perception of cues is fundamentally concerned with what elements are present, where they are located, and how fast they are moving. Without a basic perception of important information, the odds of forming an incorrect picture of the situation increase dramatically. Jones and Endsley (1996) found that 76% of SA errors in pilots could be traced to problems in the perception of needed information (due to either failures or shortcomings in the system or problems with cognitive processes). It is important to note that the inclusion of all objects may not be necessary when measuring accuracy of SA, but without recourse to Level 2 SA, it is difficult to determine which objects are relevant. There is also the issue of how to represent context. Klein (2000) states that "context is not simply the inclusion of more elements; it is the

framework for understanding the elements, and that only comes into play in Level 2 SA. This is why Level 2 SA is so critical: to allow us to emphasize context. Measures of Level 1 SA may be misleading if they suggest that SA is only the sum of the elements that correctly recalled. Your situation awareness determines how you will search the Level 1 elements" (p. 52-53).

Level 2 SA: Comprehension. Endsley concurs with Klein, explaining that "SA as a construct goes beyond mere perception. It encompasses how people combine, interpret, store, and retain information. The second level is where meaning enters" (Endsley, 2000b, p. 7). This is where diagnoses are made (e.g., Endsley & Robertson, 1996) and patterns are detected. To achieve Level 2 SA, a person must synthesize a diverse mixture of events and determine their relevance to their goals. Twenty percent of SA errors were found to involve problems with Level 2 SA (Jones & Endsley, 1996).

Flach (1995) pointed out that "the construct of situation awareness demands that the problem of meaning be tackled head-on. Meaning must be considered both in the sense of subjective interpretation (awareness) and in the sense of objective significance or importance (situation)" (p. 3). A person with Level 2 SA has been able to derive operationally relevant meaning and significance from the label 1 SA data perceived. As Flach pointed out, this aspect of SA sets it apart from earlier psychological research and places it squarely in the realm of ecological realism. For a more in-depth discussion on ecological theories and situation awareness, see Endsley, 2004 (p. 325-328).

Endsley's Level 2 SA would map directly to Klein's RPD model as the recognition of the situation itself, particularly as it leads to a determination of the most important cues, the relevant goals, and the reasonable actions.

Level 3 SA: Projection. Endsley's Level 3 SA, the projection forward into the future, is represented within the RPD model as the expectancies generated once a situation is recognized as typical. "A person can only achieve Level 3 SA by having a good understanding of the situation (Level 2 SA) and the functioning and dynamics of the system they are working with" (Endsley, 2000b, p. 18). "At the highest level of SA, the ability to forecast future situation events and dynamics (Level 3 SA) marks individuals who have the highest level of understanding of the situation" (Endsley, 2006, p. 635). "This ability to project from current events and dynamics to anticipate future events [and their implications] allows for timely decision making. Experts rely heavily on future projections as a hallmark of skilled performance" (Yates & Tschirhart, 2006). In an examination of errors in aviation, only 6% of SA errors were found to fall into this category (Jones & Endsley, 1996). Endsley explains that this is probably due to significant difficulties in obtaining Level 1 and Level 2 SA in this domain, rather than any ease in developing good Level 3 SA. "Without sufficient expertise or well-designed information systems and user interfaces, people may fail at the early stages of SA, never progressing to Level 3" (Endsley, 2000b, p.19).

The importance of time in achieving SA. "Time, both the perception of time and the temporal dynamics associated with events, plays an important role in the formulation of SA. A critical part of SA is often the understanding of how much time is available until some event occurs or some action must be taken. The phrase "within a volume of space and time" contained in the definition of SA derives from the fact that operators constrain the parts of the world (or situation) that are of interest to them based not only on space (how far away some element is), but also on how soon that element

will have an impact on the operators goals and tasks" (Endsley, 2000b, p. 7). The rate at which information changes is that part of SA regarding the current situation that also allows for the projection of future situations (Endsley, 1988). Endsley highlighted a myriad of studies in diverse domains that provide empirical support for the important role that time plays in situation awareness (Endsley, Farley, Jones, Midkiff & Hansman, 1998; Endsley & Roberston, 1996; Endsley & Rodgers, 1994), leading Klein (2000) to conclude that "the processes described by Endsley appear to be relevant for describing some aspects of decision making" (p. 57).

Expertise and situation awareness. Many of Endsley's and Klein studies build on the framework that supports a development of expertise in players of many sports at many levels, as well as other occupations which demand expert performance.

> "In thinking about expertise, we often focus on skilled physical performance (e.g., the world-class tennis player or gymnast) or skilled decision making (e.g., the chess grandmaster). In addition to these aspects of performance, however, situation awareness (SA), an up-to-date understanding of the world around them, forms a critical cornerstone for expertise in most domains, from driving to aviation to military operations to medical practice to the *pocket of a NCAA quarterback* [italics added]. The characteristics that allow people to develop high levels of SA often develop silently alongside more observable features like skilled physical performance, even in tasks such as sports that are considered primarily physical in nature" (Endsley, 2006, p. 633).

"Situation awareness plays… an important role in domains where there are many factors to keep track of and these factors can change quickly and interact in complex ways. Effective decision making depends on high levels of SA, and thus so does effective performance" (Endsley, 2006, p. 634). Endsley (2006) presents the Situation Awareness Model as the "critical component to expert performance and addresses the factors that allow it to improve with the development of expertise in a domain" (p. 634).

Schemata and mental models in recognition primed decision making.

Lipshitz and Ben Shaul (1997) used a study of expert and novice Israel Defense Force gunboat commanders in a high-fidelity simulator to inquire about the role of schemata (abstract cognitive structures that guide the construction of mental models) and mental models (specific situation representations) in recognition primed decision making. The researchers observed two experts and six novices on three standard yet challenging scenarios designed to tax the decision making ability of the most highly skilled and experienced commanders.

To make sense of their observations, the researchers chose Klein's RPD model because "trainees make decisions principally on the basis of what they see, and the model has a strong perceptual (i.e., recognition) component" (p. 297). Their observations were consistent with the RPD model. "For example, both experts and novices combined situation assessment with serial option evaluation, but experts conducted more thorough situation assessment and referred to imagined friendly and enemy actions, whereas novices focused on their own actions and reacted to the display on their screens" (Lipshitz & Ben Shaul, 1997, p. 297).

Lipshitz and Ben Shaul highlighted five key findings that emerged from the data:

1. Experts collected more information on the situation before making a decision.
2. Experts engaged in a more efficient information search.
3. Experts "read" the situation more accurately.
4. Experts made fewer bad decisions.
5. Experts communicated more frequently and elaborately with friendly units.

In explaining that "experts 'read' the situation more accurately," the researchers found that the **e**xperts were better able to distinguish between legitimate and bogus enemy targets and to deploy their boats to deal effectively with enemy targets. In contrast, one novice mistook a blip left by a flock of birds for an enemy boat, and literally chased the wind. Another inexperienced trainee miscalculated the distances between two of the targets and ended up trying to process all that was there single handedly. This observation is consistent with anecdotal evidence of how expert quarterbacks "read" the defense (Montana & Weiner, 1998; Anderson, 1995). It is also aligned with models of naturalistic decision making which link situation assessment acumen and decision making expertise to the ability to construct more accurate mental models of the situation (Endsley, 1995a; 1995b; Klein et al. 1993; Lipshitz, 1993; Reason, 1987).

But Lipshitz and Ben Shaul (1997) believe "mental models cannot be reduced to a set of cue, goals, and expectations" (p. 300), and raise the following question: "to what extent the RPD model and two hypothetical constructs schema and mental models are compatible?" (p. 297). The differences between the SA model and RPD are so subtle that Lipshitz and Ben Shaul suspect that schemata and mental models are in fact implicit in the RPD model. However, they acknowledge two important points: that Klein clearly thinks that recognition-primed decision making can be modeled without referring explicitly to these hypothetical constructs (p. 300), and that studying mental models and schemata "involves inferring the existence and nature of entities that cannot be empirically proven to exist" (Rouse, Cannon-Bowers, & Salas, 1992, p. 1304).

Reconciling ecological psychology with Endsley's SA model. While Lipshitz and Ben Shaul argue for the inclusion of hypothetical constructs of attention and memory

in recognition primed decision making, Ecological Psychology, a strand of research related to Naturalistic Decision Making, explicitly rejects these cognitive considerations. Ecological psychology sees interaction and experience with the environment as the cornerstone of recognition primed decision making. Gibson's (1966) theory of affordances, which espouses the bi-directional link between the observer and the environment, is intuitively appealing in the domain of the quarterback. The football environment is 53 and 1/3 yards in width and 120 yards in length. But the difference in the width of the hash marks on the high school, college and NFL field present unique constraints and affordances on each level. For instance the high school field has wider hash marks. When the ball is placed on the left hash the defense has to defend a much larger area to the wide side of the field. These differences would represent different affordances to the quarterback, with affordances being defined as "what the environment has to offer the quarterback."

Gibson's (1966) position that "the quarterback is a perceiver of the environment and a behaver in the environment" (p. 8) seems to be congruent with Endsley's description of Level 2 SA which "goes beyond simply being aware of the elements which are present to include an understanding of the significance of those elements in light of pertinent quarterback goals. Based upon knowledge of Level 1 elements, particularly when put together to form patterns with the other elements (gestalt), the decision maker can form a holistic picture of the environment, comprehending the significance of objects and events" (Endsley, 1995b, p. 37).

These two bodies of work have considerable similarity in their focus on quarterback goals and meaning. In the language of ecological psychology, this is in

terms of affordances. In SA, the comprehension of the elements is all about meaning which derives from the quarterbacks' goals. Lastly, while Endsley refers to SA as a cognitive construct, it is her SAGAT methodology that allows the quarterback coach to get an objective assessment of a quarterback's mental model. The researcher concurs with Endsley (2004) that there are many similarities between these two approaches to situation assessment and serially generated actions and has positioned this inquiry to find common grounds of "unification." This is not a totally altruistic endeavor; the researcher acknowledges that it will be much more appealing to talk about objective and observable measures of SA within the realm of the National Collegiate Athletic Association than to pontificate about the hypothetical constructs of attention and memory.

Pattern recognition. "Pattern recognition is defined as the act of taking in raw data and taking an action based on the 'category' of the pattern" (Duda, Hart, & Stark, 2001, p. 1). The process of pattern matching is related to Level 2 (understanding) of situation awareness. This is where the subject begins to make meaning out of the cues from the environment. Endsley (2000b) explains that people use a process called pattern matching to link cues taken in from the current situation to schemata to pick the best match from those available (p. 22). But she adds that SA is not totally dependent on process matching and calls for further studies into the link between SA and pattern matching (Endsley & Bolstad, 1994). Klein suggests that this pattern matching can be trained and that Variation 1 of the RPD model is the result. Yet, there is a paucity of research related to pattern matching in real-time or simulated, time constrained, adversarial conditions. The researcher endeavored to find a study or studies that investigated pattern recognition in the domain of football.

Valeriote (1984) conducted the only known study which attempted to explicitly investigate the relationship between pattern matching and the speed and accuracy of skilled and unskilled in the domain of collegiate football.

Using a verbal response method to analyze the latency of response among collegiate defensive backs in their attempts to "key" the offensive guard to ascertain if the play is a run or pass, the author found no difference in where the defensive backs focused their attention and no difference in their utilization of early cues.

He did however find a significant difference in the mean verbal reaction time (experts) 838 ms $\pm$ 30 (SEM) and novice 965 ms $\pm$ 40 (SEM), yet there was no significant difference among skilled and novice participants in the error rate. This led the author to deduce through subtraction logic that the difference in reaction time was the result of pattern matching or decision making.

Valeriote's use of advanced eye-tracking, random trials, i.e., partial and full cues, and blanked screens were similar to a SAGAT simulation trial. However, the present researcher provides a couple of words of caution. A total of 100% of the skilled participants had a 50% error rate, which is the most amazing, if not the most significant statistic in the study. Errors this high would not be tolerated on the field.

Secondly, defining skill vs. novice is a slippery slope that must be navigated properly, lest it skew the results of a well-designed study. Valeriote uses experience and a coach's subjective opinion to address skill vs. novice; strangely, novice # 2 had a reaction time that was faster than two of the skilled participants. Situation Awareness and Decision Making are the cornerstones of expert performance but not the only variables. There are many quarterbacks who can expertly read coverages, but do not

have Brett Farve-type arm strength. It is possible for a coach to surmise, incorrectly, that a novice's poor performance is connected to poor utilization of cues; in fact, although a player may be able to see what is happening, he may not have the physical ability to capitalize on what he is seeing.

Lastly, many times it is not possible to conduct a study *in-situ* in the wide world of sports. But in this case, Valeriote missed a golden opportunity. In lieu of a verbal response time, and similar to previous studies, the defensive backs could have executed their normal drops in coverage, maybe in a gymnasium, as they viewed the video tape. Their "live" reaction time could have been observed and recorded. Skilled performance in this endeavor is not "see and tell," but rather "see and react to the ball."

Designing virtual simulation to enhance SA in sport.

> *"I've got a guy coming in next week to talk to me about virtual reality that would probably let the quarterback use a simulator to prepare for reading the defense. The more the quarterback can see, the more he can read."*
>
> *-- Ralph Friedgen (2008a), Head Football Coach, Maryland Terrapins*

Dr. Gary Klein, renowned scholar in time constrained decision making suggests that it may be fruitful to study SA in the context of decision making incidents (both actual and simulated). The context affects the way the aspects of SA are defined. Instead of studying the question of what -- what is the content of a person's SA? -- we can study the question of how -- how the SA affects action. In doing so, we can identify some of the important aspects of SA -- those that impact judgments and decisions.

Klein explains that "experts see the things the rest of us cannot, and often experts do not realize that the rest of us are unable to detect what seems obvious to them" (1999, p. 147). Klein (1999) believes that this situation awareness expertise, particularly the part that involves pattern matching and recognition of familiar and typical cases, can be trained. Klein states that "if you want people to size up situations quickly and accurately, you need to expand their experience base" (p. 42). He espouses training programs with exercises and realistic scenarios, so the person has a chance to size up numerous situations very quickly. He asserts that "a good simulation can sometimes provide more training value than direct experience. A good simulation lets you stop the action, back up to see what went on, and cram many trials together so a person can develop a sense of typicality" (p. 43).

> "If the purpose is to train people in time-pressured decision making, we might require that the trainee make rapid responses rather that ponder all the implications. If we can present many situations an hour, several hours a day, for days or weeks, we should be able to improve the trainee's ability to detect familiar patterns. The design of the scenarios is critical, since the goal is to show many common cases to facilitate recognition of typicality along with different types of rare cases so trainees will be prepared for these as well" (Klein, 1999, p. 30).

"The difficulties associated with assessing SA in sport are primarily concerned with deriving measures that retain ecological validity as well as capturing the diversity of the sporting situations" (James & Patrick, 2004, p. 312). Ward, Williams and Hancock (2006) provide a myriad of virtual simulation tools and environments that may offer an excellent solution to this dilemma. The range and type of possible simulation environments include Computer-Aided Virtual Environment (CAVE) systems, high fidelity simulations of complex systems (e.g., a commercial passenger jet simulator), scaled worlds (e.g., Military Operations in Urban Terrain (MOUT) facilities), synthetic

environments (e.g., computational models of a task), virtual realities (e.g., immersive systems and head mounted displays), augmented realities (e.g., supplementary systems such as navigational aids) and more (see Goldiez, Ahmad, & Hancock, 2007), including simulated task environments (e.g., representative "real-world" tasks recreated using mechanical, video, or computer technology); for a review, see Gray (2002). "Although these technologies have been developed primarily for purposes other than understanding, measuring and training complex cognitive processes, they can be put to that purpose" (Ward et al., 2006, p. 244).

"A number of virtual realities have been created that simulate the sporting environment, such as EasyBowl, a virtual bowling game machine; the Pro Tee Golf simulator, an immersive golf simulator and the Virtual Football Trainer, a CAVE-based American football simulation" (Ward et al., 2006, p. 248). However, to be effective in measuring and training situation awareness and decision making of collegiate quarterbacks, the technologies must evolve into systems that provide the experiences that quarterbacks need to accomplish their goal directed tasks. "An important question to ask is whether the increased physical fidelity and cost of such systems increases their benefit to performance compared to video-or PC-based simulations" (Salas, Bowers, & Rhodenizer, 1998).

Using a fully immersive VR apparatus (Yang et al., 2005) that allows 360-degree, real-time motion capture of people and objects, Bailenson et al. (2008) addressed the benefit to performance question by examining some of the unique affordances of VR and learning by comparing participants who learn Tai Chi from a three-dimensional digital teacher while in an immersive VR simulator to ones who learn Tai Chi from a video-like

simulation. In both studies, participants learned three separate Tai-Chi moves from a recorded teacher and were tested on those moves as well as given questionnaires on their learning experience. Bailenson, Patel, Nielsen, Bajcsy, Jung, & Kurillo (2008) demonstrated that immersive VR provides better learning of physical movements than a two-dimensional video. As technology and our understanding of how to leverage the interactive aspects of that technology improves, they explain, greater gains in learning should result (Bailenson et al., p. 23).

Training and situation awareness in sport. "The thing that makes a good quarterback is how fast and accurate he can make a decision. If a quarterback has great physical tools, but can't make a decision, he will not win for you" (Friedgen, 2008b, p.68). Yet there in no empirical evidence or theory to inform the practice of training quarterbacks in how to improve their decision making ability.

"Historically, training strategies in sport have been based on intuition and emulation rather than on evidence-based practice" (Ward et al., 2006, p. 252). "This doctrine discourages coaches from explicitly investing time in the types of training that could be considered intangible (i.e., perceptual-cognitive skills such as anticipation and decision making)" (Ward et al., 2006, p. 255).

Ericsson, Krampe and Tesch-Romer (1993) concluded that the most effective learning occurs through involvement in a highly structured activity defined as deliberate practice. According to Ericsson, Krampe and Tesch-Romer, engagement in deliberate practice requires effort, generates no immediate rewards, and is motivated by the goal of improving performance rather than inherent enjoyment. The researchers demonstrated that expert performance in music was the product of extensive deliberate practice rather

than being the result of innate abilities. They suggested that to achieve expert performance, deliberate practice has to be sustained over a period of at least 10 years (also see Cote, Baker & Abernethy, 2003, p. 94).

Aspects of the Ericsson et al. (1993) theory of deliberate practice has been verified in the sport domains of soccer (Helsen, Starkes, & Hodges, 1998), karate (Hodges & Deakin, 1998), wrestling (Hodges & Starkes, 1996), figure skating (Starkes, Deakin, Allard, Hodges, & Hayes, 1996) and basketball (Baker, Cote & Abernethy, 2003).

"The emerging picture from such studies is that ten thousand hours of practice is required to achieve the level of mastery associated with being a world class expert -- in anything," writes the neurologist Daniel Levitin (2007, p. 197), who points out experts in basketball, hockey, and ice skating, as well as chess players, concert pianists and even master criminals.

But this does not answer why some people get more out of their practice sessions than others do. Sosniak (1985) suggested that although time engagement in the actual domain of expertise was a crucial factor to learning for those involved in the study, it alone was not sufficient to ensure high levels of performance in the domain. Sosniak stated: "What a learner does, how he or she does it, and how things change as the years pass are certainly more important variables than the absolute amount of time spent at an activity" (p. 409). Salas et al. (1998) concur, pointing out that "more" is not necessarily "better," and the way in which the simulation is implemented during training is of greater importance than the simulation itself. Recognizing that the capabilities now offered by simulation have created unlimited opportunities for sports training, they explain that "a

key question to ask is whether training under simulated conditions is actually useful in improving 'real-world' performance and at what cost" (Salas et al., 1998).

"The research on training perceptual-cognitive skills have been shown to be highly amenable to practice and instruction. Additionally, results from research by Ward et al. (2006) and Bailenson et al. (2008) have shown that "the transfer of training from a simulation can be very effective at improving performance on the criterion task" (Ward, et al., 2006). Moreover, the research suggests that such skills are vital to successful performance (e.g., Helsen & Starkes, 1999; Ward & Williams, 2003).

Measuring situation awareness in sport. "The difficulties associated with assessing SA in sport are primarily concerned with deriving measures that retain ecological validity as well as capturing the diversity of the sporting situations" (James & Patrick, 2004, p. 312). James and Patrick (2004) present some interesting challenges in trying to measure SA in the fast moving setting of sports. "The real time action of sports, relying heavily on cues in the body movements and expressions of other players and motion vectors of the ball, is difficult to simulate realistically" (Endsley, 2004, p. 333).

> Given the significant role of highly automatized motor movements in sport activities, many aspects of the game may not be available to conscious awareness. Yet, anecdotal information from expert players (e.g., sports interviews with professional athletes) also demonstrates a high level of cognitive awareness of certain strategic aspects of the game that also bear examination. It would be interesting to see if the higher levels of SA can also be tapped into in sports studies. (Endsley, 2004, p. 333)

By conducting a systematic analysis of the situation awareness requirements in the pocket of the NCAA quarterback, and evaluating the ability of the PlayAction PC to be used as a SAGAT Simulation tool, this study aims to empirically support the use of

Dr. Endsley's (1995a) Situation Awareness Global Assessment Technique (SAGAT), as a global tool to assess situation awareness in the domain of sports.

Summary

The recognition primed decision making model of Klein presents an intuitively, implicitly appealing scaffold for understanding the dynamic, time constrained, adversarial domain of a collegiate quarterback. Vickers eloquently positions the RPD model in the perception, cognition and decision making process inherent in sports. But this theory has never been explicitly applied in the domain of American football.

Research conducted by Endsley gives us a broader framework for understanding the construct of situation awareness in recognition primed decision making and a valid and reliable methodology to objectively measure it. But again, neither Endsley's definition of situation awareness nor her methodology has been applied to American football.

Erickson sheds some light on role of deliberate practice in the acquisition of situation awareness expertise. Salas adds that it's not just how much you practice but the quality of your practice. As Lombardi once said, "it's not how much you practice but how much you practice it the right way!" This manuscript takes a look at the process of situation assessment, the product of situation awareness expertise in the domain of football, and the potential role of virtual simulation in assessing this expertise.

And finally, the researcher asks, what is the product of all that deliberate practice? One must surmise that the answer is embedded in the phenomenon of pattern matching. The researcher found only one study that empirically investigated pattern matching in the

domain of football, and this study was from the defensive side of the football. Hence, the current investigation has much to offer in understanding these phenomena.

Down, Set, Hut; *View from the Virtual Pocket* now goes inside the offensive huddle to understand the decision making theory, situation assessment process and deliberate practice and preparation involved expertly executing an aerial hypothesis and to explore the potential role of virtual simulation in measuring and training this expertise.

Chapter 3

View from the Virtual Pocket is a proof of concept study in which a theoretical proposition about situation awareness in time constrained decision making is wedded to the affordances of a computer based simulation to ascertain if the real-world decision making in the pocket of an NCAA quarterback can be modeled successfully for simulation based learning.

Research Questions

The researcher used the Situation Awareness Global Assessment Technique (SAGAT) for the purposes of (a) analyzing and the situation awareness requirements for expert decision making and (b) to empirically assess the viability of using a computer based football simulator as a SAGAT simulation tool. The SAGAT technique is a widely tested and validated metric that has been used to objectively measure SA in a variety of time constrained, adversarial domains that seem to mirror that of the collegiate quarterback.

To understand the role of situation awareness in the decision making and performance of NCAA quarterbacks and to explore the potential of virtual simulation as a tool to measure and train situation awareness, the following questions were explored: (a) What are the situation awareness requirements for expert decision making in the domain of the NCAA quarterback? (b) Do the affordances of virtual simulation provide the information required to effectively measure the situation awareness of NCAA quarterbacks?

This research represents the first systematic SA requirements analysis in the domain of football. These questions are important to the system designer seeking to create SA-oriented design principles in the dynamic domain of sports and to the athletic coach and player seeking to incorporate evidence based practice into their decision training regiments.

