Spring January 1, 2017

Improving The Player's Recruiting Process By Using Scenario Based Analysis Methodology

Dotan I Shvorin, *Clemson University*
Kevin M Taaffe, *Clemson University*

Improving The Player‘s Recruitment Process Using Scenario-Based Decision Making Analysis

September 25, 2016

Abstract

High performance physical characteristics can be found today in most of the potential recruits for any athletic program and it has become increasingly difficult to select the right candidate based solely on these characteristics. As a result there is a growing need for a recruiter to evaluate the decision-making capability of a player in order to understand the mind of the player in addition to the player physical assessment. We employ scenario-based analysis to evaluate such decision-making capabilities while enabling any recruiting to customize the potential candidate evaluation, based on the specific program's needs. The proposed method provides a platform for decision making evaluation within a specific sport position through the use of game theory approach. In particular, we assess decisions that a player would make based on being given certain game scenarios,in an effort to identify the player's decision making type. The performance level of the athletic program depends heavily on its recruits, and scenario-based analysis can significantly enhance the capability to find the right recruit for the right position in the game and as a result, improve the athletic program management.

Key words: Decision Making, Human Performance, Scenario based Structure, Recruiting Evaluation, Sport Management

1 Introduction

Evaluating the decision-making capabilities of a potential candidate has not received the attention it deserves in the recruiting process, yet it can be one of the most critical performance determinants in game situations. Many professional recruiters tend to evaluate the physical capabilities of the player, some consider the raw talent of the player, and others still assess the player's social skills and work ethic. In the research by Dumond et al. (2008), it was demonstrated that Rivals.com, a player licensing and marketing company, utilizes various parameters and provides generic statistics of the player performance. Thus, an economic module has been conceptualized to assist in predicting player performance, but it does not indicate the player's decision-making capabilities that would enable the college recruiter to estimate performance relevant to their specific program. A multivariate model of a player's success, suggested by Spieler et al. (2008), used similar demographic characteristics. Although physical and environmental characteristics are significant factors in recruiting, Griffith et al. (1928) initiated an approach that demonstrated how there are key player characteristics, specifically psychological traits, which might prove to be more valuable. Furthering this line of research, Niednagel et al. (1992) created a classification system of sixteen groups that would define a player's brain type. Although significant steps were taken to advance the ability to

recognize potential, the task of finding the suitable player for the right position in a specific program remains as the main challenge in the recruiting process. One of the reasons is that each program manager or head coach has his/her own unique game plan, which contains a combination of various strategies and tactics. As each game plan requires different characteristics of each player/team position in the game, the coach needs to change his players for efficient player-position fit. This is the essence of recruiting and could explain why a certain player can be a successful recruit for one team but an unsuccessful recruit for another. The study of Patil and Pasodi (2012) revealed the inherent difficulty of communicating with an athlete during the recruiting process and, thus, demonstrated that an interview analysis can help bridge the gap between the coach's expectation and the player's expectation for a certain position in the game. They have indicated that more research is required in order to examine the difference between successful and unsuccessful recruits. As such, the present research would complement this line of research by evaluating the player's cognitive capabilities. Many athletic programs structure their recruiting methods to rely solely on the player's physical capabilities, only to discover that their recruits fail to deliver the expected level of performance at game time. Linhares et al. (2012) presented the hierarchy of processing in the decision making phase as well as the capability difference between a skilled thinker and a novice one. Each decision level describes a type of thinking that aids the recruiter in classifying players based on their unique decision processing. Diverse patterns may explain why successful doubles tennis players are not as successful in singles matches, or why a superb snooker player may not be as successful at pool. According to Ilundin-Agurruza (2015) and Park et al. (2015), brain EEG technology can demonstrate the difference between processing capabilities in high level players as apposed to amateurs. Each player in the game has a given decision space that determines his ability to maximize his potential. The player must be able to adapt by incorporating real-time information during the game to making his decisions accordingly.

Although these examples may have players with identical physical capabilities, the decision-making capabilities are completely different from one type of player to another. With more research and attention based on evaluating the cognitive aspects of players, progress can be made in understanding the future potential of a player. In the next section, we evaluate the recruitment process tools and their use across four different college sports. In sections 3 and 4 we introduce the player recruitment logic and framework. In section 5 we employ our suggested frame work and evaluate several players from the Clemson club tennis team. We provide conclusions and recommendation for future work in section 6.