Research design. To answer these questions, this study used a methodology called the Situation Awareness Global Assessment Technique to analyze the information requirements of NCAA quarterbacks, to develop queries designed to measure their situation awareness, and to evaluate the ability of an innovative football simulator to be used as a tool to measure and train situation awareness. The Situation Awareness Global Assessment Technique (SAGAT) is a global tool developed to assess situation awareness across all of its elements, based on a comprehensive assessment of operator SA requirements (Endsley, 1988; 2000a; 2000b).

The researcher's decision to select the SAGAT technique to empirically study situation awareness in the domain of football was based on the ability of the metric to objectively measure situation awareness, and the technique's high degree of content and predictive validity in studies marked by a time constrained, adversarial environment.

The first step in the process used a cognitive task analysis called a Goal Directed Task Analysis (GDTA). In general, "the GDTA focuses on (a) the basic goals of the operator, (b) the major decisions that need to be made to accomplish these goals, and the (c) SA requirements of each decision; the GDTA seeks to determine what operators would ideally like to know to meet each goal, even if that information is not available with current technology; the ideal information is the focus of the analysis" (Endsley,

Bolté, & Jones, 2003, p. 65). The process begins with an unstructured or semi-structured interview with subject matter experts to ascertain the Goals, Decisions and Situation Awareness requirements in a given domain. Once the interviews are completed, the information is organized into a relational hierarchy of Goals, Decisions and Information Requirements. The Goal Driven Task Analysis is then validated by the larger group of subject matter experts. Based on the GDTA, a list of SAGAT queries is created. The queries are then categorized into three levels of situation awareness, perception, understanding and projection.

Next the SAGAT probes are programmed into a SAGAT simulation tool. A SAGAT simulation tool must have the following characteristics: provide a realistic dynamic environment (ecological validity), be able to stop at randomly selected intervals, be able to make system displays go blank, and dynamically administer SAGAT probes to the participant. The displayed probes correspond to the participant's situation awareness at an exact moment in time. The participant's responses are scored either electronically or using pencil and paper according to pre-determined guidelines. In some cases, because situation awareness can be such a multi-dimensional construct, one or more subject matter experts also participate in scoring the participant responses.

This process has been shown to have a high degree of content and predictive validity. Additionally, the probes that result from this process have been shown to be sensitive and reliable.

Vidulich (2000) conducted a meta-analysis to establish the basic sensitivity of four types of SA metrics: performance based, memory probes, subjective ratings and physiological. The SAGAT technique is considered a memory probe metric that uses a

wide breadth of questions. Approximately 10% of the studies were considered a memory probe metric. If the SA measurement technique is sensitive to SA, then a high proportion of successful outcomes should occur. In this context, a "successful" outcome referred to the interface manipulation that was intended to improve SA having a statistically significant effect (at the 0.05 level) in the predicted direction. A measure was considered sensitive if the 95% confidence interval around the proportion of that measure's positive outcomes was completely above the 50% level. All of the studies that used a wide breadth of questions had a 95% confidence interval over the 50% level. This suggests that the SAGAT technique has a high level of sensitivity when using a broad range of questions.

Endlsey and Bolstad (1994), using a simulated air-to-air combat environment, investigated the link between the Situation Awareness (locate the target) and Performance (kill the target) of experienced former military fighter pilots. The researcher found that pilots with a higher knowledge of each target's location at the time of a SAGAT stop were twice as likely to later destroy the target's aircraft.

In another study of situation awareness in an air-to-air combat simulated environment, Endsley and Bolstad (1994) reported on the reliability of the SAGAT scores of four individual pilots across 36 measurement points. The subject's situation awareness was measured in relationship to their knowledge of the location of enemy aircraft. Test-retest reliability scores for each participant were calculated at 0.99, 0.92, 0.98, and 0.98, respectively, indicating a fairly high level of stability for situation awareness within the subjects.

The high levels of validity and reliability are the result of tightly woven steps that culminate in questions designed to measure situation awareness at three levels perception, understanding and projection.

Limitations of the method. The concern surrounding SAGAT which has been most noted in the literature has been the issue of the intrusiveness of the freezes during a simulation in order to collect data. In an effort to allay concerns about the intrusiveness of the SAGAT stops, Endsley (2000a) conducted a study that investigated "whether operator performance could be affected by the mere threat of a stop to collect SAGAT data" (p. 164). "One third of the subjects, participating in a simulated air-to-air fighter sweep mission, were told that only performance would be measured and no SAGAT stops would be made. Two thirds of the subjects were told that there might be a stop to select SAGAT date in addition to performance measures" (p. 162).

Half of these trials were stopped at random points to collect data. Half were not stopped. Each of the six participants completed the trials under each of the three conditions: no stop / none expected; no stop / stop expected; stop / stop expected. Analysis of variance was used to evaluate the effort of the test conditions on two performance measures of aircraft kills and losses. The test condition had no significant impact on either performance measure, supporting the null hypothesis; a stop or even the threat of a stop to collect SAGAT data did not have a significant impact on performance.

Although it is never possible to "prove" the null hypothesis (SAGAT does not influence performance), all of the studies conducted so far indicate that it does not appear to significantly influence performance (Endsley, 2000a, p. 164).

The most widely used objective measure of situation awareness, SAGAT has been shown to have good levels of criterion, construct, and predictive validity. This inquiry is replicating use of the Situation Awareness Global Assessment Technique in the domain of football.

Overview of Study Phases

The present study unfolds in five phases: semi-structured interviews, goal-directed task analysis, situation awareness global assessment questions, programming the virtual simulator, and using the PlayAction Simulator PC as a SAGAT simulator tool. An overview of these five phases of the methodology is provided here as a framework for understanding the processes of the study, and then the phases are described again individually in more detail later in this chapter for insight into the details of the methodological processes employed.

Semi-structured interviews. The results of Phases I, II, and III provide the answer to the first research question concerning the situation awareness requirements for expert decision making in the domain of the NCAA quarterback. In Phase I, the researcher conducted five voice recorded, semi-structured, emergent interviews with five record-setting NCAA coaches and quarterbacks in an attempt to uncover the information requirements for completing the cognitively demanding task of reading and recognizing complex NCAA defenses. Using the guidelines of a goal directed task analysis, the codification and analysis of the interview data identified the goals a quarterback is attempting to achieve in order to accomplish his mission, the decisions that must be made in order to accomplish these goals, and the specific information that is needed to support

these decisions (Endsley et al., 2003). The results of the analysis are presented in five separate color coded interview charts, as seen in Figure 5 below.

Name: _____

Date: _____

Location: _____

Activity	Goals	Decisions	Information Requirements	Notes

Figure 5. Interview recording chart

Goal directed task analysis. In Phase II, the results of the individual interviews were synthesized and compiled into a finalized Goal Directed Task Analysis Chart, as seen in Figure 6 below. This analysis yielded the situation awareness requirements for the collegiate Run and Shoot quarterback.

Figure 6. Goal directed task analysis chart

Situation awareness global assessment questions. Using the situation awareness requirements developed in the goal directed task analysis, the researcher developed queries designed to measure the situation awareness of a collegiate quarterback. The Situation Awareness Global Assessment questions were then categorized according to the three levels of situation awareness postulated by (Endsley, 1995b), which are Level 1 (perception), Level 2 (understanding), and Level 3 (projection). These activities comprised Phase III of the study.

The development and quality of psychometrically sound queries is an essential step in the process and a prime determinant of the effectiveness of the technique. To ensure that the questions were posed in a cognitively compatible manner, the researcher

forwarded the queries to SMU Offensive Coordinator Dan Morrison. Mr. Morrison was asked to review and validate each question based on the following criteria: (a) articulated in a domain appropriate manner, (i.e., is this the way you would ask this question?), and (b) is this question measuring what we want it to measure? The results of this process are presented in Chapter 4 in the form of 28 queries designed to objectively measure the SA of quarterbacks who are attempting to read and recognize a collegiate defense.

Armed with a set of high quality questions, the researcher unveils the processes and procedures listed below that were designed to answer the study's second research question concerning the affordances of virtual simulation as a tool to measure the situation awareness of NCAA quarterbacks.

Programming the virtual simulator. In Phase IV, using the specifications of the information requirements analysis, the researcher describes how he coordinated the programming of SAGAT queries into a virtual simulator called the PlayAction Simulator PC. The Simulator PC runs on a laptop computer and " leverages the same animation and gaming technologies used to in EA Sports' standards-setting video game titles to create a training tool that operates like a video game but works with a team's real plays" (XOS Sports, 2007, p. 1). Proof of this concept through these results are presented in the form of screen shots of the offensive and defensive reactions at pre-motion, pre-snap, post-snap, decision making and action points.

PlayAction Simulator PC as a SAGAT simulator tool. Phase V of the study focused on empirically investigating the ability of the PlayAction Simulator PC, first to provide the ecological validity required for the quarterback to extrapolate the information necessary to answer the SAGAT questions, and second, to ascertain if the PlayAction

Simulator PC can be used in conjunction with the SAGAT methodology to objectively assess a quarterback's situation awareness.

Using a proof of concept framework, the results are presented in Chapter 4 via screen shots of the live game action. The next section of this manuscript will provide the detailed procedures involved in executing each step in the process, and an overview is provided in Figure 7.

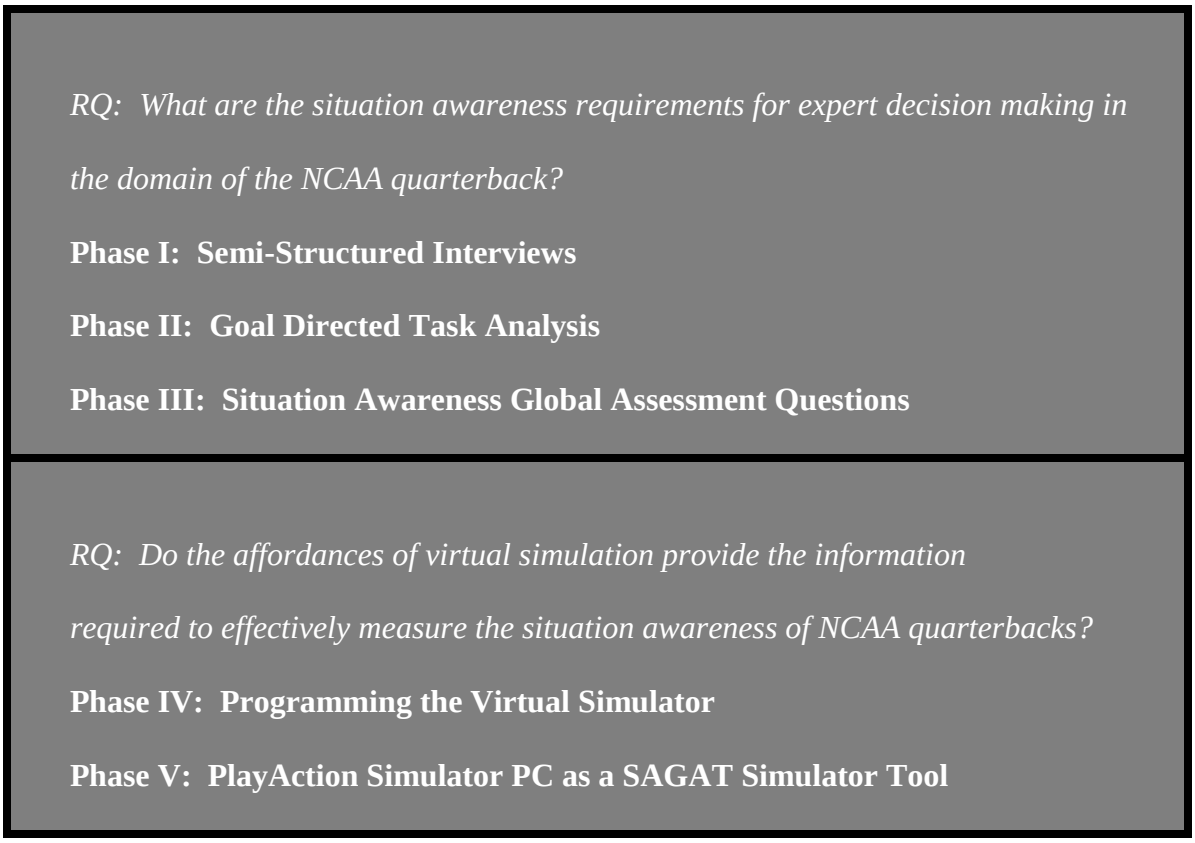


Figure 7. SAGAT methodology applied in the domain of American football

Phase I Methodology: Conducting Interviews

Recruitment and selection of participants. The participants were recruited from a pool of record-setting Run and Shoot coaches and quarterbacks. Eight letters of

invitation were emailed, mailed or hand-delivered by the researcher. The decision was made to study time constrained, adversarial decision making in Football, through the lens of the Run and Shoot quarterback for two reasons. First, the Run and Shoot offense has proved to be the most prolific passing offense of all-time at both the NCAA and NFL levels. Run and Shoot quarterback Neil Lomax, playing for head coach Mouse Davis at Portland State, threw an NCAA record seven touchdowns in one quarter. Run and Shoot quarterback David Klinger, playing for Head Coach John Jenkins at the University of Houston, threw an NCAA record 11 touchdowns in a game and in another game broke the NCAA record for most passing yards in a game -- 716! That same year (1990), David Klinger threw for an NCAA record 54 touchdown passes in 11 games. This record stood for over 15 years until another Run and Shoot quarterback, Colt Brennen, (2006), under the tutelage of Quarterback Coach Dan Morrison (2006), threw for an NCAA record 58 touchdowns while leading June Jones and University of Hawaii to a top 10 ranking.

The success of the offense is predicated on the quarterback's ability to perceive and understand the defensive coverage as well as project the future movements of (a) his receivers who are running multiple adjusting routes, and (b) an adversarial and complex defense. Essential to his success is his ability to parlay that aerial hypothesis into a correct decision within a 3.5 second window of opportunity. This is a uniquely cognitively demanding task that seems to mirror the theoretical framework described in recognition primed decision making.

Thus, qualification for participation in the study was as follows:

1. Quarterback coach, offensive coordinator or Head Coach at a university currently using the Run and Shoot Offense.

2. Former Head Coach of a NCAA record setting (points, total yardage, passing yards, etc.) Run and Shoot team.

3. Former record-setting NCAA quarterback in the Run and Shoot Offense.

4. Record setting NFL quarterback in the Run and Shoot Offense (past and present).

5. Former Head Coach of a NFL record setting (points, total yardage, passing yards, etc.) Run and Shoot team..

From this pool of coaches and quarterbacks the researcher sought to understand this decision making process through the lens of a Goal Directed Task Analysis, formulated with a team of at least one NCAA Head Coach, one NCAA Offensive Coordinator, one NCAA Quarterback Coach, one Coach who was a former player, and one highly accomplished former player associated with the prolific performance of this record setting offense along with an additional NCAA Coach to validate the findings.

Participants in the study. With their permission and informed consent, five record setting Run and Shoot coaches and quarterbacks were interviewed, including University of Hawaii Quarterback Coach Nick Rolovich, who once threw for over 1,500 yards and 20 touchdowns in three games; Southern Methodist University Offensive Coordinator Dan Morrison, who tutored two of the most prolific passers in NCAA history, Timmy Chang and Colt Brennen, the NCAA All-Time Leader in passing yards in a game (716), touchdowns in a game (11), and touchdowns in an 11 game season (54); Quarterback David Klinger; Head Coach John Jenkins who has coached Hall of Famer Jim Kelly, Heisman Trophy winner Andre Ware, and the Record Setting David Klinger; and the creator of the modern day double-slot offense, Coach Darrel “Mouse” Davis.

Every record setting Run and Shoot coach and quarterback is a part of lineage that traces back to Coach Mouse Davis.

Data collection and review procedures. Several systematic processes were used to collect, analyze and interpret the data. Explained herein are the steps for conducting the interviews, creating a narrative, coding the data obtained, and categorizing the elements of situational awareness.

Conducting the interviews. In preparation for the interviews, the researcher -- a former quarterback, receiver and coach in the run and shoot offense himself -- reviewed the current literature and instructional DVDs related to training run and shoot quarterbacks to read defenses. The literature and DVDs provide detailed guidelines concerning the following elements: the quarterback's pre-snap procedure, his basic key reads to help him easily make decisions before he gets to the end of his drop, how to recognize various coverages, and the difference between a pure progression and a key progression for the quarterback. The DVDs feature detailed drawings and film cut-ups from the highest level of competition including on the field demonstrations from NCAA and college coaches.

Additionally, the researcher thoroughly reviewed the literature on the Situation Awareness Global Assessment Technique (SAGAT) methodology including the process involved in conducting a Goal Directed Task Analysis which has been detailed previously in this chapter.

The interviews, voice-recorded, semi-structured, and emergent were conducted on-site, one-on-one with five subject matter experts (SME's). The interviews were semi-structured within the parameters of interview technique (open ended questions) pre-

determined topic (activities related to reading, recognizing and attacking defenses through the lens of the choice route structure), and pre-determined categories (Goals, Decisions and Information Requirements) using the framework listed in the chart in Figure 9, described later in this chapter. Semi-structured interviews are the preferred data collection tool used in conducting a Goal Directed Task Analysis (see Endsley et al., 2003). The semi-structured interviews lent themselves to a rich, in-depth, two-way communication between researcher and participant, related to attacking the defense and completing passes.

The interviews, iterative and sequential, were designed to help the researcher understand the teaching, learning, training and implementation associated with the decision making of the Run and Shoot quarterback through the varied and rich lens of the participants. Thus the researcher strategically interviewed the participants in an order that would uniquely build on the body of knowledge of each participant's perspectives. In an attempt to maintain confidence among the participants, the actual order is not revealed in this manuscript. The researcher probed for confirmation, extensions, commonalities, differences and distinctions among the participants to understand the link between how the information is taught and how it is implemented on the field of play. Each interview resulted in a separate interview chart which built upon the previous interview. The interviews were designed to be iterative, in other words to build on and extend the conversation of the previous participant. Thus, the researcher used a process of confirm and extend. But inherent in this technique was the discovery of commonalities, along with a few subtle and not-so-subtle differences.

Each interview began with the researcher explaining the purpose and intent of the interview, which was to gather information about the process of reading, recognizing and attacking defensive coverages using the “Choice” route structure. The researcher chose the Choice Route because the quarterback has to execute both a “read” and “pure” progression of the entire football field. The multiplicity of this play presents a cognitively demanding process for the quarterback and as such, a rigorous design challenge for the Simulator PC.

Next, using a video-based example of a collegiate quarterback executing the Choice route, the researcher presented the following scenario to each participant: describe the overarching goal of the quarterback as he walks to the line of scrimmage. Key decisions relevant to those goals and the information required to make those key decisions were elicited. It is important to note that while the beginning questions were all the same for each participant, the interviews were emergent; when a participant found a rich vein of information that confirmed, extended or distinguished about what is known about the process of reading and recognizing defenses, the researcher allowed that conversation to emerge. Each interview lasted approximately two hours.

Creating a narrative of the interviews. The researcher, using written notes from the voice-recorded interviews, transcribed the questions and answers from each interview and examined them for evidence of information that extends our knowledge of the goals, decisions and information requirements related to expert decision making in the domain of the collegiate quarterback. The narrative dialogue from the interviews was subsequently coded into the interview chart according to the guidelines listed below.

Coding the interviews. The analysis of the interviews was conducted by categorizing the interview data into the Interview Categorization Chart, listed in Figure 8 below, according to the guidelines of a Goal Directed Task Analysis, which includes recording the context of the activity (perceptual or action) and other elements of the activity into the categories of goals, decisions, and information requirements. Descriptions of these chart categories are included below.

Name: _____

Date: _____

Location: _____

Activity	Goals	Decisions	Information Requirements	Notes

Figure 8. Interview categorization chart

Definitions of interview categorization chart elements. The definitions below, developed from previous research in this area, were used to guide the data coding and

categorization processes of this study. Detailed explanations, where needed to describe particular aspects of the definitions, are provided along with references to the literature.

Activities: The activity section provides the context and flow for the topic being discussed. The information associated with the activity, such as discussion, is categorized according to the following guidelines.

Goals: Goals are higher-order objectives essential to successful job performance. The information gleaned from the interviews that led to the determination of the main goal and sub-goals of the quarterback are listed under Goals and color coded in Blue in the full-color manuscript (thus, in dark grey in reprints). The main goal has three sub-goals associated with it. The goals increase in specificity as they move down the hierarchy.

Decisions: "Decisions are associated with a specific goal, although a similar decision may play into more than one goal. These decisions are essentially the questions the decision maker must answer in order to achieve a specified goal. "These questions require the synthesis of information in order to understand the situation and how it will impact its associated goal" (Hoffman, Crandall, Klein, Jones, & Endsley, 2008, p. 121). Information gleaned from the interviews that related to the decisions a quarterback has to make to achieve the associated goals were posted under the Decisions heading and color coded in Red in the full-color manuscript (thus, in medium gray in reprints).

Situation Awareness Requirements: The information needed to answer the questions which inform the decisions. These information needs are the decision maker's situation awareness requirements. Situation awareness (SA) can be defined as "the perception of the elements in the environment within a volume of time and space, the

comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988, p. 97). From this definition, three levels of situation awareness can be identified: Level 1, which involves the most basic data that is perceived; Level 2, which involves an integration of Level 1 data elements; and Level 3, which involves projecting how the integrated information will change over time. The SA requirements analysis identifies and documents relevant information at all three of these levels. Information gleaned from the interviews that was associated with the information requirements needed to accurately answer the decision question was color coded in Green in the full-color manuscript (and thus, in light gray in reprints).

The researcher used the Notes section to provide context to the data and to show where additional sources such as books, instructional CDs, and articles were used to confirm or bolster the claims of the participant.

Phase II Methodology: Developing the Goal Directed Task Analysis

Once interviews were completed and coded into the interview chart, the results of the individual interviews were synthesized and compiled into a finalized Goal Directed Task Analysis chart. This three-step process is explained in detail in the following section. This analysis yielded the Situation Awareness requirements for the collegiate Run and Shoot quarterback.

Step 1: Develop the goal hierarchy. Step one in the process entailed the extrapolation and posting of information from the interview charts that related to the goals that the quarterback is attempting to accomplish as he walks up to the line of scrimmage. A goal represents a cognitive demand. "Cognitive demands are items that require higher-order cognitive resources" (Endsley et al., 2003, p. 71). Since goals are

essential for information acquisition and use in a variety of systems, they form the foundation for this type of cognitive task analysis.

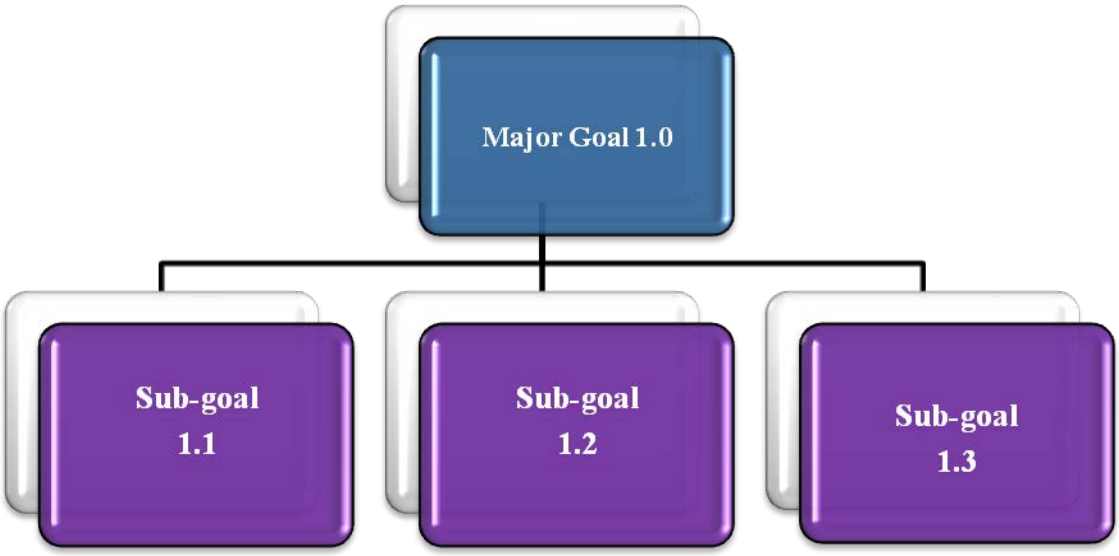


Figure 9. Sample GDTA goal hierarchy

Step 2: Identify decisions the quarterback must make. The next element of the GDTA involves the decisions which must be made in order to achieve a particular goal. "Decisions are associated with a specific goal. These decisions are essentially the questions the decision maker must answer in order to achieve a specified goal. These questions require the synthesis of information in order to understand the situation and how it will impact its associated goal" (Hoffman et al., 2008, p. 121).