2 The Recruitment Process and its Tools

Player-position recruitment is a process containing a high level of uncertainty that athletic programs are trying to eliminate. From the introduction we can understand that there is great difficulty in assessing potential candidates. In order to overcome these difficulties, each sports program creates its own set of tools in order to improve recruitment success. For example, when evaluating a baseball pitcher, according to Dan et al. (2010), the Defensive Independent Pitching Statistic (DIPS) is used in order to evaluate the level of a pitcher. A pitcher's earned run average (ERA) is at least somewhat dependent on his defensive teammates that play behind him, and DIPS tries to evaluate the pitcher based solely on variables that he can control. Dan and Davis (2010) showed that the three most important variables that correlate strongly to positive performance for pitchers were (1) strikeout rates, (2) walk rates, and to a lesser degree, (3) home-run rates. The statistic is very helpful when

evaluating past performance of pitchers, but is not as valuable when trying to gauge the potential of a pitcher, especially when the pitcher is moving from one level of competition to a higher level. A complementary approach to the statistical findings and analysis of player performance is the four A's methodology according to Scott et al. (1996). Since baseball is considered to have a unique rhythm, the team performance is heavily determined by the individual maturity of the players; thus, the recruitment process must account for more than statistical data. In assessing the academics, ability, attitude and adjustment capabilities of the recruitment candidate, the recruiter can receive an in-depth profile of the player patterns of behavior. Although implementing the four A's might be an essential tool for any given athletic program, there is still a high level of uncertainty, as this method's main assumption is that past behavior patterns will continue in the future. Moreover, the transition from high school to college or from college to professional have a tremendous effect on a player performance.

A recruitment example from the sport of American Football. The cornerback position as described by former University of Toledo head coach Frank Lauterbur, must have great speed and quickness, must be a good-to-fair tackler, and must like to hit (Lauterbur 2000). He must be able to cover open receivers to prevent them from catching passes. Traditionally, cornerbacks have been smaller than receivers, primarily because smaller players generally had more speed and agility than taller players. According to Miller (2014), popular sports scouting and news site Bleacher Report states that an ideal corner's size is over 5'10" tall and weighs around 200 pounds. Shorter, lighter corners may have trouble keeping up with today's receivers that are often 6'4" or taller. In Miller's description of recruiting tools for such a position, recruiters measure the athlete's forty-yard dash time. This test not only evaluates the athlete's straight-line speed but also gives insight into the athlete's explosion and acceleration rate. Nelson (1994) describes that one of the main areas of the cornerback's body scouts observe is how well he can turn his hips. The quicker a cornerback can change his hips, the less ground he gives up to the receiver when covering the receiver's route. Moreover, a cornerback must have good technique in his backpedal as the transition to a full sprint should be abrupt, explosive, and in one movement. Recruiters will look for the way a cornerback breaks on the ball once it is thrown, whether he is still in his backpedal or already in stride with the receiver.

Besides the physical demands of the game, Scouts Inc. (2014) states that, aside from quarterbacks, cornerbacks require the most mental toughness of any player on the field. The mental part of the game is just as, if not more, important than the physical part of the game. Cornerbacks must have excellent anticipation because they have no idea where the wide receiver will make the cut in his route or exactly when the quarterback will throw the ball. They must also have great instincts in order to be in the right place at the right time. This is something scouts place great emphasis on when recruiting for the cornerback position. Corners need to have great awareness of the receiver, as he must be able to close the distance before the ball arrives.

Stepping away from the recruitment process in team sports, we now consider athlete recruitment within track and filed - specifically the pole vaulter. Officially adopted at the first modern Olympic Games described in 1896, Jordan (2014), state that pole vaulting may present the highest level of requirements from its recruits. The sport began back in the days of the ancient Greeks, where poles were used as means of avoiding obstacles and jumping over animals. Since those days, the sport has become highly versatile and incredibly challenging, according to McCormick (2010). A recruiter may consider a variety of details such as the athletes initial stance, how he or she grips the pole, the manner in which he or she sprints, the motions that take place during the planting of the pole,

how the athlete manipulates his or her body during the swing up, how the athlete orients himself or herself when jumping over the bar, the athlete‘s speed, strength, explosiveness as well as mental characteristics such as body awareness, fearlessness, thought process, visual processing and many more factors. According to Risk (2000), vision plays a critical part in pole vaulting. The depth perception and visual tracking are important when making jump decisions. He concludes that he requires his athletes to take an 11-part test when not only recruiting but also for the development of the athletes. This allowed him to further train the team on certain vision techniques. As the National Pole Vault Chair for Canada during the 2000 Sydney Olympics, he often assessed the sprints, long jump, and hurdle events for future pole vaulting recruits due to requirements of speed and agility. He also emphasized the importance of the recruitment candidate's academic performance, because it often facilitates efficient learning and training of techniques. Lastly, he wrote that he had to make sure that this potential team member gels with the current team, in order to avoid any future conflicts. According to Nyberg (2014) there is a great difference between the physical characteristics and the mental characteristics that are expected from a pole vaulter. He discusses the complementary ability to use cognitive skills and perform an intended motor skill, such as reading music while playing the piano, and the ability to use motor skills to perform cognitive skills such as using a calculator to solve a math problem. Because this sport is very complex, the mental characteristics play a critical role for evaluating potential recruits. Thus, a tool that would help create a pole vaulter profile may reduce the level of uncertainty in the recruitment process.

While pole vaulting athletes are faced with a static challenge (a bar), tennis players are presented with a challenge in a dynamic setting (an opponent), with feedback from a certain course of action chosen by the player. According to Shvorin and Taaffe (2014), there are many performance characteristics that could be evaluated during the recruiting process. Each performance characteristic may have a direct or indirect effect on the player decision-making process that translates into a defined level of performance. Upon creating a profile for the player decision making capability, the improvement potential may be evaluated in greater depth as decision making patterns have a direct impact in real time performance in the game. In the next section we will provide inferences about the recruitment process and its tools, and provide reasoning for creating a generic framework with customizing application for each athletic discipline. Such a framework is expected to improve the recruitment process and the athletic program as a whole.

The review of the four position recruitment characteristics indicates the growing need for a systematic method to evaluate the decision-making capabilities of the athlete as the human physical capabilities have reached a certain plateau. It is becoming increasingly difficult to achieve an advantage in performance based solely on physical features when most of the elite athletes have similar characteristics. Thus, identification of the player's thinking patterns undoubtedly will better inform the level of expected performance. Although there are different performance requirements in each athletic program, we can see that there is common ground where decision making capabilities can be tested. Moreover, while game scenarios can be customized to each sport and its demand characteristics, the ability to make decisions rests with the player's predominant patterns of thinking, individual interpretation, analytic analysis, comprehension, and execution abilities. In the next two sections we will focus on the methodology development and provide the basic structure for evaluating a player's decision making capabilities, using a game theoretic approach.

3 Player Recruitment using Game Theory

Recruiting a potential candidate requires great effort on behalf of the athletic management team. Each scout or coach is trying to predict performance potential when integrating subjective experience and expertise. The difficulty that the management team is faced with is identifying a candidate who, after receiving team training and coaching, will be able to make smart decisions in actual game situations. Making the right (or smart) decision requires knowing the decision that will produce the highest gain or payoff for the team in that specific scenario. Game theory is often employed to calculate mathematically what the best response would be (Tadelis, 2013). Such an approach could also be used to test recruitment candidates by scripting various game-time scenarios and measuring their performance using a scenario-based approach. After a brief introduction to game theory in this section, we explore the model development process and employ that framework in a case study with current college tennis players.