The researcher, using the data that was coded into the interview chart, linked the associated decisions and goals. Further, after completing the process of organizing the interview notes into the relation hierarchy, existing coaching manuals and instructional DVDs were referenced to help fill in details of any concepts mentioned.

Step 3: List the information needs (SA) of the quarterback. The final element of the GDTA entailed the identification of the information the quarterback needs to know in order to answer the questions that form the decisions. These information needs are the decision maker's situation awareness requirements. Situation awareness (SA) can be defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988, p. 97). Again, from this definition, three levels of situation awareness are identified: Level 1 SA, or the detection of the environments relevant elements; Level 2 SA, or the comprehension of the element's meaning; and Level 3 SA, which involves projecting how the integrated information will change over time.

Phase III Methodology: Developing the Situation Awareness Global Assessment (SAGAT) Questions. In this phase of the study, the researcher developed and validated queries designed to measure higher levels of SA the field of football. Based on the information requirements established from the goal-directed task analysis, a list of the SA measurement queries (SAGAT) for reading complex NCAA defenses was constructed. Using guidelines developed by Endsley et al. (2003), the researcher categorized the information from the SA requirements analysis into three levels of situation awareness in the dynamic domain of the quarterback.

Developing and administering queries that are relevant to the quarterback's SA in this experimental setting is a prime determinant of the effectiveness of the technique. To ensure that the questions were posed in a cognitively compatible manner, the researcher forwarded the queries to SMU Offensive Coordinator Dan Morrison. Mr. Morrison was asked to review and validate each question based on the following criteria: (a) articulated

in a domain appropriate manner (i.e., is this the way you would ask this question?); and (b) is this question measuring what we want it to measure?

Phase IV Methodology: Programming SAGAT Probes into the PlayAction Simulator PC. In this section, the researcher describes the process that was followed in getting the virtual simulator programmed according to the specifications of the information requirements analysis and provides a detailed analysis of the results from the customized scripting of the PlayAction PC designed exclusively to train and measure the situation awareness and decision making of the Run and Shoot quarterback. Phases IV and V of the study provide the answer to the second research question concerning the affordances of virtual simulation provide the information required to effectively measure the situation awareness of NCAA quarterbacks.

XOS Sports (2007) explains that "the Simulator PC leverages the same animation and gaming technologies used to in EA Sports' standards-setting video game titles to create a training tool that operates like a video game but works with a team's real plays" (p. 2). Thus, by operating a familiar game controller, "the quarterback using this tool can practice reading a defense, picking up blitzes and making quick decisions on where to throw the ball; all based on the tendencies of the team he is going to play the upcoming weekend" (XOS Sports, 2007, p. 2). In Phase IV of this study, the researcher sought empirical evidence to support those claims.

Using the specifications of the information requirements analysis, the researcher describes the process used to program SAGAT questions into a virtual simulator called the PlayAction Simulator PC and the subsequent results of that endeavor. The programming was designed to answer two questions: (a) Can a Run and Shoot offensive

play could be programmed to run against a specific type of complex collegiate defense? (b) Can Situation Awareness Global Assessment questions could be programmed into the simulator? The results are presented in Chapter 4 and in the Appendix in the form of screen shots of the offensive and defensive reactions at pre-motion, pre-snap, post-snap, decision making and action points, and described here through representative sample figures below.

Step 1: Pilot demonstration of the product. Through-out the first Phase of this study, the researcher kept in constant (bi-monthly) contact with Mr. Joe Schrimpl, Regional Sales Manager at XOS Digital, keeping him abreast of his research efforts in preparation for programming the Simulator PC. Armed with a set of validated SAGAT questions, the researcher contacted Mr. Schrimpl, and gave him an overview of the study's needs. The researcher forwarded via email the offensive plays, defensive coverages and fronts, SAGAT questions, and diagram specifications including player alignment, field location and player movements required for the study. Mr. Schrimpl facilitated a conference phone call between himself, the researcher, and Albert Tsai, Vice President of Advanced Research and Development at XOS Digital. This meeting culminated in a web-based product demonstration featuring the PlayAction Simulator PC which highlighted the capabilities of the simulator. Seeing what the product could do in general, the researcher asked if XOS Digital could or would program and script a customized presentation centered on the unique needs of the Run and Shoot quarterback. After consulting the corporate leadership at XOS Digital, Mr. Schrimpl agreed. XOS Digital Senior Engineer John Scott was called in to program the simulator according to the unique information requirements of the Run and Shoot quarterback.

The following items in Step 2 outline the procedures involved in creating the customized plays accompanied with screen shots that demonstrate the results of this endeavor. The diagrams and explanations represent the conversations between the researcher and the simulator designers.

Step 2: Selecting the play. The researched selected the CHOICE route because it represents a cognitively demanding task for the quarterback in which the play represents a whole field progression with two types of reads, a "read" to the front-side of the route (where the ball will be thrown is dependent on the technique and positioning of the defensive player), and a "look" to the backside of the route (in which the quarterback is looking to confirm that the receiver's multiple adjusting route is attacking a weakness in the zone or creating separation versus man-to-man coverage). The researcher forwarded the following diagram (Figure 10) and its accompanying explanation to Mr. Scott with a request for programming.

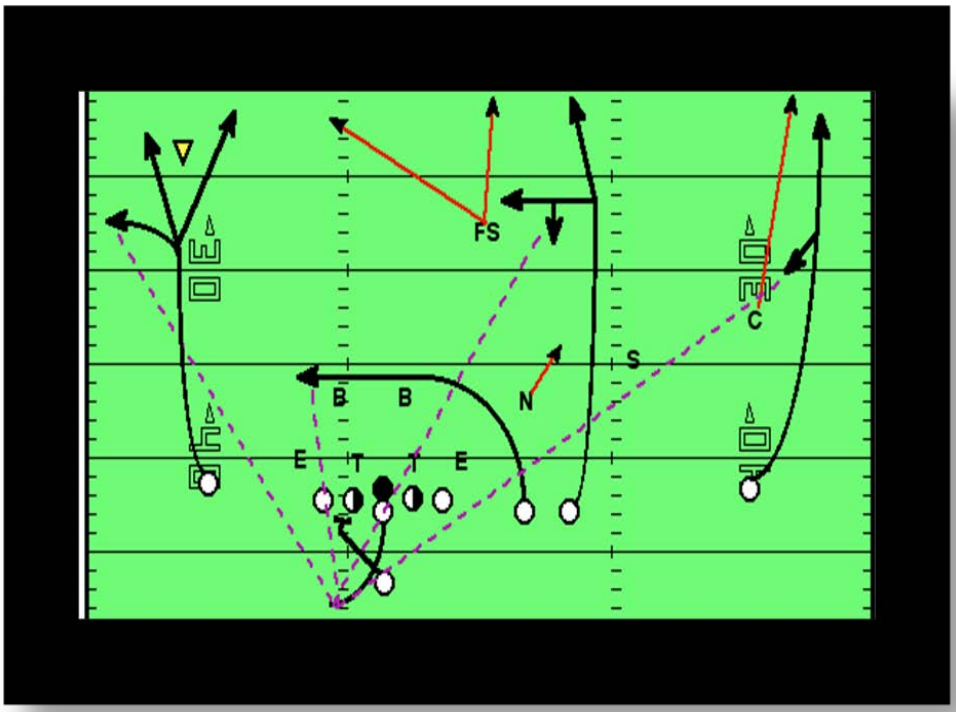


Figure 10. Choice play route diagram and explanation

The name of the play is Choice. The Choice Route is a trips formation route that is run to the single receiver side of the formation. At the snap of the football, the quarterback will take a soft roll, i.e., three steps to the left, and the running back, (called a Superback in the Run and Shoot offense) will pass-protect to the left side (play-side) of the formation, i.e., 61 protection. The receiver to the left side of the formation runs a "Choice Route" out, fade, or post, depending on the technique of the defender.

There are several possible adjustments that all four receivers will make depending on the post-snap reaction of the defense. To mitigate this dilemma, the researcher created individual play cards that were used to script the offensive and defensive movements according to the rules associated with the Run and Shoot offense. The researcher

forwarded (a) three variations of the choice route, choice, choice special and choice switch, (b) three variations of a Cover 3 (pre-rotated, buzz and cleo) defensive scheme and (c) a set of SAGAT queries. One example is provided in Figure 11, which was sent to Mr. Scott along with its accompanying explanation below.

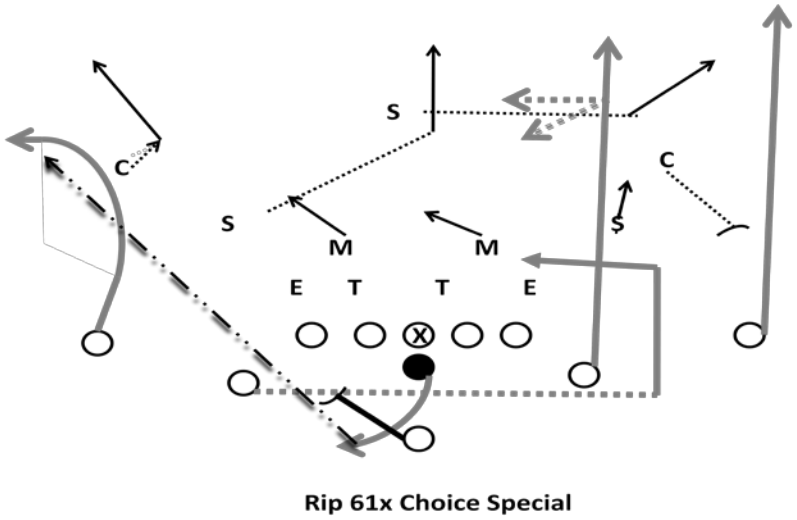


Figure 11. Sample play request and explanation sent to XOS Digital

The Play: Rip-61 X Choice (Special)

In this example, the offense will come out in a balance formation, (Even (2x2), i.e., two receivers to each side of the formation. The inside (slot receiver (w)) will come in motion to the right of the formation, Rip (motion), creating trips, i.e., three receivers, to the right side of the formation. At the snap of the football, the quarterback will take a soft roll, i.e., three steps to the left, and the running back, (called a Superback in the Run and Shoot offense) will pass protect to the left side (play-side) of the formation, i.e., 61 protection…

This play request was also sent with the instructions:

Offense: Even (2x2), Rip (motion) 61 (pass protection set to the left) in Choice (the play)

Defense: Pre-Motion (cover 3 strong side zone), Pre-Snap (cover 2), Post-Snap (cover 3, CLEO coverage)

Therefore, the programmer now had enough information to execute the appropriate decisions within the software.

Step 3: Diagramming the play. Using XOS PlayTools, a "football specific diagramming tool" (XOS Sports, 2007) to diagram the plays, along with GoToMeeting®, phone, text and email to collaborate, the researcher and XOS Digital engineer, Mr. Scott diagrammed the customized plays.

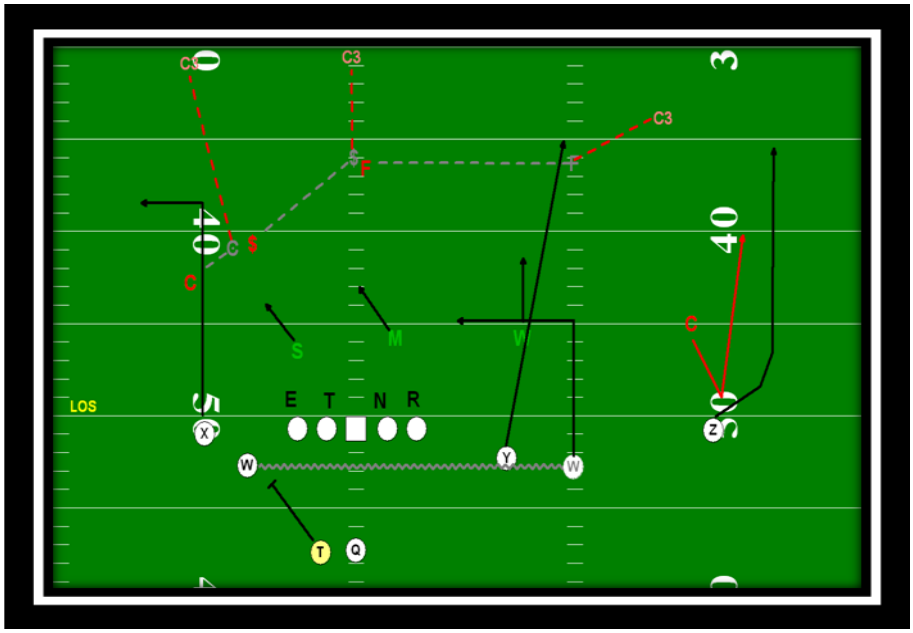


Figure 12. Sample XOS Digital customized diagram. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Step 4: Publishing the plays. After the plays were diagrammed, Mr. Scott published the plays using the XOS Publisher. The diagram in Figure 13 below is an example of the simulator result of the "published" PlayTools diagram.

Figure 13. Published simulator PlayTools diagram. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Proof of concept. After the plays were "published," the researcher sought to answer specific questions related to the capabilities of the PlayAction Simulator PC:

1. Can a Run and Shoot offensive play be programmed to run against a specific type of complex collegiate defense?
2. Can Situation Awareness Global Assessment questions be programmed into the simulator?

Results of these specific questions, as provided by the output from the PlayAction Simulator PC, are provided in Chapter 4.

Phase V Methodology: Testing PlayAction Simulator PC as a SAGAT Simulation Tool. In this phase of the study, the researcher focused on empirically investigating the ability of the PlayAction Simulator PC to be used as a SAGAT Simulation tool. As

previously described, a SAGAT Simulation tool must be able to meet the following criteria:

1. Simulation is frozen (stopped) at random intervals.
2. System displays go blank and the simulation is suspended.
3. Participants are queried as to their perception of the situation.

Phase IV provided evidence of the simulator's ability to (a) freeze at random intervals and (b) go blank and suspend the action. The most salient system requirement examined in this Phase was the ability of the PlayAction Simulator PC to provide the information necessary to answer the SAGAT questions as the screen goes blank and the questions are strategically displayed on the screen. The results are presented in Chapter 4 through screen shots of the live action.

View from the virtual pocket methods. In preparation for a customized presentation to a major Division I football program, the researcher switched the simulator to "quarterback" view, which is available by pressing the correct button on the XBox controller, to ascertain if the collegiate Run and Shoot quarterback could extrapolate the information necessary to read, recognize and attack collegiate defenses. The information threshold was aligned with the following scenario:

In Choice, the 1st Read is the play-side corner. If he is 5 yards or higher the (x) receiver will run a speed-out. On this 1st read the quarterback has to "read" the corner and "see" the outside linebacker. Check-list Question: Can the quarterback read the depth of the corner and see the outside linebacker's technique?

If the 1st read is not open, the quarterback will execute a "look" on the backside (trips side) of the route. If the Free Safety is "perfect", i.e., in the middle of the field and

high over the top, i.e., 7 yards deeper than the receiver running the seam route the receiver will run a deep in route at a depth of 14 yards and find an open lane back to the quarterback. If the FS has over-rotated i.e., pass the hash, to the roll of the quarterback, the receiver will run up the hash for a touchdown. Check-list question: Can the quarterback read the depth and technique of the Free Safety and can he "see" the open receiver?

Switching to quarterback view has implications on the ability of the Simulator to be used as a tool to train situation awareness. These implications will be discussed in Chapter 5. However, results obtained via use of the methodology described in this study appear next in Chapter 4 and in Appendix C.

Chapter 4

Overview of Results

This chapter will describe the results of a systematic analysis of situation awareness requirements in the domain of the collegiate quarterback and the process by which these results were obtained via the Situation Awareness Global Assessment Technique (SAGAT) methodology. The results contained herein represent the findings of a proof of concept study, from the idea of a theoretical proposition about the situation assessment process in time-constrained decision making to the development of global and testable measures of situation awareness in the domain of collegiate football. Embedded in the findings is an empirical investigation into the affordances of virtual simulation with respect to the ecological validity required to measure situation awareness.

The first research question was: what are the situation awareness requirements for expert decision making in the domain of the NCAA quarterback? This question was answered via a three-phase systematic informational requirement analysis in the domain of the collegiate quarterback. This analysis yielded the Goals, Decisions and Information that quarterbacks need to know in their quest to parlay a successful aerial hypothesis into a completed pass. Equally important, the results of this study highlighted the situation assessment process (perception, comprehension and projection) that the quarterback uses to acquire and use this information, and yielded a guide to developing sound questions designed to measure the quarterback's situational awareness in the virtual pocket.

The second research question was: do the affordances of virtual simulation provide the information required to effectively measure the situation awareness of NCAA quarterbacks? This question was answered through the development and programming

of a innovative virtual experimental lab that allowed the researcher to conduct a series of live trials which evaluated the ability of the Simulator to be used as a SAGAT simulation tool in the assessment of a quarterback's situation awareness. The simulator's ability to be programmed to randomly display questions which are designed to measure the SA of the quarterback provides an ecologically sound environment as well as the information the quarterback needs to answer the probes; herein they are represented by a series of screen shots of the live action.

Results of this data analysis will be presented in five phases. Question 1 was answered through the results generated through Phase I, Semi-Structured Interviews; through Phase II, Goal Directed Task Analysis; and through Phase III, Situation Awareness Global Assessment Questions. Question 2 was answered through the results contained in Phase IV, Programming the Virtual Simulator; and through Phase V, Assessing the role of the PlayAction PC as a SAGAT-Simulation Tool.

Results in Answer to Research Question 1

Phase I: Results of semi-structured interviews. With their permission and informed consent, five record-setting Run and Shoot coaches and quarterbacks were interviewed. The researcher transcribed the questions and answers from each interview and examined for evidence of information that extends our knowledge of the goals, decisions and information requirements related to expert decision making in the domain of the collegiate quarterback. The results of the narrative dialogue from the interviews were subsequently coded into individual interview charts. For a review of the procedures and guidelines involved in the elicitation and coding of the individual interviews see Chapter 3.

Coding the interviews. In order to assure that the list of situation awareness components resulting from the individual interviews was complete and representative of the situation awareness requirements for reading, recognizing and attacking the collegiate defense, the researcher conducted an analysis of the interviews by categorizing the interview data into the Interview Recording Charts as listed in Figure 8. The data was categorized according to the guidelines of a goal directed task analysis, which includes recording the context of the activity (perceptual or action) and other elements of the activity related to the categories of goals, decisions, information requirements.

The analysis aimed to establish the primary goals of the quarterback, the sub-goals appropriate to meeting those goals, the decisions that are linked to achieving those goals, and information the quarterback would like to know in attempting to make an accurate decision. An example of the knowledge elicitation procedure and resulting data coding process is provided in the charts, as seen in Appendix C. The common activity among them is “properly reading the play-side corner.”

Examples of the interview data appear in Table 1 below.

Table 1

Participant interview charts

Participant # 1

Activity	Goals	Decisions	Information Requirements	Notes
Reading the play-side corner			The first read is the corner to the single receiver side of the formation. Q. "How will I know what route the receiver will run?" A. "(1) By the cushion of the corner at the decision making point (2) by the body language of the receiver"	"Choice is a whole field progression" Explained that "It takes a lot of repetitions to develop this skill. Part of our practice routine is to have the receiver and the quarterback practice "on air," i.e., no defender so that the quarterbacks learn the body language of the receivers at their decision point.

(continued)

Participant # 2

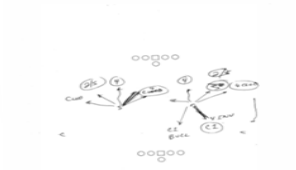
Activity	Goals	Decisions	Information Requirements	Notes
Play-Progression (note: participant is describing the sequence related to the qb's 1st read in the Choice route		"Based on the cushion of the play-side corner at the decision point the receiver will run one of three routes"		"You anticipate, but you can't predetermine based on pre-snap information." Provided the following example: "You walk to the line of scrimmage", the route is choice. "Based on the cushion of the corner at decision point, the receiver will run one of three routes. If, prior to the snap, the quarterback sees the corner at a depth of 10 yards, he may pre-determine that he will be throwing option #1, but if the defender that he is reading never gains any depth, the receiver will have closed the "cushion" on the receiver, calling for the receiver and qb to execute option #2.

(continued)

Participant #3

Activity	Goals	Decisions	Information Requirements	Notes
Q. “Take me through the read progression in the Choice Route”	Understand affordances of each coverage category as it relates to the 1st read in the Choice Route		Listed in the Qb manual.	A. “before we get to the field the quarterback has to have a complete understanding of the defensive opposition.”

Participant # 4

Activity	Goals	Decisions	Information Requirements	Notes
Read Progressions in the Choice Route	Identify the coverage and find the routes, within the route structure that attack the weakness of the defense.	What is the coverage category	 The info req. are in this diagram; You see the safeties, you see the coverage “read” the play-side cornerback and “see” the safety. read the frontside then reset his hips and feet to attack the weakness in the back coverage.	Meticulous attention to detail, high repetition, low interference learning environment. The participant diagrammed how he uses a pattern recognition system to identify the 10 coverage categories. Once he recognizes the coverage, he has a mental model of the weakness of that coverage.

(continued)

Participant #5

Activity	Goals	Decisions	Information Requirements	Notes
Choice Route· Read Progression	The goal is to "identify (read and recognize and attack the weakness in the defense". we don't believe we will score on every play but if we read it, run good routes and get good identification of the coverage, we WILL complete the pass."	What is the coverage category What is the technique of the play-side corner	"The offense lines up in a double slot formation. Inside slot comes in motion. The half-field safety follows the receiver across the formation. The other safety comes off the hash and moves to the middle of the field. The safety's eyes are on the receiver. This is a pre-snap read of "cover three man under" look that tells the quarterback how the defense will react to the backside of the play. At the snap of the ball the quarterback will read the technique of the play-side corner. Is he in a man technique, legs crossing over with his back to the sideline or in a zone technique, back peddling? If the receiver closes the cushion on the corner he will run a streak or a skinny post, if the corner is more than five yards off of the receiver the receiver will run a speed out.	Interesting note, according to the participant, the defense can be employing a zone concept, but the corner is employing a man technique. Versus zone the qb has 3 reads, versus man it's two, against man to man it's one of two routes. Quarterback has to anticipate which route the receiver will run.

(continued)

Activity	Goals	Decisions	Information Requirements	Notes
			The quarterback must make this decision by his 5th step and the ball must be out by this 7th step. If the play-side linebacker has gotten under the route via his flat responsibility or if the receiver and the quarterback make different reads the quarterback will shuffle his feet and find the receiver running the seam read. ---------- Participant says the quarterback will do this so many times in practice, "he can read the body language of the receiver. ---------- This is a sequential process and that the quarterback is only reading a portion of the defense. (serially generated)	

Phase II: Results of the Goal Directed Task Analysis

Once interviews were completed and coded into the interview chart, the results of the individual interviews were synthesized and compiled into a finalized Goal Directed Task Analysis chart. The results of this three-step process are explained in detail in the following section. This analysis yielded the Situation Awareness requirements for the collegiate Run and Shoot Quarterback.

Step 1: Develop the goal hierarchy. The next section demonstrates how the resulting interviews led to the formulation of the Goal Structure within this Goal Directed Task Analysis.