3.1 Game theory approach description

The setting of the game is one of the most important aspects as it determines certain values in the model and the decision-making alternatives that are being addressed. The most basic game theoretic model, including both uncertainty and time elements, can be found in the calculation of expected value from a decision-making tree (Tadelis, 2013). In order to establish a meaningful decision-making process, the player must be able to compare uncertain consequences when he makes a certain decision. We introduce a simple lottery model in this section to describe the decision-making process. Consider a decision situation where x_i denotes the ith outcome ($i = 1, \cdots, n$), thus by definition, a simple lottery over outcomes $X = (x_1, x_2, x_3, \cdots, x_n)$ is defined as a probability distribution $P = (p(x_1), p(x_2), p(x_3), \cdots, p(x_n))$ where $p(x) \geq 0$ is the probability that x_i occurs and $\sum p(x_i) = 1$. The next example can explain the simple model structure.

Consider a simple lottery model where player has a 70% chance to receive \$10 if he chooses lottery A and 80% chance to receive \$8 if he chooses lottery B. In order to evaluate a certain decision in an uncertain condition we will use the expected payoff calculation. By definition, if $u_{(x)}$ is the payoff function (utility) of the player over outcomes of $X = (x_1, x_2, x_3, \cdots, x_n)$ such that $p(x)$ is a lottery over X, and $p(x_i) = P_r(x = x_i)$, then we define the expected payoff from lottery $p(x)$ as:

$$E[u_{(x)}|p(x)] = \sum_{i=1}^{n} p_{(x_i)} \cdot u_{(x_i)} = p_{(x_1)} \cdot u_{(x_1)} + p_{(x_21)} \cdot u_{(x_2)} + p_{(x_3)} \cdot u_{(x_3)} + \cdots + p_{(x_n)} \cdot u_{(x_n)} \quad (1)$$

In order to evaluate the simple lottery, lottery A returns a \$7 expected payoff and lottery B returns a \$6.40 expected payoff. Therefore, a rational player who would like to maximize his profit should choose to play lottery A, despite the higher probability of success associated with lottery B. In order to utilize this simple model in the recruiting process we need to define certain basic characteristics in the decision making space. Similar to the lottery example, a sport recruit will need to decide between a number of alternative in order to identify the best decision in a specific scenario settings. From the simple lottery model we can understand that there are a few guidelines that need to be defined in order to create a decision-making evaluation for a potential recruit.

4 The Recruitment Framework

In this section, we present the recruitment model that evaluates a player's approach to decision making in game scenarios. To make use of our approach, we assume that the coaching staff has a need at a particular player position. Each sport has its own set of unique player positions, and each position requires unique player characteristics. Moreover, desirable player characteristics could vary among teams, due to the abilities of existing players on the team and the strategic plan of the coaching staff. For example, in Basketball, a point guard who is highly skilled in maneuvering the ball would be a key player to recruit in a team that already has skills in shooting guards, power forwards and centers. However, a team that is disadvantaged in these positions may require a point guard who is a skilled shooting guard as well, in order for him to have the desired impact or significance. This is just one aspect of player characteristics that should be addressed in the recruiting process and, thus, it is extremely important to determine exactly what the goals are for the recruiter. In preparing the player recruitment analysis, the following steps in a player recruitment model are proposed.

1. Describe the specific game scenario
2. Map the player's decision alternatives
3. Identify performance characteristics critical in decision making
4. Create a performance scale and evaluate a player's relative advantage
5. Perform cost and benefit analysis for each tactic
6. Quantify expected payoff per player based on player execution capability
7. Evaluate a game plan

4.1 Describe the specific game scenario

We must first describe a specific scenario in the game that challenges a player's decision-making. Each coach has his/her own unique set of strategies and tactics he uses to govern the players in the game. There are many situations in the game that can demonstrate the decisions of the players; thus, if the decision follows the guidelines of the coach, the player would meet the coach's expectations. However, if the decision of the player is different from the coach's expectation, it creates difficulty for the coach to establish tactical plays in the game. A player's decision-making process should be evaluated in the recruitment stage rather than during real-time performance. By evaluating the thinking preferences of the player early in the recruiting process, the recruiter would quickly recognize player compatibility with the coach's approach to the game. This compatibility would prove to be most valuable in real-time under pressure where the cognitive capability and the motor skill of the player are put to the test.

4.2 Map the player's decision alternatives

There are many levels of decision-making in the game and many different player positions. A player could be a part of a team and have a determined decision-making space (e.g. basketball players positions) or he could be an independent individual responsible for a wider space of decision

making in the game (e.g. tennis, ping-pong, snooker). The space of the player decision-making can be very large or very small; however, the importance of the decision is independent of the size of the decision-making space.

Each position may require up to two levels of decision-making: a strategic decision and a tactical decision. In some disciplines there is much confusion among professionals regarding the definition of the two concepts, however, this research aims to create a common language. A strategy is the overarching objective that aims to take advantage of the gap between the cumulative strengths and cumulative weaknesses. We suggest identifying a strategy by answering the following question: *What do I need to do in order to win the game?* Examples could be to play at a fast pace, play with power or be aggressive, play with patience, play to the weaker side of the opponent, play with high consistency, play under pressure and play to create the element of surprise. A tactic, on the other hand, is a short-term alternative that helps attain the overall strategy as well as aims to take advantage of the gap between strengths and weaknesses in an isolated situation. We suggest identifying a tactic by answering the following question: *How should I achieve my selected strategy?* A few examples here would create the set of alternatives for the chosen strategy. If we assume that our strategy is to play at a fast pace, tactical alternatives could be to physically perform activities faster, eliminate any disturbances, breaks or delays during the game to increase game flow, execute operations sooner so that the opponent would have less time to prepare, etc.

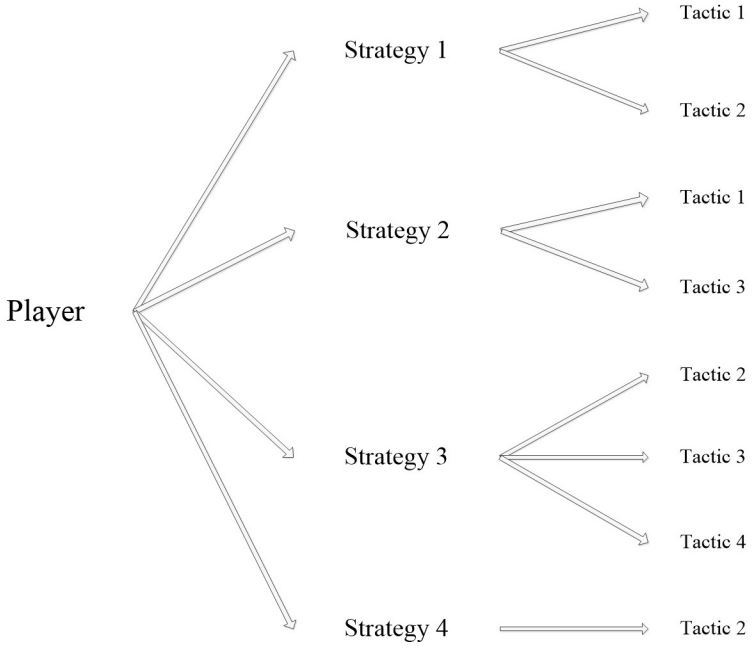
Consider the following scenario. A quarterback leads his team by selecting a certain play to run that will give the team the highest payoff in his objective of yards gained towards a touchdown. In selecting a strategy, he asks himself what he should do in order to have the highest probability of scoring a touchdown or advancing in the field. Our quarterback identified that the rival team has weaker defensive capabilities on the left side based on prior experience. Thus, his strategy is to play to the weaker left side of the rival team. In selecting a tactic, he needs to decide which play to run. Thus, a tactic would be to select one among alternatives, such as a long pass, a short pass, an inside run, etc. Evaluating the position decision-making choices would lead to a creation of a decision making tree that articulates the possible strategies and tactics from which to choose.

A decision tree can demonstrate the decision process based on a given scenario - surroundings, performance level of the opponent, and expected decisions of the opponent. Figure 1 demonstrates how to map out the decision-making process based on that scenario. In the example, a player can choose between four different strategies. Each strategy contains different tactical alternatives and, in some cases, the same tactic alternatives (tactic 2 can be selected for strategies 1, 3, 4). The key outcome is the establishment of a game plan. A game plan, by definition in this research, is the set of decisions selected for execution by the player. Let $S(1)$ and $T(1)$ denote the sets of strategies and tactics for player 1. Consider a strategy $s \in S(1)$ and a tactic $j \in T(1)$. This $\{s, j\}$ combination represents one decision making possibility, where a group of selected $\{s, j\}$ combinations would comprise a game plan $G(1)$ for player 1. In Figure 1, we see that player 1 has eight strategy/tactic combinations from which to choose in a certain scenario. It is worth noting that, while there are eight combinations, there are still only four tactics to employ. In other words, player 1 will only have four unique responses in that situation.