Goal 1.0, attacking the defense. There was a general agreement among the participants about the overarching goal of the quarterback (attack the defense) as evidenced by the following responses. Participant # 1: "Complete the pass and attack the weakness of the defensive coverage"; Participant # 2: "Be productive…productive equates to completing passes, ideally at a rate of three TD's to one interception"; Participant # 3: "The goal of the quarterback is to understand, read, and recognize the defensive coverage", because it's "always about the physical task of completing the pass." The researcher asked, participant # 5: "So the mental goal is to read and recognize the defensive coverage?" Participant #5 stated that reading and recognizing the defense is only a part of the cerebral equation. He indicated that the goal is to "identify (read and recognize) and attack the weakness in the defense. We don't believe we will score on every play but if we read it, run good routes and get good identification of the coverage, we WILL complete the pass." Participant # 4's approach was slightly different, stating the goal of the quarterback is to "throw touchdowns, score, score quickly, score in one. We were not interested in 10 play drives. We wanted to score now!"

A synthesis of the interviews led to a determination that the goal or cognitive demands of a quarterback when attempting to complete a pass is to successfully attack the defense. Three sub-goals emerged from the goal of successfully attacking the defense: identifying the coverage category, understanding the strength and weakness of

the coverage category, and understanding how the conversion routes will adjust to the identified coverage.

Sub-goal 1.1, identifying the coverage category. Participant #1 and Participant #2 highlighted the process of reading, recognizing and attacking the defensive coverage. Participant #2 and Participant #5 shared the six families of coverages. Participant #3 extended the family tree to 10 coverage categories, showing a myriad of variations to each category and demonstrating the dynamic nature of unveiling the disguises of complex collegiate defenses. This data from the interview charts was merged and posted in the Goal Hierarchy of the GDTA. This process of synthesizing and posting the data in the appropriate section of the GDTA chart is manifested in each step of the compilation process.

Sub-goal 1.2, understanding the strength and weakness of the coverage category. Participant #3 identified the strength and weakness of each coverage and gave the researcher unfettered access to his innovative coaching manual. In the manual are football field diagrams drawn to scale. The diagrams, coupled with film clips, give the quarterback a visual image of the affordances that each coverage category provides. According to Participant #4, the offense is executed on the field exactly as it is diagrammed in the coaching manual.

Sub-goal 1.3, understanding how the conversion routes will adjust to the indentified coverage. All of the participants contributed to the discussion of how the Choice play adjusts to coverage. All agreed that this knowledge is indispensible in the quest to successfully attack the defense.

The results of Step 1 of the GDTA chart are shown in Figure 14.

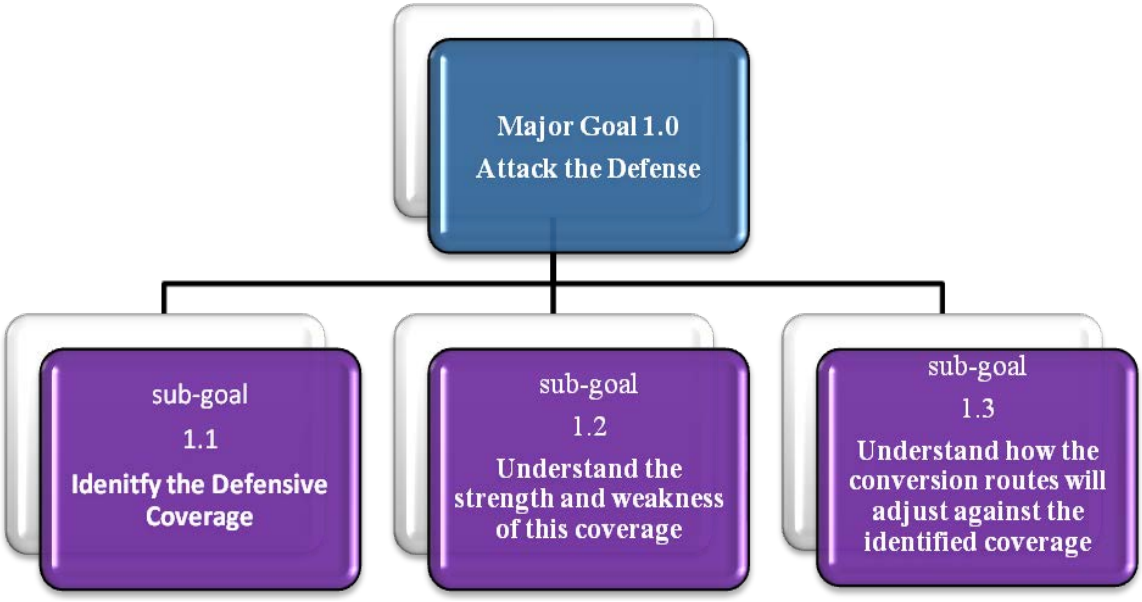


Figure 14. Step 1 GDTA results chart

Step 2: Identify decisions the quarterback must make. The next element of the GDTA involves the decisions which must be made in order to achieve a particular goal. "Decisions are associated with a specific goal. These decisions are essentially the questions the decision maker must answer in order to achieve a specified goal. These questions require the synthesis of information in order to understand the situation and how it will impact its associated goal" (Hoffman et al., 2008, p. 121).

The researcher, using the data that was coded into the interview chart, linked the associated decisions and goals. After the researcher completed the process of organizing the interview notes into the relational hierarchy, existing coaching manuals and instructional DVDs were referenced to help fill in any details about concepts mentioned.

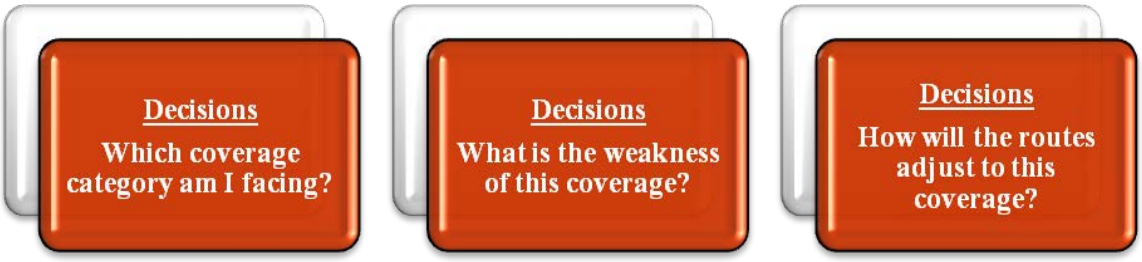


Figure 15. Step 2 GDTA results chart

Participants #1 and #2 introduced the researcher to the decisions the quarterback has to make and the process for making those decisions, as evidenced by a few of these highlighted quotes: Participant #1: "When reading the coverage you need to understand the defensive responsibility"; Participant #2: " There are a lot of 'layers' to this process. Part of the layering process is 'identifying coverages and understanding the route structure' and 'What is the coverage, how will the routes adjust to this coverage, and what is the context of the game?' By understanding coverages, i.e., the, Choice Route vs. Three Deep-Zone, Man Free, Two Deep Zone, Two-Deep Man, Four Deep Zone, Four Across Man, and the route structure, i.e., how the receivers will adjust their routes against those coverages, the quarterback can better anticipate what will happen but his pre-snap 'aerial hypothesis' must be confirmed on every play"; Participant #3 then identified ten general categories of pass coverages: 4 INVERT, 4 BUZZ, 4 CLEO, 4 CLEO PREVENT, 4 ACROSS, COVER 2, COVER 5, COVER 1, WING COMBO and PURE MAN (BLITZ), and reviewed the strengths and weaknesses of each coverage category.

"How do you identify coverages?" asked the researcher of Participant #4. Participant #4 explained the thought process related to identifying coverages. "Pre-snap, I'm thinking…of the play, the weakness of the coverage, what plays or route takes

advantage of this. You see the safeties, you see the coverage." He diagrammed and explained how the safeties tell him the coverage category and how the cornerback lets him know man versus zone, which is provided in Figure 16.

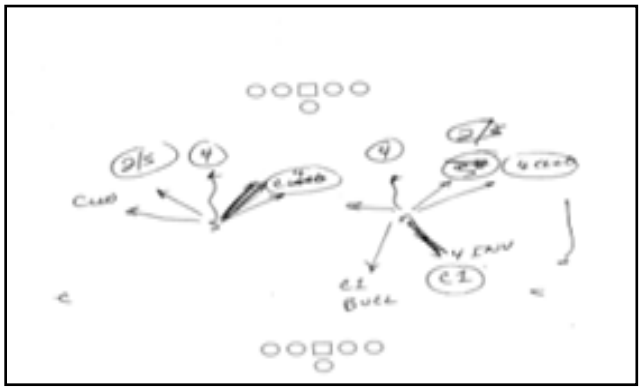


Figure 16. Participant #4's safeties diagram

As per the decision making process Participant #2 stated "What is the coverage, how will the routes adjust to this coverage, and what is the context of the game?" and Participant #3 explained that players must (a) identify the defensive coverage, (b) understand the strengths of the defense, (c) understand the play in relation to the coverage, and (d) know how to attack the weakness of the defense. The researcher asked Participant #5 to critique the researcher's understanding of the decision making process, by explaining "identify the defensive coverage, which coverage category am I facing, what are the strengths of the coverage, understand how the conversion routes adjust to this coverage." The participant nodded in the affirmative and used the Choice play to demonstrate how this process is implemented on the field. Participant #4 explained how to do this and then diagrammed how he uses a pattern recognition system to identify the ten coverage categories. Once he recognizes the coverage, he has a mental model of the

weakness of that coverage. He understands how the multiple adjusting routes will adjust to the coverage. He looks for the routes within the play structure that will take advantage of the weakness in the coverage. "The defense can do amazing things prior to the snap of the ball, but after the snap they don't keep secrets," Participant #4 explained. "After the ball is snapped, it's like reading a bad book for the thousandth time or seeing the same bad movie over and over again. You see the safeties, you see the coverage." He diagrammed and explained how the safeties tell him the coverage category and how the cornerback let him know man versus zone.

As a result of this section of the interviews, the decisions section of the GDTA chart was filled in, including the decisions "which coverage category am I facing?" and "what is the weakness of this coverage?" and "how will the routes adjust to this coverage?" which are added to the appropriate section of the chart.

Step 3: List the information needs (SA) of the quarterback. The final elements of the GDTA involve the information needed to answer the questions that form the decisions. These information needs are the decision maker's situation awareness requirements. Situation awareness (SA) can be defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1988, p. 97). From this definition, three levels of situation awareness are identified: Level 1 SA, or the detection of the environments relevant elements; Level 2 SA, or the comprehension of the element's meaning; and Level 3 SA, which involves projecting how the integrated information will change over time.

The SA requirements analysis listed below represents the relevant information at all three SA levels that the quarterback would like to know in order to answer the decision questions. Note that the information requirements are related only to the "Choice Route" and serve to link the decision with the information requirements. As mentioned earlier, in executing the Choice Route the quarterback has to execute both a "read" and "pure" progression of the entire field. The multiplicity of this play presents a cognitively demanding process for the quarterback and a rigorous design challenge for the simulator PC.

The researcher asked, "What would I like to know to answer the question, 'what coverage category am I facing?'" The perceptual cues involve the movement and the eyes of the defenders. Participant #5 explained how the cues of multiple defenders should be aligned and when they don't align, it triggers a cue that one or more of the defenders is attempting to disguise his intentions.

Participant #3 opened his innovative quarterback manual to explain and demonstrate a myriad of pre-snap motion and pre-snap reads or "cues" that the quarterback will use to anticipate or "project" how the defense will react at the snap of the ball including: Are they attempting a rotation coverage or to lock in a pre-rotation coverage? How will the secondary defenders react to motion? And as for the safeties, how will the safeties react to motion? Will the defender over the motioning slot receiver come across the formation? If yes, where are his eyes looking? Will the defender over the motioning slot receiver come to the line of scrimmage or reduce? Are the defenders in tight press coverage? If yes, will the under-coverage be locked on or will they employ

a “banjo” concept? What is the technique of the play-side corner? And what about his eyes? Leverage?

The key word here, according to Participant #2, is “anticipate” not “pre-determine.” He explained, “All of the cues gathered prior to the snap must be confirmed after the snap. Your pre-snap information allows you to better anticipate, but you can’t predetermine based on pre-snap information. . . If, prior to the snap, the quarterback sees the corner at a depth of 10 yards, he may pre-determine that he will be throwing option #1, but if the defender that he is reading never gains any depth, the receiver will have closed the ‘cushion’ on the receiver, calling for the receiver and the quarterback to execute option #2.” Participant #3 explains that” through miles and miles of repetitions” most of the decision making can be done after the snap of the ball. Participant #2 concurred, stating that “90% of the decision making process takes place after the snap of the ball.” Participant #4 explains that “the defense can do amazing things prior to the snap of the ball, but after the snap they don’t keep secrets.” Participant #3 adds that the “defensive backs and inside linebackers can provide cues but they are in a better position to disguise their intentions. Participant #4 explained, “You see the safeties, you see the coverage.”

The researcher also asked, “What would I like to know to answer the question, ‘what are the strengths and weakness of the coverage category?’”

According to Participant #3 this should be the first category that the quarterback masters; “before we get to the field the quarterback has to have a complete understanding of the defensive opposition.” Participant #2 and Participant #5 identified six families of coverages. Participant #3 expanded the conversation to ten coverage categories, for

which he identified these general categories of pass coverages: 4 INVERT, 4 BUZZ, 4 CLEO, 4 CLEO PREVENT, 4 ACROSS, COVER 2, COVER 5, COVER 1, WING COMBO and PURE MAN (BLITZ) , which included pre-rotated balanced coverages, rotated coverages, coverage variations and combination coverages. He explained and demonstrated the affordances of each coverage category through a maze of diagrams that were drawn to scale. Most of the analysis for this category was completed via the interview with Participant #3, information gleaned from his quarterback manual, and a review of video clips from the 1992 season and video clips from the instructional videos of Participant # 2 and Participant #5.

The iterative process of synthesizing and posting the interview data into the appropriate section of the GDTA chart culminated in the finalized GDTA chart listed in Figure 17 below.

Figure 17. Step 3 GDTA results chart

Phase III: Results of the Situation Awareness Global Assessment (SAGAT) Questions

In this phase of the study, the researcher developed questions designed to measure the entire range of the quarterback's needs related to reading, recognizing and attacking the defensive coverage with the Choice Route. Based on the information requirements established from the goal-directed task analysis, a list of the SA measurement queries (SAGAT) for reading complex NCAA defenses was constructed. Using guidelines developed by Endsley et al. (2003), the researcher categorized the information from the SA requirements analysis into three levels of situation awareness in the dynamic domain of the quarterback. The process entails turning the data gleaned from goal directed task analysis into questions that represent a global assessment of the quarterback's situation awareness requirements. After the questions were constructed, they were categorized according to the definitions of Level 1 (perception), Level 2 (comprehension), and Level 3 (projection) components. For an in-depth review of this process see Chapter 3. An example of the categorizing process is shown in Figure 18 below. The Situation Awareness Requirement in this example is the Safeties' Post-Snap Reaction to Motion.

<table>
<tr><td>Goal 1.0:
Attack the Defense</td><td rowspan="4">Creating and Categorizing a SAGAT Question

Example:

Based on the reaction of the safeties to motion, what is the coverage category?
This is a Level 2 question because…

To answer this question the Qb must <u>Perceive</u> the reaction of the Safeties (Level 1) and <u>Understand</u> what the movement means (Level 2)</td></tr>
<tr><td>Sub-Goal 1.1:
Identify the Defensive Coverage</td></tr>
<tr><td>Decision
What coverage category am I facing?</td></tr>
<tr><td>(one) S.A. Requirement
The Safeties Post-Snap Reaction to Motion</td></tr>
</table>

Figure 18. Sample SAGAT questions expected.

The following SAGAT questions, and their accompanying descriptor levels and answers, indicate aspects of SA which were found via the study interviews and the GDTA chart compilation.

- Level 1 Perception: The detection of the environments' relevant elements
- Level 2 Comprehension: The comprehension of the elements' meaning
- Level 3 Projection: The projection of the elements' status into the future

Level ONE questions. The following questions relate to Level 1 SA.

1. How do the safety/safeties react to motion?

   Invert / Follow the motioning receiver / No reaction
2. Did the defender over the motioning slot receiver come across the formation?
   a. If yes, where are his eyes looking? The Quarterback or the Receiver
   b. What does that tell you? Man-to-Man or Zone
3. Did the defender over the motioning slot receiver come to the line of scrimmage or reduce? Reduce or Come to the line of scrimmage
4. How do the safety/safeties react at the snap of the football?
5. How did the inside linebackers react to the quarterback roll away from trips?

   They stay perfect
6. What is the depth of the linebackers drop? 10 yards
7. What is the technique of the play-side corner? Zone Technique, or back pedaling and square to the line of scrimmage or a man technique, back to the sideline, legs crossing over
8. Is the corner three to five yards off of the receiver? Yes / No
9. What is the play-side receiver's body language as he runs the choice route?
10. How does the Free Safety React to the Roll of the Quarterback? Deep Middle / Rotated To The Near Hash
11. What is his depth?

12. Can the Free Safety be turned (hips and shoulders) with the deep vertical game? Yes /No
13. How does the Free Safety react to a pump fake? Stays perfect / turns hips and shoulders / Favors one hash
14. What is the technique of the inside linebackers? They take flow moving drops to the roll of the quarterback, they stay perfect.
15. Is the free safety staying perfect or rotating with the roll of the quarterback? Perfect
16. Do the inside linebackers take deep drops, such as Tampa 2, or are they SB conscious?
17. Is the weak-side corner locked on the outside deep receiver? Yes / No
18. Is the weak-side corner high over the top?
19. What is the technique of the weak-side corner? Deep third or fall back on the seam route? Has he attempted to "pin" the deep outside receiver hip-to-hip or does he turn his hips and shoulders to the field and clues the inside routes and the quarterback

Level TWO questions. The following questions relate to Level 2 SA.

20. Is the defense attempting a rotation coverage or are they locked in a pre-rotation coverage?
    Rotation / Pre-Rotation
21. Based on the reaction of the safeties to motion, what is the coverage category?
    Cover 3

Also, what does this information tell you about his defensive responsibility? Rusher or Flat Defender

22. Why is his defensive responsibility important? Important to the pass protection / Possible Area Outside-Flat Defender or Area Inside-Curl Defender
23. Based on this reaction, what is the coverage category? Cover 3
24. Why is this important? Has implications for the seam and under route
25. Based on the movement/reaction of the safeties what is this coverage category? Cover 3
26. What is the weakness of this defensive category?
    - Cover 3 is not and has not ever been designed to handle the short passing game; the offense can patiently take the short gains available on the third Choice and settle for the four yard continual gain.
    - The balanced zones can be repeatedly ripped by our own flooding routes: Motion Back Flag, Wing Post or Flag, Y Flag, S Flat, etc.
    - Cover 3 is beaten deep by our own design in stretching the vertical areas and hitting the deep overlap seams. For example, the second receiver running up the college hash area in the choice route.
    - Rotation coverage in Cover 3 leaves the defense “hanging out” as the corner is attacked in seam areas.
    - Pass Rush: If fewer lineman approach the scene, then you as a QB will have more delivery time and it merely turns into a “shooting gallery”

27. Why is the technique important? If the corner is in a zone technique he can get a better break on the speed out, so be sure he is at least five yards off of the corner. In other words, versus a man technique look for at least a three yard cushion

Level THREE questions. The following questions relate to Level 3 SA.

28. Based on the technique and cushion of the corner, what route will the play-side receiver be running?
29. If the linebacker did not come across the formation with the motioning slot receiver, what did he do at the snap of the football? Rush / Seam / Flat
30. Based on the Free Safeties technique what route will "A" receiver run?
31. Based on the technique of the weak-corner, what route will the receiver run?

To mitigate any concern about the validity and reliability of each question, the researcher forwarded the queries to one of the record-setting participants in this study. The participant was asked to review and validate each question based on the following criteria: (a) articulated in a domain appropriate manner, (i.e., is this the way you would ask this question?), and (b) is this question an appropriate measure of the quarterback's perception, comprehension or projection?

The 31 approved and validated Situation Awareness Global Assessment questions, designed to measure a quarterback's situation awareness at perceptual, understanding and projection levels, were then programmed into a virtual simulator called the PlayAction Simulator PC.

Results in Answer to Research Question 2

Phases IV and V of the study provide the answer to the second research question concerning the affordances of virtual simulation in relationship to the information required to effectively measure the situation awareness of NCAA quarterbacks.

Phase IV: Results of Programming SAGAT Probes into PlayAction Simulator PC.

In this section, the researcher will provide a detailed analysis of the results from the customized scripting of the PlayAction Simulator PC, configured to train and measure the situation awareness and decision making of the Run and Shoot quarterback. According to the developers, "The quarterback using this tool can practice reading a defense, picking up blitzes and making quick decisions on where to throw the ball; all based on the tendencies of the team he is going to play the upcoming weekend" (XOS Sports, 2007, p. 2). In Phase IV of this study, the researcher sought empirical evidence to support those claims.

The programming was designed to answer two questions: (a) Can a Run and Shoot offensive play could be programmed to run against a specific type of complex collegiate defense? (b) Can Situation Awareness Global Assessment questions be programmed into the simulator? The results are presented in the form of screen shots of the offensive and defensive reactions at pre-motion, pre-snap, post-snap, decision making and action points.

After the plays were selected and diagrammed (see Chapter 3 for a complete review of this process), Mr. Scott, the system engineer, published the plays using the XOS Publisher. A brief review of the process is listed below. It should be noted that in

addition to being cognitively demanding on the quarterback, these tasks present a rigorous design challenge for the systems designer.

Selecting the play: The choice route. The researched selected the Choice route because it represents a cognitively demanding task for the quarterback since the play represents a whole field progression with two types of reads, a "read" to the front-side of the route (meaning where the ball will be thrown is dependent on the technique and positioning of the defensive player), and "look" to the backside of the route (where the quarterback is looking to confirm that the receiver's multiple adjusting route is attacking a weakness in the zone or creating separation versus man to man coverage).

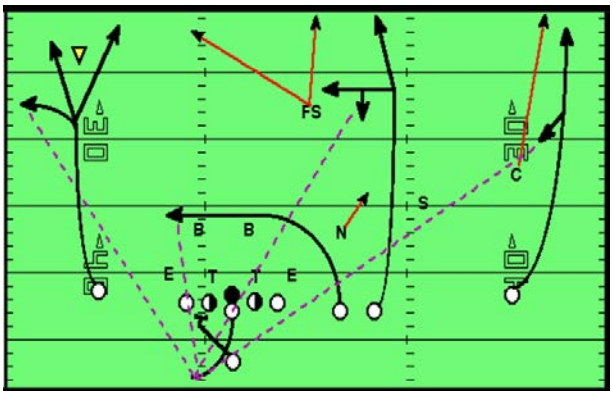


Figure 19. The choice route

Individual play cards. The researcher forwarded to the programmer: (a) three variations of the choice route, choice, choice special and choice switch; (b) three variations of a cover 3 (pre-rotated, buzz and cleo) defensive scheme; and (c) a set of SAGAT queries. One example of a variation is provided in Figure 20 below.

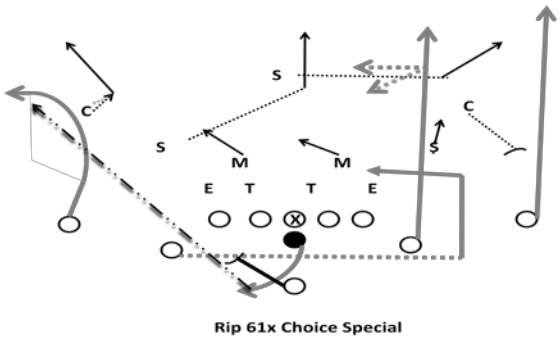


Figure 20. Choice route vs. cover 3 cleo coverage

Diagramming the play. Using XOS PlayTools, a "football specific diagramming tool" (XOS Sports, 2007) to diagram the plays, and GoToMeeting®, phone, text and email to collaborate, the researcher and XOS Digital engineer, Mr. Scott diagrammed the customized plays. An example of a diagrammed play is shown in Figure 21.