4.3 Identify decision making performance characteristics

Performance characteristics are features of physical, mental and emotional capability that affect the quality of any activity that is executed in the game. These features are inputs into our decision-making process and are the key ingredients for creating a winning game plan. Unlike the lottery

Figure 1: Mapping player 1 strategies and tactics - decision making tree.



model where we deduce our ability to win by calculating a static probability, identifying a game plan that presents the highest probability to win requires a synthesis of human performance characteristics and their impact on the decision-making alternatives. Physical performance characteristics are more concrete and, as such, easier to identify, whereas mental and emotional performance characteristics are more challenging to identify.

In each game scenario, some performance characteristics are more salient than others in the player decision-making process, and it is up to the player to take them into consideration. For example, a boxer starting his first round recognizes that his opponent has very quick jabs and moves quickly. The boxer also notices his advantage in delivering more powerful punches. In this scenario, the performance characteristics that play a critical role are the boxer's agility, endurance and power. Assuming that our boxer is starting the fifth round, he notices that his fast and agile opponent begins to anticipate his slow but powerful punches. Moreover, his opponent is demonstrating a behavior of superiority and ego, while our boxer demonstrates a calm and collected behavior. In this example, the performance characteristics that play a critical role in the decision-making process are the ones that reflect the relative advantage between the two boxers such as anticipation, awareness, focus and arrogance. In order to devise a winning game plan for both boxers, we need to consider the physical, mental and emotional performance characteristics of each one.

When considering these performance characteristics, one game plan for our boxer could be to conserve effort, move the opponent around so he will get tired, present a high variety of punches and go for the knockout punch. On the other hand, his opponent's game plan could be to circle around while studying moves, demonstrating irritating behavior in order to create distractions, and deliver as many punches to establish a high scoring margin. Selecting the performance characteristics and identifying an appropriate performance scale for representation is explained in the following section.

4.4 Evaluate a player's relative advantage

It is very difficult to quantify the level of a certain performance characteristic in a player; however, it is more attainable to define performance characteristics relative to other players or teams. Each player needs to be able to assess himself as well as his opponent in order to determine what are his strengths and weaknesses. This scaling process is used in quality engineering as it helps reduce uncertainty and create a quantified method for continuous improvement. In Montgomery (2013) and Foster (2013) as well as many more quality engineering educational text books, many tools require scaling. For example, quality function deployment (QFD), failure mode and effects analysis (FMEA), servqual, prioritization grids, matrix diagrams and six sigma (DMAIC), have a way to determine relativity between factors of influence. In our case, human performance characteristics needs to be scaled in order to identify relative advantage. For example, height is a basic parameter that contains inherent scaling in inches or centimeters. This characteristic can pose a major element for a point guard when he is considering a two-point shot or a three-point shot. The same reasoning can be inferred from other performance characteristics such as anticipation, adaptability, endurance, patience, agility as they are all participating in our decision making process.

This is the basic stage for evaluating a certain decision in the game, as each decision can be compiled from different performance characteristics. Consider the set of performance characteristics I and a set of players K. The level of performance characteristic i ($i \in I$) for player k ($k \in K$) can be denoted as $L_i(k)$. The relative advantage emerges from the difference between the levels of each player's performance characteristic. Consider the abilities of two players – player k and his opponent k^o. Denote characteristic i as a strength of player k if $L_i(k) - L_i(k^o) > 0$, or a weakness of player k if $L_i(k) - L_i(k^o) < 0$. We illustrate this comparison through an example containing two players – 1 and 2. Table 1 presents the levels of each performance characteristic for players 1 and 2.