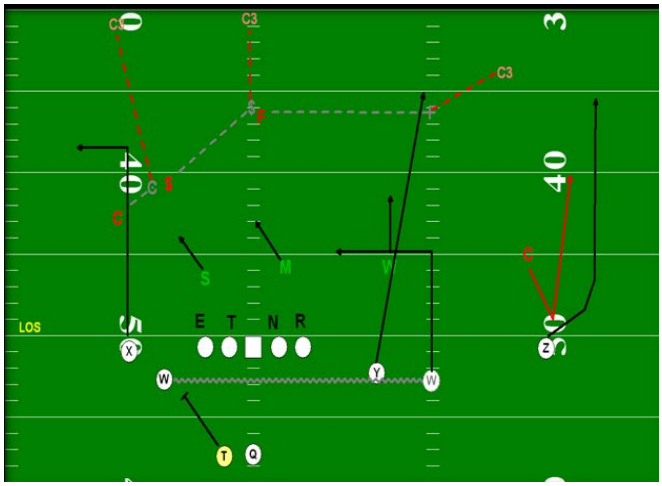


Figure 21. Sample XOS digital customized diagram. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Publishing the plays. After the plays were diagrammed, Mr. Scott published the plays using the XOS Publisher. The diagram in Figure 22 below is an example of the simulator result of the "published" PlayTools diagram.

Figure 22. Published simulator PlayTools diagram. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Proof of concept. After the plays were "published," the researcher sought to answer specific questions related to the capabilities of the PlayAction Simulator PC: (a) Can a Run and Shoot offensive play be programmed to run against a specific type of complex collegiate defense? And (b) Can Situation Awareness Global Assessment questions be programmed into the simulator? Results of these specific questions, as provided by the output from the PlayAction Simulator PC, are provided below.

The results of simulator checks. In the sequence of screen shots listed below, the researcher sought clear and compelling evidence of the simulator's ability to program and publish a specific offensive play to be run against a specific defense. Checks were

given if the simulator met the various individual requirements of each instance, and results thus described in this way.

Of Figure 23 below, the researcher asked:

Is the offense in a Balanced, i.e., Even formation? (check) ☑

Is the defense aligned in a pre-snap cover 3 strong side zone? (check) ☑

Offense: (check) ☑ Even (2x2), Rip (motion) 61 (pass protection set to the left) Choice (the play)

Defense: (check) ☑ Pre-Motion (cover 3 strong side zone), Pre-Snap (cover 2), Post-Snap (cover 3, CLEO coverage)

(check) ☑ Offense is in a balance 2x2 formation and the Defense is aligned in a pre-snap cover 3 strong side zone

Figure 23. Pre motion even formation vs. cover 3. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Of Figure 24 below, the researcher asked:

Does the receiver motion to the right of the formation? (check) ☑

Does the defense react to the motion by moving into a pre-snap cover 2 look? (check) ☑

The Results

Offense: (check) ☑ Even (2x2), (check) ☑ Rip (motion), 61 (pass protection set to the left), Choice (the play)

Defense: (check) ☑ Pre-Motion (cover 3 strong side zone), ☑ Pre-Snap (cover 2), Post-Snap (cover 3, CLEO coverage)

(check) ☑ Offense-(w) receiver motions to the right (rip) and Defense reacts by moving into a Pre-Snap (cover 2) look.

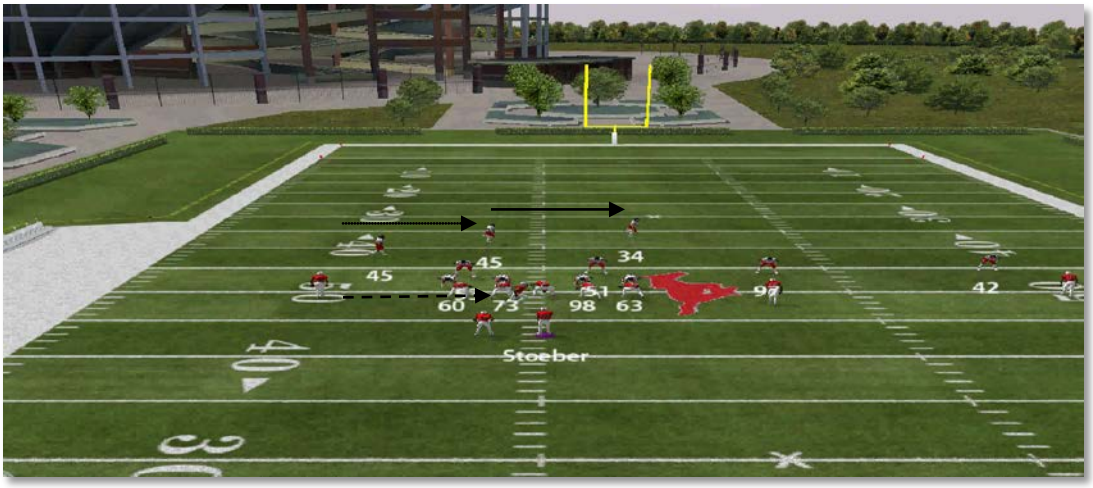


Figure 24. Defense reacts to motion. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

The Defense is now aligned in a Pre-Snap Cover 2 look, and the Offense is now aligned in a trips right formation (see Figure 25 below).

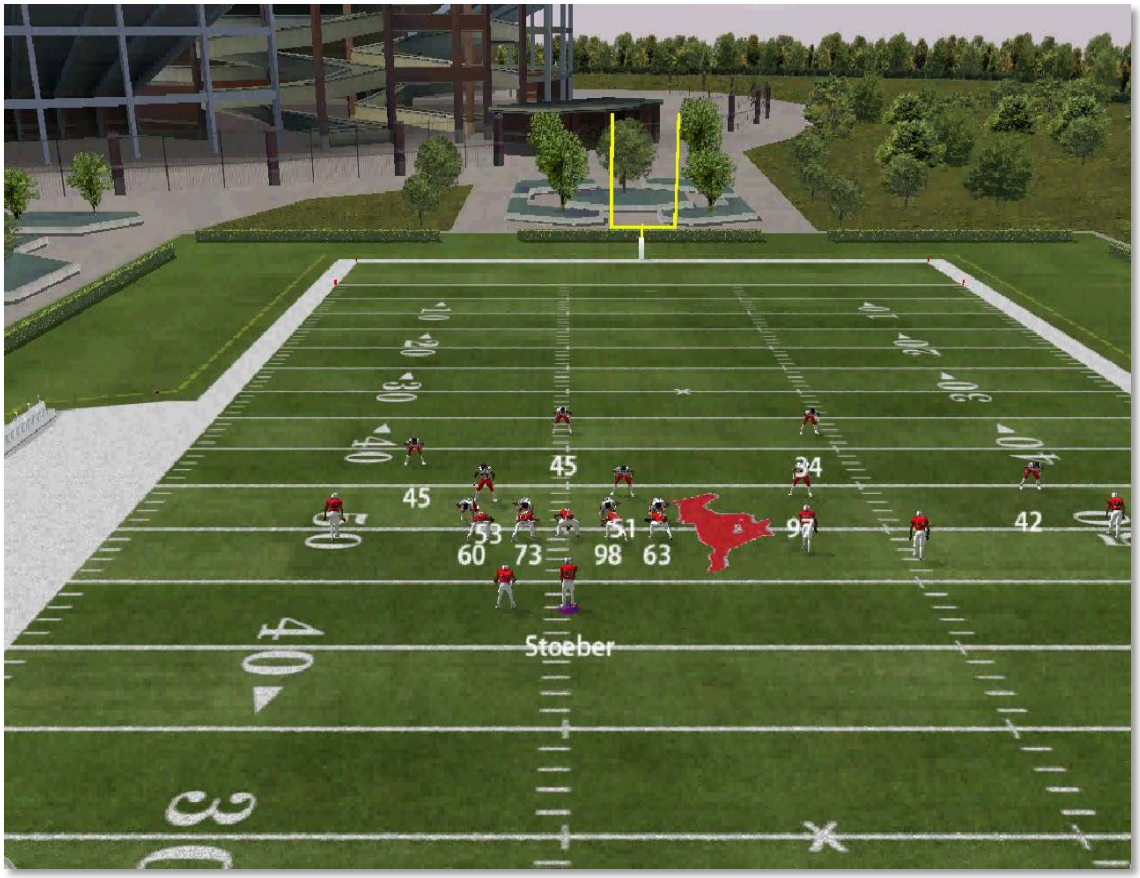


Figure 25. Pre-snap trips right vs. cover 2. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Of Figure 26 below, the researcher asks:

Has the offense set the protection to the play-side of the formation? (note the white arrow), which shows the super-back is blocking to the left side, i.e., play-side of the formation? (check) ☑

Has the defense deployed a CLEO coverage, meaning the defense is using a cover 3zone to the single receiver side of the play (circle in red) and using a corner roll-cover 2 look on the backside, (circled in blue) (check) ☑

The Results

Offense: (check) ☑ Even (2x2), (check) ☑ Rip (motion), (check) ☑ 61 (pass protection set to the left) Choice (the play)

Defense: (check) ☑ Pre-Motion (cover 3 strong side zone), (check) ☑ Pre-Snap (cover 2), (check) ☑ Post-Snap (cover 3, CLEO coverage)

Offense has set the protection to the play-side of the formation, (note the white arrow, which shows the super-back is blocking to the (left) which is the play-side of the formation.

Defense has deployed a CLEO coverage, meaning the defense is using a cover 3 zone to the single receiver side of the play and using a corner roll-cover 2 look on the backside.

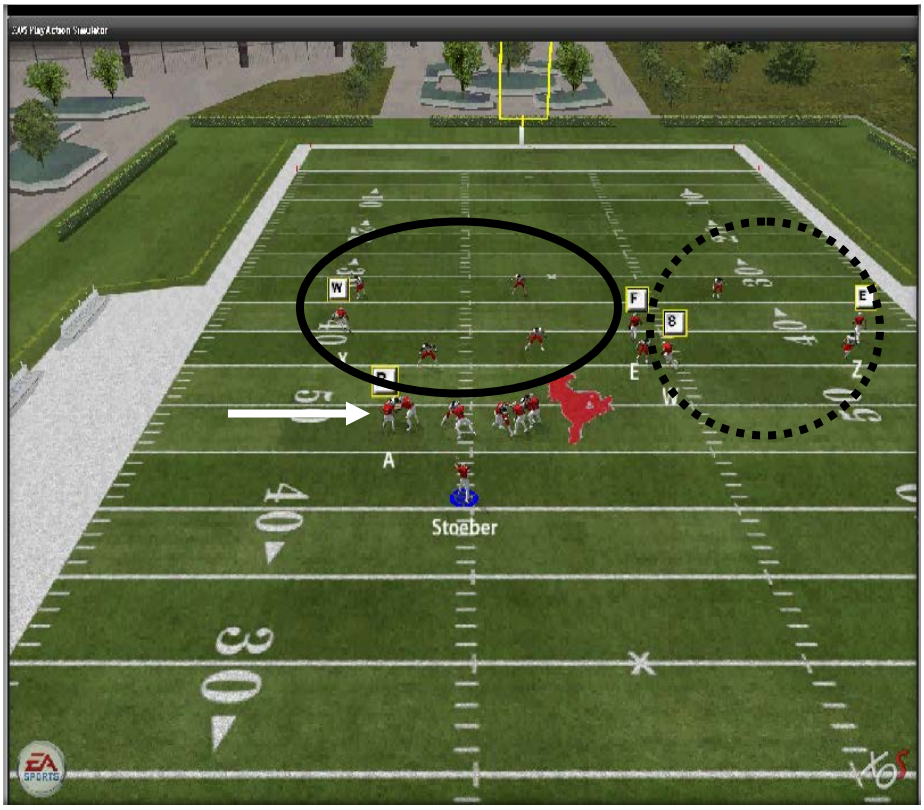


Figure 26. Post snap read vs. cleo coverage. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Of Figure 27 above, the researcher asks:

Can the quarterback, using an x-box controller, read the coverage, select and throw the ball to the correct receiver? (check) ☑

The Results

Offense: (check) ☑ Even (2x2), (check) ☑ Rip (motion), (check) ☑ 61 (pass protection set to the left)

(check) ☑ Choice (the play)

Defense: (check) ☑Pre-Motion (cover 3 strong side zone), (check) ☑ Pre-Snap (cover 2), (check) ☑ Post-Snap (cover 3, CLEO coverage)

Using an XBox controller, the researcher has successfully read the coverage and selected and thrown the ball to the correct receiver (see Figure 27 below).

Figure 27. Correct receiver. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In the sequence of screen shots listed below, the researcher is seeking clear and compelling evidence of the ability of the simulator to be programmed to display Situation Awareness Global Assessment Questions. Again, a check (☑) is given when the system meets the necessary information and procedural requirements.

The system engineer has programmed the Offense to motion from a balanced formation to a trips right alignment. The protection is set to the left. This is Choice Special, a variation of the Choice Route as the two inside slot receivers will exchange route responsibilities. The defense has been programmed to employ a Pre-Rotated

Cover 3 strong sidezone (see Figure 28 below). Note: There will be no reaction to motion.

Figure 28. Offense motions into trips formation. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In Figure 29 below, a Pre-Snap Question is randomly displayed. What is the coverage category? (check) ☑ and (check) ☑

Figure 29. Pre-snap question. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In Figure 30 below, the correct answer appears; Cover 3 is displayed by pressing the “X” button on the XBox controller.

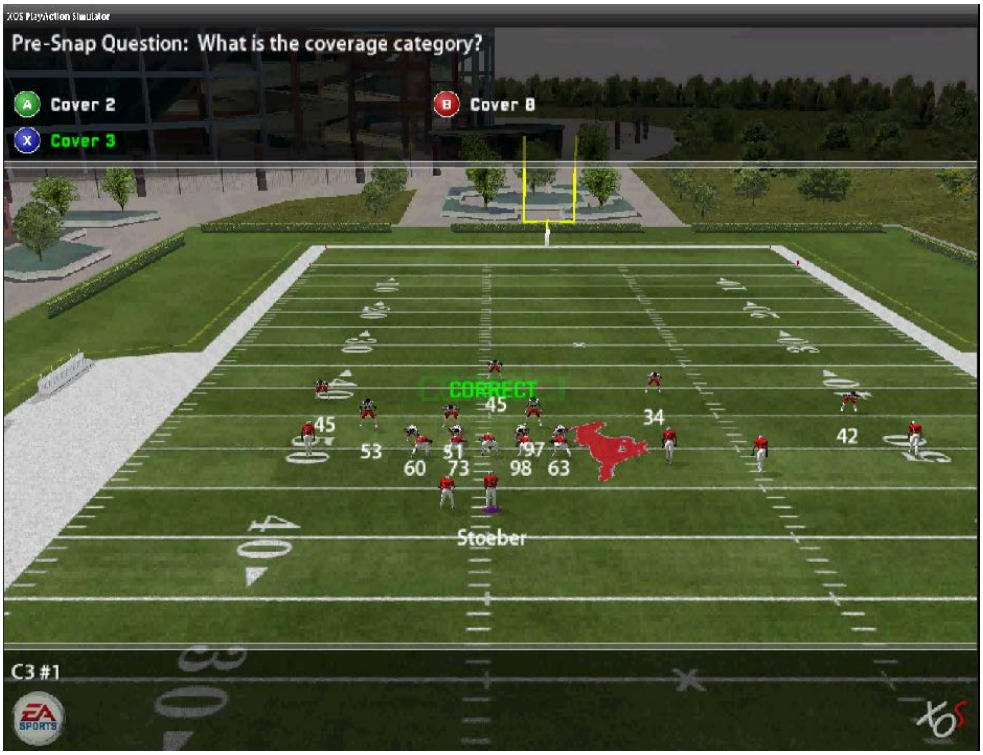


Figure 30. Pre-snap answer. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In Figure 31 below, the play is run with no stops, creating a performance / action based trial. In this scenario, the quarterback’s Post Snap process is: (a) read the coverage, (b) recognize the coverage, (c) select the receiver.

Figure 31. Continuous action example no freeze. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Figure 32, below, reveals that the quarterback has made the correct decision.

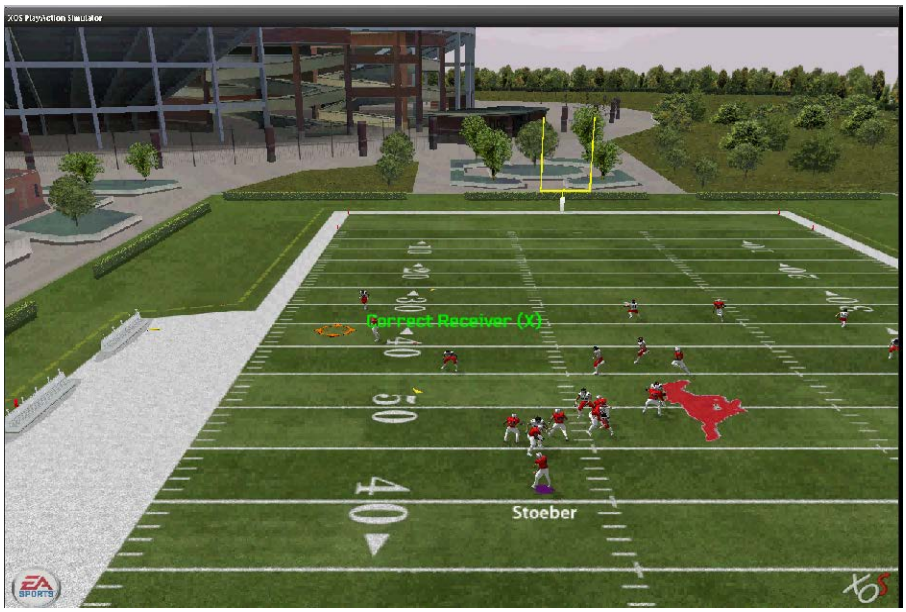


Figure 32. RPD decision no freeze. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In the next trial, demonstrated in Figure 33 below, the simulator is stopped at a random decision point and the Post Snap Question is displayed: What was the cushion of the play-side corner? (check) ☑

Figure 33. Post play question. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In Figure 34 below, the post snap answer (5+ yards) was display by pressing the "B" button on the XBox controller. (check) ☑

Figure 34. Post play answer. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

These figures provide clear and compelling evidence that multiple choice questions designed to test the situation awareness and decision making of the quarterback can be programmed into the simulator PC. In answering the question about whether multiple choice questions could be programmed into the simulator PC designed to test the situation awareness and decision making of the quarterback, the simulator received another (check) ☑ in the affirmative. Thus, based on the series of screen shots, can Situation Awareness Global Assessment questions be programmed into the simulator? Yes, (check) ☑

Phase V: Results of Investigation of the PlayAction Simulator PC as a SAGAT Simulation Tool. In Phase V of the study, the researcher empirically investigated the ability of the PlayAction Simulator PC to provide the ecological validity required for the quarterback to extrapolate the information necessary to answer the

SAGAT questions, and second, to ascertain if the PlayAction Simulator PC can be used in conjunction with the SAGAT methodology to objectively assess a quarterback's situation awareness.

Specifically, the researcher focused on the ability of the PlayAction Simulator PC to be used as a SAGAT Simulation tool. A SAGAT Simulation tool must be able to meet the following criteria:

1. Simulation is frozen (stopped) at random intervals.
2. System displays go blank and the simulation is suspended.
3. Participants are queried as to their perception of the situation.

Phase IV provided evidence of the simulator's ability to (1) freeze at random intervals and (2) go blank and suspend the action. The most salient system requirements still to be examined were (a) the ability of the screen to go blank as the questions are strategically displayed on the screen and (b) whether the system is able to provide collegiate quarterbacks, using the PlayAction Simulator PC, the ability to extrapolate the information necessary to answer the SAGAT questions.

The resulting evidence in support of the aforementioned questions is presented through the screen shots of the live action listed in the figures below.

View from the Virtual Pocket Results

To ascertain if the collegiate Run and Shoot quarterback could extrapolate the information necessary to read, recognize and attack collegiate defenses, the researcher switched the system to "Quarterback View." Switching to quarterback view has implications on the ability of the simulator to be used as a tool to train situation awareness. These implications will be discussed in Chapter 5.

In this trial, the researcher is evaluating the ability of the simulator to provide the quarterback with the information required to successfully read, recognize and attack the defense.

In Figure 35 below, the information required to identify a pre-motion cover 2 category is the alignment and movement of the safeties. Thus, the researcher asks, can the quarterback see the safeties? (check) ☑

Figure 35. Pre-motion cover 2. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In Figure 36 below, the pre-snap reaction to the motioning receiver is displayed along with the defensive adjustment into a cover three scheme. Again, you see the safeties, you see the coverage.

Figure 36. Pre-snap reaction to motion receiver cover 3. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

In Figures 37 and 38 below, the quarterback scans the defensive alignment. The information required to identify a post-motion defensive invert coverage category in a trips right offensive formation is the alignment and movement of the safeties and a side-line to side-line view of the offense. Thus, the researcher asks, can the quarterback see the movement of the safeties and the offensive receivers? (check) ☑

Figure 37. Post-motion invert coverage. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Figure 38. Post-motion trips right offensive. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Figure 39 below reveals a post snap coverage category of 4 invert. To identify 4 invert, the quarterback has to read the corner and "see" the safety and the area-outside

defender. Thus the researcher asks: can the quarterback read the corner and "see" the safety and the area-outside defender? (check) ☑

Figure 39. Post-snap coverage category of 4 invert. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Read progression: the 1st read is the play-side corner. The (X) receiver will be running one of three routes depending the on technique of the play-side corner, *fade, out, or skinny post.* The researcher asks: can the quarterback see that the play-side corner's cushion is over 5 yards? (check) ☑

In this scenario, the receiver is reading the technique of the play-side corner, his technique causes the receiver to run the out route. But the area-outside defender is taking this option away from the quarterback. The researcher asks: can the quarterback "see" the area outside defender running to the flat? (check) ☑

What does this mean? DECISION: (X) receiver is covered. The quarterback must now move to his 2nd read. The 2nd read in the progression is a "look." The (w) or (y)

receiver will run a seam read based on the reaction of the Free Safety. If he over-rotates to the play-side, he will continue up the hash. If the safety is "perfect" and high, more than 5 yards, over the top, the receiver will run a deep end route. Against 4 invert, he will find an open area in the middle of the zone.

The quarterback has to trust that the slot receiver is "seeing" the same coverage technique as he is and will make the anticipated throw.

Using Figure 40 below, the researcher asks,

1. Can we see the technique of the FS? (check) ☑
2. Can we see the technique of the weak-side corner? (check) ☑
3. Can we see the corner's cushion on the (y) receiver? (check) ☑
4. What does his technique tell you? That the (w) receiver will run a deep in. (check) ☑

Figure 40. Read progression. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

As mentioned on page 111, The following system requirements -- (a) Simulation is frozen (stopped) at random intervals, and (b) Participants are queried as to their perception of the situation -- were validated in Phase IV.

The next system requirement to be examined was the ability of the screen to go blank as the questions are strategically displayed on the screen. Using a proof of concept framework, the researcher sought to demonstrate that the simulator displays could go blank and electronically display SAGAT questions.

The researcher and the XOS Digital senior software engineer worked collaboratively to ensure that the timing of each freeze was programmed to be random and unpredictable enough so that a quarterback can't prepare for them in advance. The results are presented through screen shots of the live action listed below.

Figure 41 below captures the Blank screen that was programmed to be displayed at the quarterback's decision point.

Figure 41. Blank screen. Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

The post snap question was “What is the technique of the Outside Linebacker?” The live screen shots provide clear and compelling evidence that the simulator was successfully programmed to go blank at the each stage of the quarterback’s decision making point or at a time within milliseconds of the need for a required action. In terms of the ability to provide a blank screen at randomly selected times the simulator was awarded the check (☑) of approval. See also Figure 42 for an example of a question as displayed by the simulator.

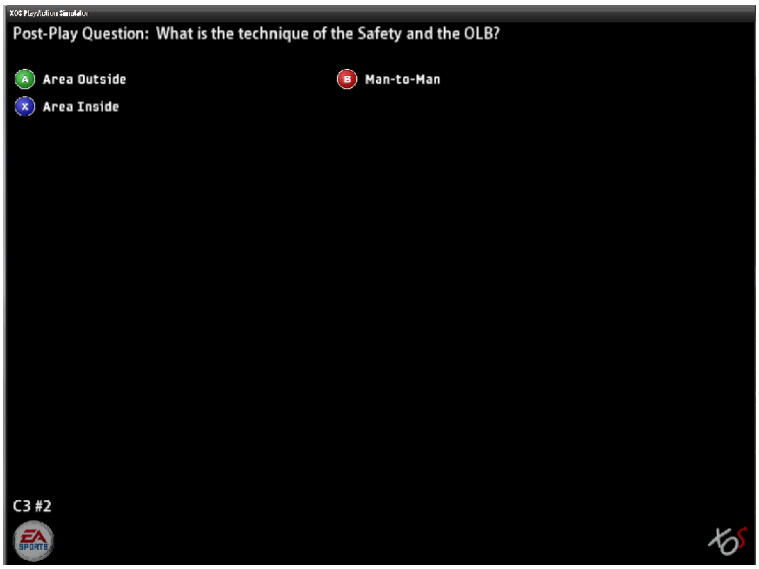


Figure 42. Screen example of stop-action results (SAGAT Question). Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

Figure 43 below captures the post-snap answer to the aforementioned question. The correct response “area inside” was display by the pressing of the “X” button on the XBox controller.

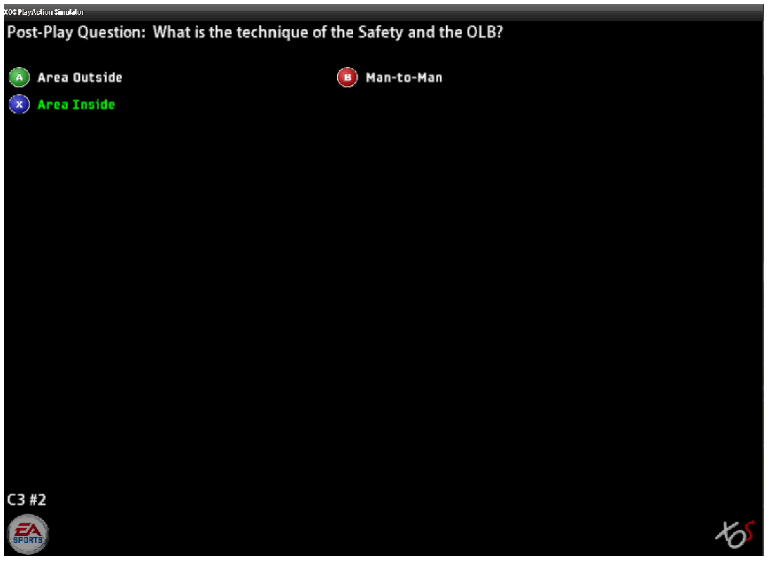


Figure 43: Post snap stop-action results (SAGAT Answer). Reprinted from XOS Digital PlayAction Simulator PC. Orlando, FL. Copyright 2009 by XOS Digital, Incorporated. Reprinted with permission.

These figures provide clear and compelling evidence that multiple choice questions designed to test the situation awareness and decision making of the quarterback can be programmed into the simulator PC. Thus, in answering the question: Can multiple choice questions be programmed into the simulator PC designed to test the situation awareness and decision making of the quarterback, the simulator received another check (☑) in the affirmative.

Summary of Results

By using virtual simulation to recreate the dynamic, adversarial, time constrained domain of the collegiate quarterback, this study has advanced our understanding of the situation assessment process in recognition primed decision making, and has given us a window into objectively measuring what was previously believed to be a hypothetical construct -- situation awareness.

By examining the information requirements, one overarching goal, three sub-goals, three decisions and 60 situation awareness requirements for expert decision making in the pocket of the collegiate quarterback, the researcher uncovered the goal, decisions and situation awareness requirements for expertly parlaying an aerial hypothesis into a completed forward pass.

By creating and validating 31 situation awareness global assessment questions, the researcher unveiled the perception, understanding and projection acumen that underlies the expert decision making and exemplary performance of the NCAA's most prolific quarterbacks.

By successfully programming and empirically assessing the ability of virtual simulation to measure situation awareness, the researcher, in collaboration with XOS Digital, revealed a blueprint for designing systems that support situation awareness in the wide world of sports.

While the process and results of this study are highly valid in the domain of the Run and Shoot quarterback who is using the Choice route structure to attack a collegiate defense, the researcher raises the following cautions.

The process of reading, recognizing and attacking collegiate defenses employed by the participants in the study are unique to the Run and Shoot offense. It is important to understand that the situation awareness survey in this study centered on the specific requirements related to the Choice route structure. Thus, while the decision making process has far-reaching application to other features of the Run and Shoot offensive scheme, the specific information requirements listed for the Choice Route are non-transferrable to other offensive systems, as each system has its own unique situation

awareness requirements. Even within the Run and Shoot offense, the situation awareness requirements of the Choice route structure used in this study is different from the information requirements of other route structures, such as Go and Slide, found in the Run and Shoot offense. The reader is reminded that the multiplicity of the Choice route versus the multiple dimensions of Strong Side Cover 3 zone were chosen because this coupling represented a rigorous design challenge for the simulator PC.

In contrast, the researcher generalizes that the simulator's ability to expertly program offensive and defensive plays, to insert sound questions designed to measure situation awareness and decision making, and to provide an ecologically valid virtual football environment that allows the quarterback to extrapolate the information needed to answer those questions, as measured by the results of this study, uniquely positions the product to replicate these design feats in other offensive schemes.

Chapter 5

Disscussion

The results contained in Chapter 4 represent the findings of a proof of concept study, from the idea of a theoretical proposition about the situation assessment process in time-constrained decision making, to the development of global and testable measures of situation awareness in the domain of collegiate football. Embedded in the findings is an empirical investigation into the affordances of virtual simulation with respect to the ecological validity required to measure situation awareness.

To understand the role of situation awareness in the decision making and performance of NCAA quarterbacks, and to explore the potential of virtual simulation as a tool to measure and train situation awareness, this study explored the following questions. What are the situation awareness requirements for expert decision making in the domain of the NCAA quarterback? This question was answered via a three phase situational awareness requirement analysis in the domain of the collegiate quarterback. This analysis yielded the Goals, Decisions and Information that quarterbacks need to know in their quest to parlay a successful aerial hypothesis into a completed pass. Equally important, the results of this study highlighted the situation assessment process, (perception, comprehension and projection) that the quarterback uses to acquire and use this information and yielded SAGAT questions designed to measure the quarterback's situational awareness in the virtual pocket.

Do the affordances of virtual simulation provide the information required to effectively measure the situation awareness of NCAA quarterbacks? This question was answered through the development and programming of a innovative virtual experimental

system that allowed the researcher to conduct a series of live trials that evaluated the ability of the simulator to be used as a SAGAT simulation tool in the assessment of a quarterback's situation awareness. The simulator's ability to be programmed to randomly display SAGAT questions designed to measure the SA of the quarterback, and to provide an ecologically sound environment that provides the environment and information the quarterback needs to answer the probes, was represented by a series of screen shots of the live action.

In this chapter, the researcher will discuss conclusions drawn from the results and supported by the literature, the implication of these conclusions, and recommendations for further research.

Introducing the Decision Making Model for Quarterbacks

Through the design of this study and the results therein, coupled with a comprehensive review of the literature, the researcher has fused two concepts -- Klein's RPD model, and Endsley's SA Model -- that recognize decision making as a recognition and reasoning process of serially matching situation with appropriate action (Lipshitz & Ben Shaul, 1997) to create a hybrid model, the Decision Making Model for Quarterbacks (DMM4Qb). The DMM4Qb integrates the situation assessment portion of the SA Model into the RPD Model to create a descriptive model of the situation assessment process in the domain of the quarterback. Thus, the DMM4Qb incorporates a three-step recognition process that can objectively measure what was heretofore considered a hypothetical construct. Klein's (1998) situation assessments of (a) Relevant Cues, (b) Expectancies', (c) Plausible Goals and (d) Action, are intuitively appealing in the domain of football, but do not provide an objective measure for this process. The researcher is aligned with

Endsley's definition of SA which includes a component on the aspect of time, and is using her methodology to develop objective measures of Situation Awareness. So why not use Endsley's SA model? Because Endsley's model is grounded in cognitive psychology's information processing model. Klein (1998) clearly thinks that recognition-primed decision making can be modeled without referring explicitly to mental models and schemata, and that studying the hypothetical constructs "involves inferring the existence and nature of entities that cannot be empirically proven to exist" (Rouse et al., 1992, p. 1304).

Ecological psychology, a strand of research related to Naturalistic Decision Making, explicitly rejects these cognitive considerations. Ecological psychology sees interaction and experience with the environment as the cornerstone of recognition primed decision making. "In this theory the quarterback is not burdened with the task of developing symbolic memory structures through training, observational modeling and competitive performance; rather, the perceptual systems become progressively more attuned to the invariant information available in his environment through direct experience in practice and performance contexts. With task-specific experience, the information that the learner picks up becomes more subtle, elaborate and precise" (Davids, Button, & Bennett, 2008, p. 64).

What has morphed from this convergence is a descriptive model that replaces Klein's four by-products of situation assessment with Endsley's three by-products of Perception, Understanding and Projection. The Decision Making Model for Quarterbacks (DMM4Qb) provides the research community with a situation assessment

process that can be validly and reliably measured, but also maintains a theoretical framework grounded in an ecological perspective to decision making (see Figure 44).

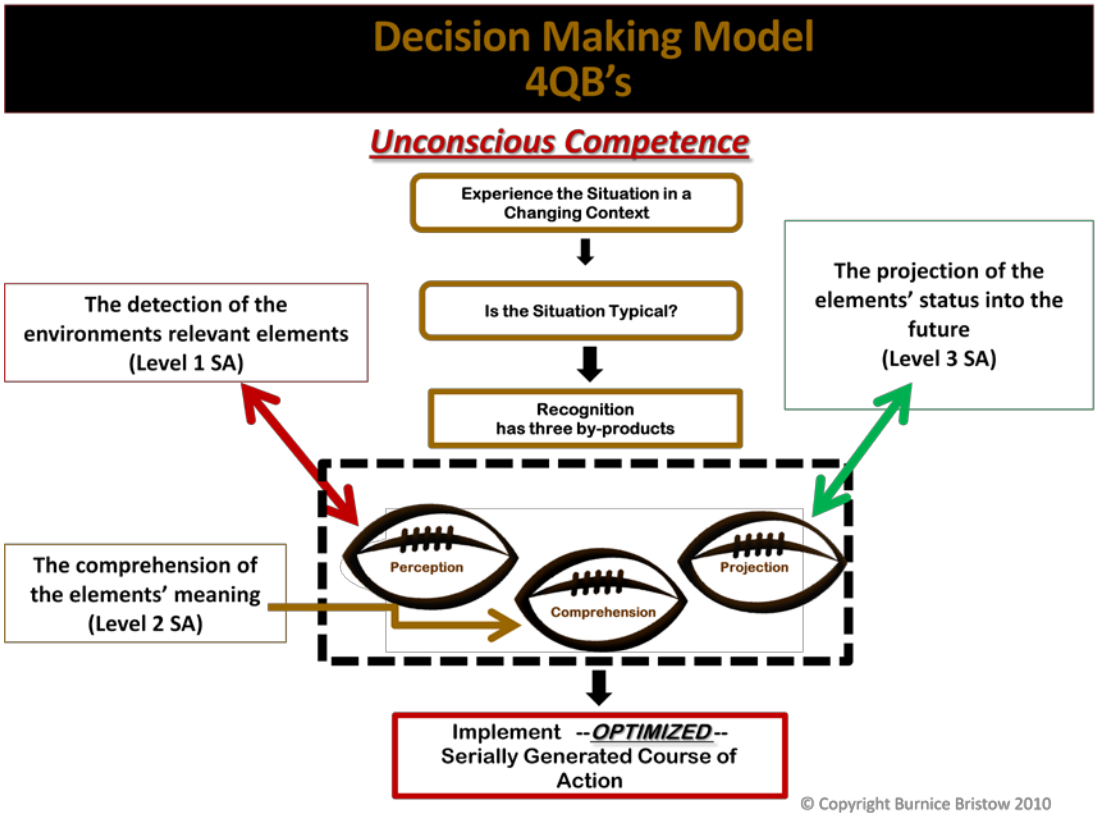


Figure 45. Decision making model for quarterbacks

The Role of Pattern Recognition in the Situation Assessment Process

Noting this study's theoretical proposition about the situation assessment process in recognition primed decision making, this next section discusses the researcher's conclusions related to the role of pattern recognition in how the quarterback integrates or combines information to read, recognize and attack defensive coverages.

"Pattern Recognition is defined as the act of taking in raw data and taking an action based on the 'category' of the pattern" (Duda, 2001, p. 1). The process of pattern matching is related to Level 2 (understanding) of situation awareness. This is where the

subject begins to make meaning out of the cues from the environment. Endsley (2000b) explains that people use a process called pattern matching to link cues taken in from the current situation to schemata in order to pick the best match from those available (p.22). Klein (1998) suggests that this pattern matching can be trained and that Variation 1 of the RPD model is the result.

This section will detail the researcher's findings and conclusions derived from information gleaned from semi-structured interviews and a goal directed task analysis. The most salient feature in this section is the researcher's position on the optimization of serially generated options and its inclusion in the Decision Making Model for Quarterbacks.

Serially Generated Options

The researcher uncovered -- through a review of the literature, experience as a player and coach, semi-structured interviews and subsequent goal directed task analysis -- that the Run and Shoot is indeed designed to be a serially generated process of read progressions.

In the Choice Route, which was used in this study, the first read is the play-side corner. Thus, these steps occur:

Step 1: Participant #1 stated that "Choice is a whole field progression." The first read is the corner to the single receiver side of the formation.

Step 2: Participant #5 stated that at the snap of the ball, the quarterback will read the technique of the play-side corner.

The read of the play side safety is the beginning of a serially generated read, and of recognition of the defensive coverage.

Step 3: Participant #2 says, “Based on the cushion of the corner at decision point the receiver will run one of three routes.”

In this approach to attacking the defense, at the snap of the ball the quarterback’s attention is focused squarely on the play-side corner and if he is in a man or zone technique, keeping in mind that the defender can be in a man technique while the defense is employing a zone scheme. At the decision making point, the receiver will run one of three route options. Miles of repetitions have created a synergy between the receiver and quarterback to the degree that as the quarterback reads the corner, he can tell by the body language of the receiver if he will run the correct route adjustment. This advanced level of pattern recognition has to do with the ability to read the technique of the corner in unison with the body language of the play-side receiver. Thus, in the example provided in this study -- in a serially generated action -- if the corner has a cushion of over 5 yards, with no threat of a flat defender, the ball will be thrown to the play-side receiver. While this play-side assessment is taking place, the back side of the defense could all fall down, and it would have no effect on this first read.

This process is aligned with a strategy called satisficing, in other words, selecting the first option that works (Simon, 1957). In the domain of the quarterback, this is accomplished through his read progressions. In contrast to satisficing is the concept of optimizing. Optimizing is finding the best course of action.

Klein (1998) artfully compares and contrasts these two concepts.

> When you order from a menu, you probably compare the different items to find the one you want the most. You are performing a comparative evaluation because you are trying to see if one item seems tastier than the others. In contrast, if you are in an unfamiliar neighborhood and you notice your car is low on gasoline, you start searching for service stations and stop at the first reasonable place you find. You do not need the best service station in town. (p. 20)

Optimization of the Serially Generated Options

This research uncovered yet another level of advance pattern recognition, a process the researcher is calling the "optimization of the serially generated options." One assertion of the RPD model is that time pressure need not cripple the performance of decision makers who have considerable expertise, because they use pattern matching.

The most critical assertion of the RPD model is that "people can use experience to generate a plausible option as the first one they consider. If this assertion is invalid, the rationale for the RPD model disappears" (Klein, 1997, p. 288). "An RPD involves an assessment of the situation, recognition of events as typical, and a resultant course of action based on previous experience" (Holmquist & Goldberg, 2007, p. 2).

The Decision Making Model for Quarterbacks represents the researcher's conclusion that the decision making expertise by the quarterback, deemed unconscious competence, is marked by an ability to optimize, i.e., find the best answer rather than safisficing, and in other words, selecting the first option that works in this time constrained adversarial environment. The quarterback's ability to expertly perceive and comprehend the affordances available in his environment allows him to rapidly meet his information requirements, thereby minimizing or eliminating the time constraint that cripples most decision making efforts. The researcher has provided information gleaned from data and analysis of the information needs of the collegiate quarterback in support of this conclusion.

Participant #4 shares his situation assessment process as he walks to the line of scrimmage as quarterback: "I'm thinking of the play, I'm thinking about the weakness of the coverage and what plays or route takes advantage of this. After the snap he begins a

process of elimination of the 10 coverage categories based on how the defense reacts after the snap of the football. The defense can do amazing things prior to the snap of the ball, but after the snap they don't keep secrets."

Participant #4 further explains that "You see the safeties, you see the coverage." A participant in Anderson's (1995) study on the mental strategies of football quarterbacks supports Participant #4's position by stating that "in films we look for a certain rotation of the secondary. Our key reads are usually the safeties. If we know where the safety is going in a certain spot, then that tells us where we should throw the ball. If you watch certain spots, then you see how it happens, and things open up, exactly like the coach tells you" (p. 44).

Participant #4 diagrammed and explained how the safeties tell him the coverage category, and how the cornerback lets him know man versus zone. In the Choice route he can "read" the play-side cornerback and "see" the safety. Through an advanced pattern recognition system, once this participant extrapolates information regarding the safeties he can also detect what type of coverage is being applied on the backside of the route. For instance, if the defense is employing a "Cleo" or "Buzz" variation to the trips side of the formation, he knows this by cues provided by the safety or safeties. In this manuscript's review of the literature, Joe Montana was quoted as stating that he knew by the second step where he would be throwing the football. One goal of the situation awareness analysis was to answer how Montana knows this when most experts agree that the defense reveals itself by the third step. The findings in this study provided the answer to that question by determining what the quarterback needs to know and how he is satisfying those information needs.

Our understanding of the how the quarterback is extrapolating cues from the environment to meet his information needs advances our understanding of the situation assessment process in dynamic time constrained conditions. Specifically, these findings and conclusions have advanced our knowledge of the use of the pattern matching process in the domain of football.

The quarterback is bringing the sum total of all of his knowledge and experience to each snap of the football including his knowledge of the strengths and weakness of each coverage category. The cues in the environment, i.e., the movement of the defense at the snap of the ball, tell the quarterback what coverage category he is facing. Thus, once he identifies the coverage category, he simultaneously gets a mental picture of this coverage and the affordances available through that coverage. Based on his mental recognition of the coverage he knows how the multiple adjusting routes will adjust to this particular coverage. When I watched Participant #4 on film, many times he completed a pass outside of the "structure" of the run and shoot offense. This study has revealed that this is the result of him reading the entire defense and serially generating options to attack the defense, in lieu of locating and attacking a particular defender. Each play in his arsenal is another variation that he can use to attack the defensive coverage. Participant #4 further explained that he teaches this process to his little league quarterbacks!

Dr. Gary Klein (1998), renowned scholar in time constrained decision making, explains that these "experts see the things the rest of us cannot, and often experts do not realize that the rest of us are unable to detect what seems obvious to them" (p.147). In this case, he could not be more correct!

Implications for Further Research

Analyzing the learning environment. In the aforementioned sections, the researcher discusses the implications of his conclusions by way of a pattern recognition hierarchy, with one pattern recognition system being higher or superior to the other system. The researcher recommends that further research be conducted to address the role of pattern recognition in time constrained decision making in order to ascertain if the differences in pattern recognition identified in this study are hierarchical, divergent, or the product of different learning environments.

The head coach who designed the learning environment for Participant #4 is a former wide receiver coach, quarterback coach, and Head Coach in the Run and Shoot offense. As the Head Coach, he also serves as this own Offensive Coordinator. The receivers, quarterbacks and position coaches attend the same meetings, for the purpose of mitigating what the Head Coach described as “interference.” By eliminating interference, players are constantly hearing the same message and coach is incessantly delivering the same message. Please note that the coach is not attempting to stifle innovation. Coaches can and do bring suggestions to improve the practice environment. But no change can be implemented without the expressed verbal consent of the Head Coach so that he can communicate that change to everyone involved in the process.

Equally important to the concept of mitigating interference, is this coach’s emphasis on understanding and attacking defenses. He explains that his quarterbacks will not throw a pass until they understand defenses. He gave the researcher unfettered access to his innovative playbooks and conducted a one-on-one five hour session with the researcher related to the strengths and weakness of 10 coverage categories. Through

access to the aforementioned information, coupled with a semi-structured interview of one of his record-setting quarterbacks, and subsequent goal directed task analysis, the researcher concludes that unconscious competence in the dynamic pocket of the collegiate quarterback, the goal of the Decision Making Model for Quarterbacks, may indeed be the result of a quarterback's ability, through the expert detection and comprehension of the cues available from the environment, to optimize, and thus, to select the best choice from his serially generated options.

The link in the development of both pattern recognition systems is an enhanced learning environment that is aligned to the learning outcome. You will see practice sessions that feature multiple quarterbacks throwing to multiple receivers, in a rapid succession of drills and live repetitions. The practice sessions are video-taped. The video-based review is conducted in the classroom at the conclusion of the practice session.

The consistently common thread throughout the Run and Shoot community is an understanding that we learn by doing. In the words of Participant #5, you can teach this process in the classroom, but you can only learn it through miles and miles of repetitions on the field!

To the research community, the researcher's conclusions signals a call for further research on the connection between the learning environment and the acquisition of advanced pattern recognition in football and beyond. To the football community this question has implications for how we design the learning environment for our practice sessions.

Klein (1998) believes that this situation awareness expertise, particularly the part that involves pattern matching and recognition of familiar and typical cases, can be trained. Klein states that "if you want people to size up situations quickly and accurately, you need to expand their experience base" (p. 42). He espouses training programs with exercises and realistic scenarios, so the person has a chance to size up numerous situations very quickly. He asserts that "a good simulation can sometimes provide more training value than direct experience. A good simulation lets you stop the action, back up to see what went on, and cram many trials together so a person can develop a sense of typicality" (p. 43).

While acknowledging the potential of virtual simulation Klein (1998) offers the following sage advice, "if the purpose is to train people in time-pressured decision making, we might require that the trainee make rapid responses rather that ponder all the implications. If we can present many situations an hour, several hours a day, for days or weeks, we should be able to improve the trainee's ability to detect familiar patterns" (p. 30). The design of the scenarios is critical, since the goal is to show many common cases to facilitate recognition of typicality along with different types of rare cases so trainees will be prepared for these as well" (Klein, 1998, p. 30).

PlayAction Simulator PC as a SAGAT simulation tool. Evaluating the ability of the PlayAction Simulator PC to be used as a SAGAT simulation tool was at the core of this inquiry. This study was interested in the PlayAction simulator as a tool to measure and train the situation assessment portion of the decision making process. Specifically, the researcher asked, can the simulator be programmed to randomly display sound questions designed to measure the SA of the quarterback and provide an ecologically

sound environment that provides the information the quarterback needs to answer the probes? The answer to those questions was affirmed and represented by a series of screen shots of the live action.

The PlayAction Simulator PC delivered a predictive and high fidelity artificial intelligence to the desktop that fueled an appealing and realistic interface. In quarterback view, the researcher was able to extrapolate the cues from the environment that enabled him to read and recognize the defense. At the press of a button on the simulator controller, the researcher was launching perfectly thrown passes into an area vacated by a surprisingly adept defense. The defense was able to present a myriad of pre-snap disguises that forced the researcher to make post-snap decisions. In test mode, the screen would go blank at a randomly selected time and display sound questions designed to test the user's awareness, or cycle through the entire trial allowing the user to implement his aerial hypothesis. The screen shots and researcher's experience of the live action provide vivid and compelling evidence that the PlayAction Simulator PC can be used as a SAGAT simulation tool.