Table 1: Performance levels by characteristic - players 1 and 2

i	Performance Characteristic	$L_i(1)$	$L_i(2)$
1	Anticipation	5	8
2	Adaptability	5	9
3	Endurance	7	5
4	Patience	9	4

We can see that player 1 has a relative advantage in his endurance capability and in his patience, while player 2 has a relative advantage in anticipation and adaptability. If we can look at this analysis from a general point of view, some strategies and tactics should come to mind in order to maximize the performance of player 1 or 2 in the game. In the next section, we will construct a cost and benefit analysis when considering certain decisions in the game.

4.5 Perform cost and benefit analysis for each tactic

From Section 3.1 (lottery model) we saw that the model presented a prize and a risk (winning probability) associated with each possibility. Different from the lottery model, prizes and risks in this research methodology are not given but rather created, based on the analysis of the player's performance characteristics, game plan selection and execution capabilities.

In order to create a game plan the player will select a set of decisions (i.e., strategies and tactics) to execute in a game. In order to determine the benefit or cost resulting from a certain decision in the game, the advantage scale is applied to the play of each tactic j. Benefits and costs for tactic j are denoted as the average relative advantage, or disadvantage, based on the set of performance characteristics that apply to tactic j, or I^j. The average benefit of tactic j for player k, when playing against player k^o, can be denoted as:

$$B_j(k) = \frac{\sum_{i:L_i(k) \geq L_i(k^o); i \in I^j} [L_i(k) - L_i(k^o)]}{|I^j|} \tag{2}$$

The average cost of tactic j for player k can be denoted as:

$$C_j(k) = \frac{\sum_{i:L_i(k) < L_i(k^o); i \in I^j} [L_i(k) - L_i(k^o)]}{|I^j|} \tag{3}$$

When looking at the example from Table 1 and the decision making mapping from Figure 1, we see that there are four available tactics for player 1. Each tactic presents different characteristics that are critical to the player performance. In Table 2 we assign the performance characteristics that are involved in each tactic.

Table 2: Tactics and their influencing performance characteristics

i	Performance Characteristics	$L_i(1)$	$L_i(2)$	Tactic 1	Tactic 2	Tactic 3	Tactic 4
1	Anticipation	5	8	X		X	
2	Adaptability	5	9		X	X	X
3	Endurance	7	5	X	X	X	
4	Patience	9	4	X			X

Note that tactic 1 has three performance characteristics that play a critical role in the player performance. Endurance means that this tactic includes intensive physical effort. Anticipation presents the capability to predict the opponent plays and patience reflects the ability to consider long term payoff with little or no benefit in the short term. In tennis for example, playing long rallies while trying to wrong foot the opponent can explain what tactic 1 might look like in the game.

After associating each characteristic with the possible tactics, we can calculate a tactical benefit and cost as shown next in Table 3 calculate the benefit and cost using equations 2 and 3.

Again, notice that for a certain tactic only those performance characteristics critical for that tactic are included in the calculation. In addition, each tactic has a certain probability of success when the player is executing it such that if the player successfully execute his tactic then he is rewarded by the tactic benefit, but if he fails to execute his tactic, he accepts the value of his loss.

Table 3: Tactical benefits and costs for player 1

i	Tactic 1		Tactic 2		Tactic 3		Tactic 4	
	Benefit	Cost	Benefit	Cost	Benefit	Cost	Benefit	Cost
1	-	3			-	3		
2			-	4	-	4	-	4
3	2	-	2	-	2	-		
4	5	-					5	-
$B_i(1)$ and $C_i(1)$	2.33	1	1	2	0.67	2.33	2.5	2

4.6 Quantify expected payoff per tactic using execution capability

Establishing a clear connection between the plan type and the likelihood for execution success is critical. We ensure reliability in the decision making evaluation by incorporating execution quality into the measurement. The value of execution quality represents the ability to deliver a consistent level of performance, regardless of the conditions or environment. Identifying and measuring a player's execution quality in this context requires the expertise of the coach in order to evaluate the long run probability of success for each tactic in a certain scenario. Since it is very difficult to provide a single value to represent this qualitative measurement, we propose a tolerance for execution capability.