So what are the ramifications of these findings?

The researcher has presented a hybrid RPD/SA model called the Decision Making Model for Quarterbacks. He defines the product of this process as Unconscious Competence and concludes that the action taken after the assessment is an optimized serially generated option.

Implicit in his conclusions is that the bridge to expert decision making in the pocket of the collegiate quarterback is the ability to quickly and accurately assess the defensive situations that unfold during live action. The researcher welcomes future

studies aimed at validating or refuting these findings. To effectuate these aims, future researchers will need two constructs, sound probes and a simulated experimental environment that meets the ecologically valid bar set by the PlayAction Simulator PC.

Fortunately for the research scientist, system designer, quarterback coach and aspiring All-American quarterback, this product delivered one shining moment in the advancement of virtual simulation as a tool to measure and train time constrained decision making. Absent from this groundbreaking application, there is currently no other experimental environment for measuring a quarterback's situation awareness.

Field testing the reliability of the probes. Inherent in the Goal Directed Task Analysis of the quarterback is the formulation of sound questions. The process of generating and categorizing questions derived from the Goal Directed Task Analysis cannot be overemphasized. The 31 questions generated from this analysis and every subsequent study MUST be tested for reliability. The researcher attempted to mitigate any concerns about the validity of the questions by having them reviewed and approved by the subject matter experts. But these questions must still be field tested for reliability.

The development of psychometrically sound probes is critical because the probes will be the focal point of the design effort. The system engineer will be designing and programming virtual simulations that provide an ecologically sound environment for the quarterback, in which he is able to extrapolate the information required to answer those questions. Without valid and reliability metrics for measuring the SA of the quarterbacks, we will have no way of empirically investigating the predictive validity of PlayAction Simulator PC as a tool that links SA to decision making and ultimately exemplary performance on the field.

For the coach, the benefits are equally immense. The current practice, either on the practice field or in the film room, is to infer a quarterback's SA based on his action. If these questions are found to be reliable, they would give the quarterback coach, and the quarterback for that matter, research-based metrics designed to measure the quarterback's situation awareness prior to the decision point. This allows the coach to diagnose and troubleshoot decision making errors at three levels of SA, perception, understanding and projection and to create interventions designed to correct those deficiencies.

Historically, training strategies in sport have been based on intuition and emulation rather than on evidence-based practice (Williams & Ward, 2001; 2003). Training methods are passed down from coach to coach, and are usually based on tradition rather than scientific evidence. Thus, a coach may be treating the disease of bad decision making, (one based on the result of the incorrect action, for example), instead of the symptoms of this behavior, such as a lack of understanding of the perceptual cues.

Future designs. This researcher has validated the use of the SAGAT methodology to analyze the information requirements of the collegiate quarterback and create sound metrics that measure the quarterback's situation awareness. Additionally, the findings affirm the ability of the PlayAction PC to be used as a SAGAT simulation and measurement tool.

Recognizing that the capabilities now offered by simulation have created unlimited opportunities for measuring and training decision making, "a key question to ask is whether training under simulated conditions is actually useful in improving 'real-world' performance and at what cost" (Salas et al., 1998, p. 206).

To answer this question we must examine the predictive validity of the experimental setting to performance on the field. The systems designer wants to be able to say to the major college football coach and athletic administrator that this product is empirically correlated to performance on the field. Specifically, with *x* amount of hours of exposure to the experimental environment, the user will experience a statistically significant increase in the percentage of correct decisions made on the field.

Thus, we need to ask, what is the relationship between situation awareness and the decision making of NCAA quarterbacks?

"Situation awareness forms the critical input to decision making and decision making is the basis to all subsequent action" (Endsley et al., 1998, p. 1). But ultimately, quarterbacks have to effectively parlay their situation awareness into the correct course of action.

SAGAT is a knowledge-based measure that attempts to ascertain the subject's mental model or knowledge at different times throughout an experiment. In measuring the situational awareness of collegiate quarterbacks we can only make a reasonable guess about the subject's real-time actions (Adams, Tenney, & Pew, 1995).

In the next phase of the research agenda, researchers must move beyond the inference of highly accomplished decision making with the introduction of performance based measures that measure the final decision making performance of the NCAA quarterback. "Testable responses will provide a mechanism to unambiguously ascertain subjects' situation awareness from their performance" (Pritchett & Hansman, 2000, p.201). These psychometrically sound and testable responses must be "isolated, experimentally controlled events that cannot be anticipated through any means other than

good situation awareness, and that require a discernible, identifiable action (or set of actions)" (Pritchett & Hansman, 2000, p.197)., by the quarterback or conducted *in-situ*, during live game action.

"The performance based measure allows the experimenter to ascertain the timing and substance of a user's reaction to realistic situations" (Pritchett & Hansman, 2000, p.197). "Thus, the root cause of incorrect actions can be identified as a problem with situation awareness or as a situation when the quarterback has correct situation awareness but has problems with making and executing a satisfactory decision" (Pritchett & Hansman, 2000, p. 189).

Game On!

How accurate is accurate enough?

-- Aldrich (2003, p. 102)

As the researcher watched the realistic hologram-type images powered by EA Sports during the pre-game football analysis on ESPN, he concluded that accurate enough is here, right now!

The researcher envisions this emerging technology as the world's great cerebral sports enhancement. Implicit in the study is a hypothesis that once the lines of real-time action have been mapped in a quarterback's brain, the PlayAction Simulator stimulates and enhances those domain specific areas in the brain of the quarterback.

Which takes us back to the driving question in this inquiry: How did Tom Brady, operating in high stakes adversarial environment, under extreme time constraints, on the biggest stage in professional sports, the Super Bowl, display such unparalleled examples of expert decision making and performance? "Simply the way he stood back in the pocket

the rush coming in at high tide, the lineman working so furiously to keep it out, the receivers on their anaerobic flights downfield -- all of this took place while he stood back there perusing the field like a man standing in front of a painting" (Keown, 1997, p. 1). Gonzalez (2004) states that Brady's "ability to perceive the situation clearly; plan and take correct action, is based on his training, experience and capacity for his logical neocortex (the brain's thinking part) to override the primitive amygdala portion of his brain" (p. 10). So was the realistic, re-playable, game like artificial intelligence similar to that found in the PlayAction Simulator PC his secret weapon? These and other profound questions shape the landscape of the next frontier in understanding and advancing our knowledge of time constrained decision making.

Democratization of Access to Quality Deliberate Practice through Virtual Simulation

"Great NFL quarterbacks make the correct decision over 95% of the time"

(Montana & Weiner, 1998, p.71).

According to Participant #5, you can teach the decision making process in classroom, but you can only learn it on the field, in live game time action. Let us acknowledge that ideally, for optimal quarterback development, a real-time practice environment that allows learning to take place *in-situ* under the watchful eye of a master coach that can provide quality feedback in response to the player's deliberate practice is ideal. If experience is the best teacher, the most exciting feature of the PlayAction Simulator PC may be the Democratization of Access in building the experiential base of the aspiring quarterback.

As mentioned in Chapter 2 of this manuscript, Ericsson et al. (1993) concluded that the most effective learning occurs through involvement in a highly structured activity defined as deliberate practice. According to these researchers, engagement in deliberate practice requires effort, generates no immediate rewards, and is motivated by the goal of improving performance rather than inherent enjoyment.

Sosniak (1985) suggested that although time engagement in the actual domain of expertise was a crucial factor to learning for those involved in the study, it alone was not sufficient to ensure high levels of performance in the domain. Sosniak stated: "What a learner does, how he or she does it, and how things change as the years pass are certainly more important variables than the absolute amount of time spent at an activity" (p. 409). Salas et al. (1998) concur, pointing out that "more" is not necessarily "better" and the way in which the simulation is implemented during training is of greater importance than the simulation itself.

Klein (1998) asserts that "a good simulation can sometimes provide more training value than direct experience. A good simulation lets you stop the action, back up to see what went on, and cram many trials together so a person can develop a sense of typicality" (p. 43).

"If the purpose is to train people in time-pressured decision making, we might require that the trainee make rapid responses rather that ponder all the implications. If we can present many situations an hour, several hours a day, for days or weeks, we should be able to improve the trainee's ability to detect familiar patterns" (Klein, 1998, p. 30).

The engineers at XOS Digital have used virtual simulation to turn the aforementioned "if" into a reality. From the NCAA coach who is pinning his BCS

championship hopes on the right arm and left brain of an 18-year-old phenom, to the 3rd string, 6th round draft pick (see Tom Brady) that just needs “game time” experience to blossom into a “prime-time” NFL quarterback, Democratization of Access to Quality Deliberate Practice through Virtual Simulation renders the PlayAction Simulator PC priceless.

REFERENCES

Adams, M. J., Tenney, Y. J., & Pew, R. W. (1995). Situation awareness and the Cognitive management of complex systems, *Human Factors, 37*(1), 85-104.

Anderson, D. C. (1995). *Mental strategies of football quarterbacks for training and competition.* (Unpublished master's thesis). University of Ottawa, Canada.

Aldrich, C. (2003). *Simulations and the future of learning: An innovative (and perhaps revolutionary) approach to e-learning*. San Francisco, CA: Pfeiffer.

Bailenson, J.N., Patel, K., Nielsen, A., Bajcsy, R., Jung, S., & Kurillo, G. (2008). The effect of interactivity on learning physical actions in virtual reality. *Media Psychology, 11*, 354–376.

Baker, J., Cote, J. & Abernethy, B. (2003). Sport-specific practice and the development of expert decision-making in team ball sports. *Journal of Applied Sport Psychology, 15*, 12-25.

Beier, K., (2001). The virtual football trainer. Retrieved January 10, 2008, from http://www-vrl.umich.edu/beier/index.html

BusinessWire. (2007). XOS Technologies and EA SPORTS declare 'Game on!' Retrieved May 20, 2008, from http://www.businesswire.com/portal/site/google/index.jsp?ndmViewId=news_view&newsId=20070430005959&newsLang=en

Calderwood, R., Klein, G. A., & Crandall, B. W. (1988). Time pressure, skill, move quality in chess. *American Journal of Psychology, 101*(4), 481-493.

Charness, N. (1989). Expertise in chess and bridge. In D. Klahr and K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon* (pp. 183-208). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cote, J., Baker, J., & Abernethy, B. (2003). From play to practice: A developmental framework for the acquisition of expertise in team sports. In J. L. Starkes and K. A. Ericsson (Eds.), *Expert performance in sports* (pp. 89-114). Champaign, IL: Human Kinetics.

Davids, K., Button, C., & Bennett, S. (2008). *Dynamics of skill acquisition: A constraints-led approach.* Champaign, IL: Human Kinetics.

De Groot, A. D. (1978). *Thought and choice in chess*. New York, NY: Mouton.

Duda, R. O., Hart, P. E. & Stork, D. G. (2001). *Pattern classification* (2nd ed). New York, NY: Wiley-Interscience.

Elo, A. E., (1978). *The rating of chess players, past and present*. New York, NY: Arco.

Endsley, M. R. (1988). Design and evaluation for situation awareness enhancement. In *Proceeding of the Human Factors Society 32nd Annual Meeting* (pp. 97-101). Santa Monica, CA: Human Factors Society.

Endsley, M. R. (1995a). Measurement of situation awareness in dynamic systems. *Human Factors, 37*(1), 65-84.

Endsley, M. R. (1995b). Toward a theory of situation awareness in dynamic systems. *Human Factors, 37*(1), 32-64.

Endsley, M. R. (1995c). Direct measurement of situation awareness in simulations of dynamic systems: Validity and use of SAGAT. In D. J. Garland and M. R. Endsley (Eds.), *Experimental analysis and measurement of situation awareness* (pp.107-113). Daytona Beach, FL: Embry-Riddle University.

Endsley, M. R. (1997). The role of situation awareness in naturalistic decision making. In C. Zambock & G. Klein (Eds.), *Naturalistic decision making* (pp.269-284). Mahwah, NJ: Lawrence Erlbaum Associates.

Endsley, M. R. (2000a). Direct measurement of situation awareness: Validity and use of SAGAT. In M. R. Endsley & D. J. Garland (Eds.), *Situation awareness analysis and measurement* (pp.147-173). Mahwah, NJ: Lawrence Erlbaum Associates.

Endsley, M. R. (2000b). Theoretical underpinnings of situation awareness: A critical review. In M. R. Endsley & D. J. Garland (Eds.), *Situation awareness analysis and measurement* (pp.3-32). Mahwah, NJ: Lawrence Erlbaum Associates.

Endsley, M. R., (2004). Situation awareness: Progress and directions. In S. Banbury & S. Tremblay (Eds.), *A cognitive approach to situation awareness: Theory and application* (pp. 317-341). Burlington, VT: Ashgate.

Endsley, M. R. (2006). Expertise and situation awareness. In K. A. Ericsson, N. Charness, P. J. Feltovich, R. Hoffman (Eds.) *The Cambridge handbook of expertise and expert performance* (pp. 633-651). Cambridge, UK: Cambridge University Press.

Endsley, M. R., & Bolstad, C. A. (1994). Individual differences in pilot situation awareness. *International Journal of Aviation Psychology, 4*(3), 241-264.

Endsley, M. R., Bolté, B., & Jones, D. G. (2003). *Designing for situation awareness: An approach to user-centered design.* Boca Raton, FL: Taylor & Francis Group.

Endsley, M. R., Farley, T. C., Jones, W. M., Midkiff, A. H., & Hansman, R. J. (1998). *Situation awareness information requirements for commercial airline pilots* (ICAT-98-1). Cambridge: Massachusetts Institute of Technology International Center for Air Transportation.

Endsley, M. R., & Robertson, M. M. (1996). Team situation awareness in aviation maintenance. In *Proceedings of the 40th Annual Meeting of the Human Factors and Ergonomics Society, Vol. 2* (pp. 1077-1081). Santa Monica, CA: Human Factors and Ergonomics Society.

Endsley, M. R., & Rodgers, M. D. (1994). Situation awareness information requirements for en route air traffic control. In *Proceedings of the Human Factors & Ergonomics Society 38th Annual Meeting, Vol. 1* (pp. 71-75). Santa Monica, CA: Human Factor & Ergonomics Society.

Ericsson, K. A., Krampe, R. T., & Tesch-Romer, C. (1993). The role of deliberated practice in the acquisition of expert performance. *Psychological Review, 100,* 363-406.

Friedgen, R. (2008a). Teaching quarterbacks to attack defenses. In E. Browning (Ed.), *Coaching quarterbacks* (pp. 48-64). Monterey, CA: Coaches Choice Books.

Friedgen, R. (2008b). Training quarterbacks to run and pass. In E. Browning (Ed.), *Coaching quarterbacks* (pp. 65-84). Monterey, CA: Coaches Choice Books.

Flach, J. M. (1995). Situation awareness: Proceed with caution. *Human Factors, 37*(1), 149-157.

Gibson, J. J. (1966). *The senses considered as perceptual systems*. Boston, MA: Houghton Mifflin.

Goldiez, B., Ahmad, A.M., & Hancock, P.A. (2007). Wayfinding and navigation in augmented reality. Manuscript submitted for publication. Retrieved June 2, 2008, from http://www.peterhancock.ucf.edu/Downloads/ref_pubs/Goldiez_Ahmad_Hancock_2007.pdf

Gonzales, L. (2004). *Deep survival: Who lives, who dies, and why*. New York, NY: W. W. Norton.

Gray, W. (2002). Simulated task environments: The role of high-fidelity simulations, scaled worlds, synthetic environments, and laboratory tasks in basic and applied cognitive research. *Cognitive Science Quarterly, 2*, 205-227.

Helsen, W. F., Starkes, J. L., & Hodges, N. J. (1998). Team sports and the theory of deliberate practice. *Journal of Sport & Exercise Psychology, 20,* 12-34.

Helsen, W. F., & Starkes, J. L. (1999). A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology, 13,* 1-27.

Hodge, T. & Deakin, J. (1998). Deliberate practice and expertise in the martial arts: The role of context in motor recall. *Journal of Sport and Exercise Psychology 20,* 260-279.

Hodges, N. J., & Starkes, J. L. (1996). *Wrestling with the nature of expertise: A sport specific test of Ericsson, Krampe and Tesch-Romer's (1993) theory of 'deliberate practice.'* (Unpublished master's thesis). McMaster University, Hamilton, Ontario, Canada.

Hoffman, R. (2001). Project could alter way teams prepare for games. Retrieved April 23, 2009, from http://www-vrl.umich.edu/project/football/AANews_Story/index.html

Hoffman, R., Crandall, B., Klein, G., Jones, D., & Endsley, M. (2008). Protocols for cognitive task analysis. Unpublished report. Retrieved June 2, 2009, from http://www.ihmc.us/research/projects/CTAProtocols/ProtocolsForCognitiveTaskAnalysis.pdf

Holding, D. H., & Reynolds, R. I. (1982). Recall or evaluation of chess positions as determinants of chess skill. *Memory and Cognition,10,* 237-242.

Holmquist, J. P. & Goldberg, S. L. (2007). Dynamic situations: The soldier's situation awareness. Retrieved April, 21, 2008, from http://74.125.45.132/search?q=cache:gkT8o4pJLX4J:ftp://ftp.rta.nato.int/PubFullText/RTO/TR/RTO-TR-HFM-121-Part-II/TR-HFM-121-Part-II-06.pdf+Dynamic+Situations:+The+Soldier%E2%80 %99s+Situation+Awareness&hl=en&ct=clnk&cd=2&gl=us

James, N., & Patrick, J., (2004). The role of situation awareness in sport. In S. Banbury & S. Tremblay (Eds.), *A cognitive approach to situation awareness: Theory and application* (pp. 297-316). Burlington, VT: Ashgate .

Jones, D. & Endsley, M. R. (1996). Sources of situation awareness errors in aviation. *Aviation, Space and Environmental Medicine, 67*(6), 507-512.

Keown, T. (1997). Joe's mystical cool couldn't be duplicated. Retrieved August 28, 2008, from http://www.sfgate.com/cgi-bin/article.cgi?file=/c/a/1997/12/15/SP35988.DTL

Klein, G. A. (1997a). Naturalistic decision making: Where are we going? In C. Zsambok & G. A. Klein (Eds.), *Naturalistic decision making* (pp. 383-397). Mahwah, NJ: Lawrence Erlbaum Associates.

Klein, G. A. (1997b). The recognition-primed decision (RPD) model: Looking back, looking forward. In C. E. Zsambok & G. Klein (Eds.), *Naturalistic decision making* (pp. 285-292). Mahwah, NJ: Lawrence Erlbaum Associates.

Klein, G. A. (1999). *Sources of Power: How people make decisions.* Cambridge, MA: MIT Press.

Klein, G. A. (2000). Analysis of situation awareness from critical incident reports. In M. R. Endsley & D. J. Garland (Eds.), *Situation awareness analysis and measurement* (pp. 51-71). Mahwah, NJ: Lawrence Erlbaum Associates.

Klein, G. A., Calderwood, R., & MacGregor, D. (1989). Critical decision method of eliciting knowledge. *IEEE Transactions on Systems, Man and Cybernetics, 19,* 462-472.

Klein, G. A., Calderwood, R., & Clinton-Cirocco, A. (1985). Rapid decision making on the fire ground (KA-TR-84-41-7). Yellow Springs, OH: Klein Associates Inc. (Prepared under contract MDA903-85-G-0099 for the U.S. Army Research Institute, Alexandria, VA).

Klein, G.A., Calderwood, R., & Clinton-Cirocco, A. (1986). Rapid decision making on the fire ground. In *Proceedings of the Human Factors Society 30th Annual Meeting* (pp 576-580), Santa Monica, CA: Human Factors Society.

Klein, G. A., Orasanu, J., Calderwood, R., & Zsambok, C. E. (Eds.) *Decision making in action: Models and methods*. NJ: Ablex Publishing Corporation.

Klein, G. A., Wolf, S., Militello, L., & Zsambok, C. (1995). Characteristics of skilled Option generation in chess. *Organizational Behavior and Human Decision Processes, 62*(1), 63-69.

Levitin, D. (2007). *This is your brain on music: The science of a human obsession.* New York: Plume.

Lipshitz, R. (1993). Converging themes in the study of decision making in realistic setting. In G. A. Klein, J. Orasanu, R. Calderwood, & C. Zsambok (Eds.), *Decision making in action: models and methods,* (pp.103-137). Norwood, NJ: Ablex.

Lipshitz, R., & Ben Shaul, O., (1997). Schemata and mental models in recognition-primed decision making. In E. Zsambok & G. A. Klein (Eds.), *Naturalistic decision making: Expertise, research and application* (pp. 293-303). Mahwah, NJ: Lawrence Erlbaum Associates.

Montana, J., & Weiner, R. (1998). *Joe Montana's art and magic of quarterbacking: The secrets of the game from one of the all-time best.* New York, NY: Holt Publishing.

Pritchett, A. R., & Hansman, R. J. (2000). Use of testable responses for performance-based measurement of situation awareness. In M. R. Endsley & D. J. Garland (Eds.), *Situation awareness analysis and measurement* (pp. 189-209). Mahwah, NJ: Lawrence Erlbaum Associates.

Raab, M., de Oliveira, R., & Heinen, T. (2009). How do people perceive and generate options? *Progress in Brain Research, 174,* 49-59.

Reason, J. (1987). A preliminary classification of mistakes. In J. Rasmussen, K. Duncan, & J. Leplat (Eds.), *New technology and human error* (pp. 15-20). New York, NY: Wiley.

Rouse, W. B., Cannon-Bowers, J. A., & Salas, E. (1992). The role of mental models in team performance in complex systems. *IEEE Transaction on Systems, Man and Cybernetics, 22*, 1296-1308.

Salas, E., Bowers, C. A., & Rhodenizer, L. (1998). It is not how much you have but how you use it: Toward a rational use of simulation to support aviation training. *The International Journal of Aviation Psychology, 8,* 197-208.

Simon, H. A. (1957). *Models of man: Social and rational*. New York, NY: Wiley.

Sosniak, L.A. (1985). Phases of learning. In: B. Bloom (Ed.) *Develop talent in young people* (pp. 409-438). New York, NY: Ballantine Books.

Soh, B. K. (2007). *Validation of recognition-primed decision model and the roles of common sense strategies in an adversarial environment*. (Unpublished doctoral dissertation). Virginia Polytechnic Institute and State University, Virginia.

Starkes, J. L., Deakin, J. M., Allard, F., Hodges, N. J., & Hayes, A. (1996). Deliberate practice in sports: What is it anyway? In K. A. Ericsson (Ed.), *The road to excellence: The acquisition of expert performance in the arts and sciences, sports and games* (pp. 81-106). Mahwah, NJ: Lawrence Erlbaum Associates.

Valeriote, S. (1984). *Analysis of differences in a perceptual skill between defensive backs in Canadian football.* (Unpublished master's thesis). York University, Toronto.

Vickers, J. N. (2007). *Perception, cognition, and decision training: The quiet eye in motion.* Champaign, IL: Human Kinetics.

Vidulich, M. (2000). Testing the sensitivity of situation awareness metrics in interface evaluations. In M. R. Endsley & D. J. Garland (Eds.), *Situation awareness analysis and measurement* (pp. 227-248). Mahwah, NJ: Lawrence Erlbaum Associates.

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

Ward, P., Williams, A. M., & Hancock, P. A. (2006). Simulation for performance and training. In K. A. Ericsson, N. Charness, P. J. Feltovich, R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp.243-262). Cambridge, UK: Cambridge University Press.

Wickens, C. D. (1992). *Engineering psychology and human performance* (2nd ed.). New York, NY: Harper Collins.

Willes, E. (2008). Brett Favre is the Picasso of pigskin perfection. Retrieved August 27, 2008, from http://www.canada.com/topics/sports/story.html?id=e50daaa4-8d2c-400a-8647-fa2f5a5ff8a3

Williams, A. M., & Ward, P. (2001). Developing perceptual skill in sport: The need for evidence-based practice. In A. Papaioannou, M. Goudas, & Y. Theodorakin (Eds.), *Proceedings of the 10th world congress of sport psychology, Vol. 3* (pp. 159-161). Skiathos, Hellas: International Society of Sport Psychology.

Williams, A. M., & Ward, P. (2003). Perceptual expertise: Development in sport. In J. L. Starkes & K. A. Ericsson (Eds.), *Expert performance in sport: Advances in research on sport expertise* (pp. 220-249). Champaign, IL: Human Kinetics.

Wolgast, L. C. K. A. (2005). Command decision-making: Experience counts. USAWC Strategy Research Project, U. S. Army War College. Retrieved June 13, 2010, from http://www.au.af.mil/au/awc/awcgate/army-usawc/cmd-decis-mkg.pdf

XOS Sports (2007). Facilities design & integration overview. Retrieved June 21, 2006, from http://www.nmnathletics.com/SportSelect.dbml?&&&&&&&& DB_OEM_ID=40&KEY=&SPID=9207&SPSID=79446&SSPID=276&NSPID= 401

Yang, Z., Liang, J., Yu, B., Cui, Y., Nahrstedt, K., Jung, S. H., & Bajcsy, R. (2005, December). TEEVE: Tele-immersive environment for everybody. In *Proceedings of IEEE International Symposium of Multimedia* (pp. 112–119). December 12-14, 2005, Irvine, CA.

Yates, J. F., & Tschirhart, M. D. (2006). Decision-making expertise. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. Hoffman (eds.), *The Cambridge handbook of expertise and expert performance* (pp. 421-438). Cambridge University Press.

Zsambok, C. E., & Klein, G. (Eds.). (1997). *Naturalistic decision making*. Mahwah, NJ: Lawrence Erlbaum Associates.

APPENDIX A: Text of Inquiry to Potential NCAA Coach Participants

Dear X,

My name is Burnie Bristow, and I am a doctoral student at the Graduate School of Education and Psychology at Pepperdine University. I am studying the use of immersive virtual simulation as a tool to train and assess the Decision Making of collegiate and professional athletes; this study is conducted in partial fulfillment of the requirements for the degree of Doctor of Education in Learning Technologies at Pepperdine University. I had the privilege of meeting with you and briefly discussing my project while attending the Mega Football Clinics in Texas; the design of the study has finally been approved by my dissertation committee and the institutional review board at Pepperdine University.

The purpose of this study is to empirically investigate the link between situation awareness and decision making in the domain of the NCAA quarterback and to explore the potential of immersive virtual simulation as a tool to measure and train situation awareness. Before I can measure a quarterbacks situation awareness or effectively evaluate a product designed to enhance decision making I need to ascertain what quarterbacks need to know in order to accomplish their goals. I'm attempting to attract the most recognized and prolific Run and Shoot Coaches and Quarterbacks (past and present) in the country to help formulate a Goal Directed Task Analysis that will yield the situation awareness requirements for reading complex NCAA defenses.

This letter is an invitation to participate in this ground breaking study. In formulating a Goal Directed Task Analysis for reading complex collegiate defenses I anticipate four face-to-face interviews lasting two hours a piece. Each interview will be

followed up with a 30 minute session conducted via cell phone, text, virtually or any other method most convenient to you. The interviews, conducted individually, will use the following format:

Part I: We will develop a goal structure that will serve as the baseline for future iterations, helps in the process of aggregating information, and helps direct information gathering efforts during the next round of interviews.

Part II: One section of the GDTA will be selected for further review, and each component of that section will be discussed at length.

Part III: Additional interviews will be conducted and the GDTA revised until a comprehensive GDTA has been developed.

Part IV: Printouts of the final GDTA will be distributed to Darrel "Mouse" Davis. Mr. Davis will identify missing information or errors. Needed corrections will be made.

Please note: Information in the GDTA is concerned with the goals and information requirements, not current methods and procedures for obtaining the information or performing the task. Thus, this study is NOT a look into the intricacies and secrets of the Run and Shoot offense. I chose the Run and Shoot offense as a vehicle to understand the decision making process because of the dynamic synergy that must take place between the quarterback and receiver in such time constrained, adversarial conditions and because of my familiarity with the offense as a player and coach.

The methodology has been approved by the Institutional Review Board of Pepperdine University; all believe there are no significant risks to participants in this study. Your participation in this study is strictly voluntary, and you may revoke your participation at any time.

Please return the attached Informed Consent Form with your signature if you would like to participate in this ground-breaking study. Fax your signed form to the doctoral researcher, Burnie Bristow, at (973) XXX. Once your form is received, you will be contacted to confirm your participation and arrange interview dates and times.

Sincerely,

Burnie Bristow, MA, NBCT

Doctoral Candidate, Learning Technologies

Graduate School of Education and Psychology

Pepperdine University, CA

Email: bbristow@pepperdine.edu

Phone: 973-xxx-xxxx

APPENDIX B: Informed Consent Required of Participants

Informed Consent

The following information is provided to help you decide whether you wish to participate in this research study. The purpose of the study is to: (1) empirically investigate the link between situation awareness expertise and decision making expertise in the domain of the NCAA quarterback and (2) to explore the potential of immersive virtual simulation as a tool to measure and train situation awareness.

This study is conducted in partial fulfillment of the requirements for the degree of Doctor of Education in Learning Technologies at Pepperdine University.

Based on your extraordinary success as a Player/Coach in the Run and Shoot offense you have received a special invitation to join a minimum of six record setting Run and Shoot coaches and quarterbacks in the creation of a Goal Directed Task Analysis (GDTA). The GDTA will yield the information requirements necessary to read and recognize complex NCAA defenses.

Your participation in this study will benefit: (1) system designers who are seeking valid and reliable methods to design and evaluate products that enhance decision making in time constrained, adversarial conditions (2) researchers seeking to objectively measure situation awareness in the domain of sports (3) coaches at all levels seeking to implement evidence based practices into their coaching repertoire (4) and athletes seeking to improve their decision making ability.

To complete this endeavor, I'm anticipating four face-to-face interviews, conducted individually and lasting no more than two hours a piece. Each interview will be followed up with a 30 minute session conducted via cell phone, text, virtually or any

other method most convenient to you. I will be conducting the interviews at a site and time most convenient to you. Information obtained through the interviews will be organized into charts depicting a hierarchy of goals, decisions and information requirements. The finalized Goal Directed Task Analysis will be reviewed by all of the coaches and quarterbacks participating in the study.

The minimum risk to participation is the potential time commitment involved in knowledge elicitation interviews. To address the time burden, the researcher used a structured interview process called the Situation Awareness Global Assessment Technique (Endsley, 1995c). This methodology allows me to control this burden, i.e., each interview is designed to last no more than two hours, and provides the participant with a build in mechanism for opting out at any time.

Additionally, because your experience and expertise are at the core of this study, there is risk involved with maintaining the anonymity of your individual responses and protecting the individual and collective reputation of the coaches and quarterbacks. To mitigate these risks the following procedures will be followed:

Information gathered through the individual knowledge elicitation interviews remain in the sole custody of the researcher for the duration of the study. The participant's identity will be protected with a pseudonym name and individual responses will not be seen by the other participants. After each round of interviews (1) Goals (2) Decisions (3) Information Requirements, I will put the aggregated data into a Goal Directed Task Analysis (GDTA) hierarchy chart. The participants will review the contents of the GDTA for accuracy. Additionally, the participants will review and approve the finalized Goal Directed Task Analysis Hierarchy Chart. No information, in

individual or aggregate form, will be published without the expressed written consent of the participants. The consent will be in the form of a signature on the GDTA. Participants can withdraw from the study at any time. Backup copies of the data will be maintained on a backup external hard drive and stored in a bank safe-deposit box. The data will be destroyed after three years.

Your participation is voluntary. You are free to decide not to participate or to withdraw at any time without affecting your relationship with me, Pepperdine University or any other entity. Please rest assured that my class standing, grades or job status will not be affected by your refusal to participate or by withdrawal from the study. Upon your request, I will provide a copy of any published papers or professional presentations that take place as a result of this study.

In order for me to use what I learn from you in my research and publication, I am required to ask for your permission and for your agreement to participate as described. Please initial the appropriate line to confirm your wishes for acknowledgement or anonymity, and then sign the bottom of this form to indicate your interest in participating in this study.

_____ I agree to permit the researcher to use my name, professional
(please initial) affiliation and the name of my organization. I understand that my individual responses will not be associated with my name or institution, and results will only be presented in aggregate form.

-OR-

_____ I agree to permit the researchers to refer to me only by a pseudonym
(please initial) from a "generic organization" (e.g. Mr. John Smith from Team A) I understand my identity and the name of my organization will be kept confidential at all times

Please feel free to ask any questions about this study before we begin or during the course of the study by contacting Burnie Bristow, Principal Investigator, at 973-980-2671 or by email at bbristow@pepperdine.edu, or Dr. Linda Polin, dissertation chairperson, at 310-568-5641, or by email at lpolin@pepperdine.edu. For any other general information regarding your rights pertaining to this study, please contact Dr. Doug Leigh, IRB Chairperson at Pepperdine University's Graduate School of Education and Psychology at 310-568-2389.

At this point, I am required to ask you if you fully understood my statements and if so, to initial next to the category that applies to you and sign this form.

Name _____

Signature _____ Date _____

APPENDIX C: Interview Results Charts

Name: Participant # 1

Activity	**Goals**	**Decisions**	**Information Requirements**	**Notes**
Walking to the Line of Scrimmage	**Q. As I walk to the line of scrimmage what is my goal, what am I trying to accomplish A. Complete the pass and attack the weakness of the defensive coverage**			
		"When reading the coverage you need to <u>understand</u> the defensive responsibility"		
				"Choice is a whole field progression"
Walking through the progressions…			**"The first read is the corner to the single receiver side of the formation"** **Q. "How will I know what route the receiver will run? "**	Questions has implications for the decision making process.

Reading the play-side corner			**A. "(1) By the cushion of the corner at the decision making point (2) by the body language of the receiver" The participant explained that "It takes a lot of repetitions to develop this skill. Part of our practice routine is to have the receiver and the quarterback practice "on air", i.e., no defender so that the Qb's learns the body language of the receivers at their decision point**	
Reading the backside of Choice			**Q. "When reading the back side of Choice, do you read the man or do you read the safety."** **A. The participant responded "the Safety."**	

Name: Participant # 2

Activity	Goals	Decisions	Information Requirements	Notes
Quarterback walks to the line of scrimmage	**Be productive… productive equates to completing passes, ideally at a rate of three TD's to one interception** **"at its simplest denominator the quarterback has to make good decisions and make good throws."**	**Part of the layering process is "identifying coverages and understanding the route structure."**	**"When asked how do you extrapolate information regarding these constructs, the reply was "how many safeties and their location on the field, the (corners, depth, eyes, leverage, body language)"**	
"You walk to the line of scrimmage," the route is choice.	**in a multiple adjusting route system, "there will be times when more than one receiver is open.**	**"What is the coverage, how will the routes adjust to this coverage, and what is the context of the game?"**		
Context (responses related to Goals and Decisions)	**Depending on the context, down, distance, time, score, etc, a quarterback may decide**			

Mapping Coverages +Route Structures	**to take a shorter route or hold the ball to wait for a deeper route to develop. But this decision making is done within the route structure." By structure of the scheme we mean who will be open, when and where.**	**By understanding coverages, i.e., Choice Route vs. Three Deep-Zone, Man Free, Two Deep Zone, Two-Deep, Four Deep Zone, Four Across Man and the route structure, i.e., how the receivers will adjust their routes against those coverages, the quarterback can better anticipate what will happen but his pre-snap "aerial hypothesis" must be confirmed on every play.**	**The participant revealed the critical cues associated with a safety's reaction at the snap of the football "Most of the disguises will manifest with secondary defenders coming "downhill"**	
Play progression		**"Based on the cushion of the corner at decision point the receiver will run one of three routes.**		

Pocket Awareness = Dynamic Conditions + Time Constraint		**"You don't just drop back and count to four".** **You have to "believe what you see". "If you can't see the defender you are reading or the receiver in your read progression you must maneuver in the pocket to find a passing lane.** **Q. What if you can't find the information you need, what do you do?** **A. The participant responded, "go to your next read, or throw the ball away if you "feel" the pocket is about to collapse."**		

Name: Participant # 3

Activity	**Goals**	**Decisions**	**SA Requirements**	**Notes**
"When the quarterback walks up to the line of scrimmage what is he trying to accomplish".		**"Before we get to the field the quarterback has to have a complete understanding of the defensive opposition."**		The learning environment… video based, note taking, Q&A
Identifying coverages **Strength and weakness of each coverage**		**The participant opened his Quarterback manual and thoroughly reviewed the strengths and weakness of each coverage**	**1.) Are they attempting a rotation coverage or lock in a pre-rotation coverage.** **2.) How will the secondary defenders react to motion?** **Safeties…** **a.) How will the safeties react to motion?** **b.) Will the defender over the motioning slot receiver come across the formation?** **---If yes, where are his eyes looking?** **c.) Will the defender over the motioning slot receiver come to the line of scrimmage or reduce?** **d.) Are the defenders in tight press coverage?** **---if yes, will the under-coverage be locked on or will they employ a**	

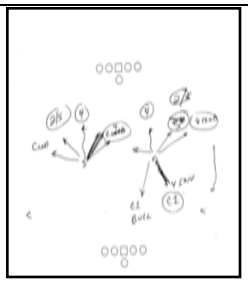
			"banjo" concept? e.) What is the technique of the play-side corner? ---eyes ---leverage	
Decision making process		**He explained the affordances of each technique for the quarterback**	"On many of the qb's initial weak side applied reads you will actually be viewing a complete 4 invert concept. For instance on 61X Choice s-Flat your initial read diagnoses 4 invert as you clue the corner and the A.O. defenders specific drop. You may not see the strong-side development or change-up unless you work back in your progression sequence to your #2 or #3 selection". 1985 Qb-Manual. P.127	
Cues		**(1) identify the defensive coverage, (2) understand the strengths of the defense (3) understand the play in relation to the coverage (4) know how to attack the weakness of the defense. He stated that" through miles and miles of repetitions" most of the decision making can be done after the**	**The "defensive backs and inside linebackers can provide cues but they are in a better position to disguise their intentions", i.e., the press and bail in a cover 3 concept, and back-off and then jam the receiver in a cover 2 concept.**	

		snap of the ball.		
Match-ups **The concept of multiple adjusting routes & MARS using Choice**				
			The participant explained how, based on Run and Shoot principles, these "umbrella" routes never occupy the same space. How each stem will manifest within the route structure is a key info req. (also see Tiger Ellison)	See participant's qb manual for an in-depth discussion Also, see Tiger Ellison Run and Shoot Football: The Now Attack p. 95

Name: Participant # 4

Activity	Goals	Decisions	SA Requirements	Notes
The researcher asked, as you walk to the line of scrimmage what are you attempting accomplish?	**"throw touchdowns, score, score quickly, score in one. If I execute 90% of the time, we win!" " How do you protect a lead? Score some more." The researcher quickly understood the goals of the most prolific QB in NCAA history.**			Researcher endeavors to understand how the innovative teaching techniques are implemented on the field.
"Going back to your college days, explain the process for achieving these goals."	**what do you do when you get a big lead, to which the participant responded, " the best way to protect a lead was to score again."**	**"when you play for participant #3 the first thing he hands you is a manual of defensive fronts and coverage's which outline the strength and weaknesses of ten coverage categories**	**I need to understand the structure of the play based on how I'm being defended.**	Context disappears… Rarely did I pay attention to game situations.

	"We were not interested in 10 play drives. We wanted to score now!"			
Multiple Adjusting Route System ("umbrella routes",) **Connecting the R&S back to Tiger Ellison**			**Participant's Diagram** **Also see Tiger Ellison**  **Understanding R & S Concepts (Umbrella Routes)** **The routes intersect but don't connect)**	the off-set of the quarterback. " coupled with the protection schemes make it easier to identify the coverage's and make the defense more vulnerable.
The process		**Pre-snap, I'm thinking…of the play, the weakness of the coverage, what plays or route takes advantage of this** **Post-Snap, "You see the safeties, you see the coverage".** **He begins a process of elimination of**	**He diagrammed and explained how the safeties tell him the coverage category and how the cornerback let him know man versus zone** **"The defense can do amazing things prior to the snap of the ball, but after the snap they don't keep secrets."** **To learn this, you need "miles of repetitions…**	After the ball is snapped, it's like reading a bad book for the 1000th time or seeing the same bad movie over and over again.

		the 10 coverage categories based on how the defense reacts after the snap of the football. Identify the coverage and find the routes, within the route structure that attack the weakness of the defense.	 **(meticulous attention to detail, high repetition, low interference ,learning environment)**	
Choice			**"read" the play-side cornerback and "see" the safety. read the frontside then reset his hips and feet to attack the weakness in the coverage.**	
Pattern recognition			**the participant diagrammed how he uses a pattern recognition system to identify the 10 coverage categories. Once he recognizes the coverage, he has a mental model of the weakness of that coverage. Through his frontside read of the coverage, he understands how the multiple adjusting routes**	 **Participant's Diagram**

			will adjust to the coverage. He looks for the routes with the play structure that will take advantage of the weakness in the coverage.	

Name: Participant #5

Activity	Goals	Decisions	Information Requirements	Notes
As the Qb walks up to the line of scrimmage, what is his over-arching goal?	**the goal of the quarterback is "always about completing the pass." participant agreed that this is a physical task The researcher asked, so the mental goal is to read and recognize the defensive coverage? The participant stated that reading and recognizing the defense is only a part of the cerebral equation. The goal is to "identify (read and recognize) and attack the weakness in the defense". we don't believe we will score on every play but if we read it, run good routes and get good identification**			The details of this interview include a combination of excerpts from the participant's best selling instructional video and information gleaned for the interview. In the video the participant presents an extensive overview of how to use the Choice Route is used to attack four categories of defensive coverages. The researcher sought to check his understanding of the information on the tape and get answers to "how" this information is actually implemented by the quarterback.

	of the coverage, we WILL complete the pass."			
Pre-snap Motion			**The perceptual cues involve the movement and the eyes of the defenders.** **----------** **the cues of multiple defenders should be aligned and when they don't align it triggers a cue that one or more of the defenders is attempting to disguise his intentions.** **----------** **pre-snap movement of the defense helps the quarterback get a pre-snap read of the coverage category and man versus zone.**	
The Process		**Researcher reviews the process** **(1) identify the defensive coverage,** **(2) which coverage category am I facing,** **(3) what are the strengths of the coverage,** **(5)**		

		understand how the conversion routes adjust to this coverage. The participant nodded in agreement and used the Choice play to demonstrate how this process is implemented on the field.		
Walk-through of "Choice."		**"Quarterback get a pre-snap read of what the coverage is" How?** **The offense comes out in an even formation. You see a balanced 3 deep look. Inside slot goes in motion,..** **if the AO defender runs across the formation with the receiver, what do his eyes tell you?** **The defender over the motioning**	**"the offense lines up in a double slot formation. Inside slot comes in motion. The half-field safety follows the receiver across the formation. The other safety comes off the hash and moves to the middle of the field. The safety's eyes are on the receiver. This is a pre-snap read of "cover three man under" look that tells the quarterback how the defense will react to the backside of the play. At the snap of the ball the quarterback will read the technique of the play-side**	

Using the Eyes: Quarterback has to use his eyes to manipulate the coverage or a particular defender		**receiver does not follow the receiver, instead the safety inverts. What does this tell you?** **Ball is snapped the quarterback will be reading the corner on the single receiver side of the ball.** **The decision must be made by the qb's 5th step and the ball must come out by the qb's 7 step.** **. Corner can only play man or zone .**	**corner. Is he in a man technique, legs crossing over with his back to the sideline or in a zone technique, back peddling? If the receiver closes the cushion on the corner he will run a streak or a skinny post, if the corner is more than five yards off of the receiver the receiver will run a speed out. The quarterback must make this decision by his 5th step and the ball must be out by this 7th step. If the play-side linebacker has gotten under the route via his flat responsibility or if the receiver and the quarterback make different reads the quarterback will shuffle his feet and find the receiver running the seam read.** **Participant says the quarterback will do this so many times in practice, "he can read the body language of the receiver. If his decision is unclear,**	Interesting note, according to the participant, the defense can be employing a zone concept, but the corner is employing a man technique. Versus zone the Qb has 3 reads, versus man it's two, against man to man it's one of two routes. Quarterback has to anticipate which route the receiver will run.

			he will shuffle his feet and find the receiver running the seam read. If the safety has over-rotated to the play-side of the formation the slot receiver will continue up the hash for a touchdown. If the weak-side corner has collapsed on the seam route, then he proceeds to the third read. If the strong safety is in his face, showing a man technique, the receiver will break the route back across his face. If the strong safety finds an area to defend the Z receiver will find an open area back-side. **this is a sequential process and that the quarterback is only reading a portion of the defense. (serially generated)** 	

Developing Team SA			**There are two critical factors to the success of the play. That the quarterback and the receiver are seeing the same thing "P.-# 3" also highlighted the synergy that must take place between the QB and Rec. He was adamant that "if the Qb does not have faith that the rec. will run the right route, we will get rid of that rec. And he has!" The participant 5 stated that "you can teach this information in the classroom, but it has to be learned on the field." "Give the chalk to your players". "you remember 95% of what you can teach**	

APPENDIX D: Permissions for Reprints

Figure 2. Klein's RPD model, variation 1
Figure 3. Klein's RPD model, variation 2
Figure 4. Klein's RPD model, variation 3

-----Original Message-----
From: Pamela L Quick <quik@MIT.EDU>
To: bstow1906@aol.com <bstow1906@aol.com>
Sent: Mon, Mar 7, 2011 9:48 am
Subject: Re: Permissions & Rights Info, Books

Dear Burnie Bristow,

Thank you for the additional information. I am happy to grant to you non-exclusive permission to reprint figure 3.1 from SOURCES OF POWER, to appear in your dissertation for Pepperdine University. Please credit the reprinted figure to SOURCES OF POWER, HOW PEOPLE MAKE DECISIONS, Gary Klein, and The MIT Press.

Please let me know if you have any questions.

Very best,

Pamela Quick
MIT Press Permissions

Figure 1. Virtual football trainer

-----Original Message-----
From: Klaus-Peter Beier <beier@umich.edu>
To: bstow1906@aol.com
Sent: Mon, Mar 7, 2011 4:56 pm
Subject: Re: Permission to reprint image

No problem, go ahead and use the image.

Peter Beier

On Mar 6, 2011, at 8:43 PM, bstow1906@aol.com wrote:

Dear Dr. Beier,

My name is Burnie Bristow. I'm a doctoral candidate at the Pepperdine University Graduate School of Education of Psychology with a specialization in Learning Technologies.

I'm seeking permission to reprint the image below in my dissertation

<football trainer-page 1.jpg>

Permissions for Figures 22-44

PEPPERDINE UNIVERSITY

Graduate School of Education and Psychology

March 1, 2011

Dear Joe Schrimpl,

My doctoral dissertation at Pepperdine University is in the final stages of publication through the ProQuest UMI Disertation Publishing database. It is entitled "VIEW FROM THE VIRTUAL POCKET: USING VIRTUAL SIMULATION AND VIDEO GAME TECHNOLOGY TO ASSESS THE SITUATION AWARENESS AND DECISION MAKING OF NCAA QUARTERBACKS."

I have attached a draft of the manuscript for your review, approval and signature.

Your signature represents your permission for me to use the attached information and diagrams in my dissertation.

Thank you for your participation.

Sincerely,

Burnie Bristow

Approved ☒ _____ 3/15/2011

Name Date

Please approve, sign, and date this form and fax it to (973) 321-2298 or mail it back to:

Burnie Bristow
Sports Business Academy
311 Redwood Avenue - Suite G30
Paterson, NJ 07522