Table 4: Proposed tolerance for execution capability

Success Level	Probability of Success	
	Lower bound	Upper bound
Low	20%	40%
Average	50%	70%
High	80%	95%

In Table 4 we see three levels (and ranges) of execution capability and the probability of success that is associated with each level. This table will help us evaluate the best decision for a certain scenario in the game as it represents the variability for ranges of performance. This range allows the coach to assign the long run probabilities for the tactic success when considering the player execution capabilities. Low level means that the player is having difficulty in executing a certain type of tactic. Average level means that the execution capability of the player is partly successful. High level means that the player execution is really good and can perform a certain tactic with ease. Each tactic will produce a certain reward if successfully executed, however the level of risk involved is expressed through the player probability of success. Thus, the coach needs to find the right mix between a certain tactic selection and its execution capability.

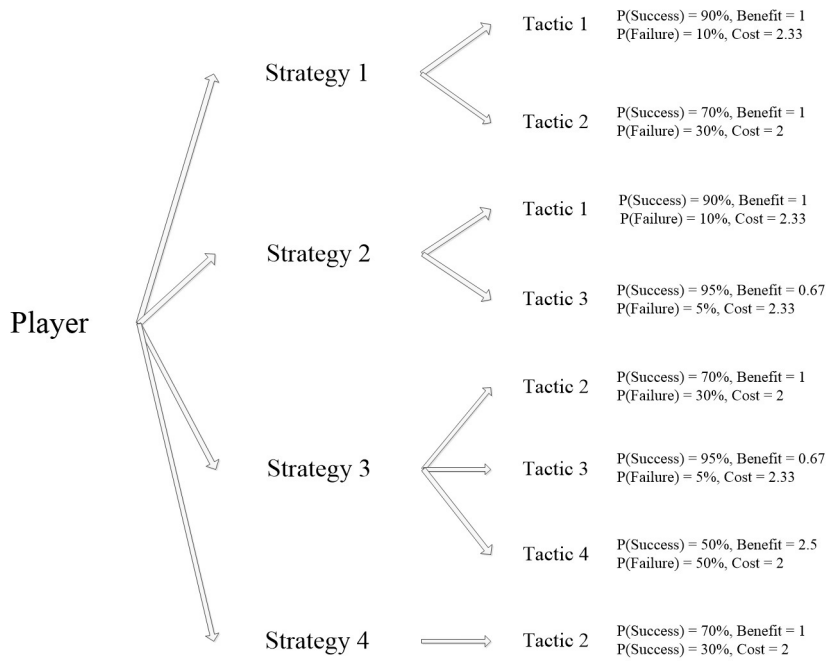
Using equation 1, where in this case p_j denotes the probability of successfully implementing tactic j, the expected payoff Y of using tactic j for player k would be:

$$E[Y_j(k)] = p_j \cdot B_j(k) - (1 - p_j) \cdot C_j(k) \tag{4}$$

In Figure 2 we present the decision tree structure when uploading the information from Table

3 and assigning the execution quality to each tactical decision as articulated in Table 4. We can see that Tactic 1 and Tactic 3 have a high level of execution quality while Tactic 2 and Tactic 4 have average and low execution quality respectively.

Figure 2: Mapping tactical benefit, cost, and execution capability to the decision making tree.



For example, the expected payoff for tactic 1 would be $0.9 \cdot 1 - 0.1 \cdot 2.33 = 0.667$. The next table summarizes the expected payoffs for all four tactics.

Table 5: Expected payoff analysis for each tactic

Tactic	Expected Payoff
1	0.6
2	0.1
3	0.5
4	0.2

4.7 Evaluate a game plan

In order to respond to an opponent's game plan, a prediction of the opponent's tactical choices and capabilities is needed for our player to make a decision. Taking the opponent's tactic choice into account will have an impact in the effectiveness of a player's decision. Assume that the cost incurred by one player can be assigned as a benefit to the other player (in a two player game like tennis). Let $T_l(k^o)$ denote that the opposing player k^o chooses to play tactic l. If player k chooses

tactic j and his opponent k^o chooses tactic l, we now have benefit and cost equations that depend on the choice of the opponent's tactic, and they are presented below:

$$B_j(k)|T_l(k^o) = B_j(k) + C_l(k^o) \tag{5}$$

$$C_j(k)|T_l(k^o) = C_j(k) + B_l(k^o) \tag{6}$$

This leads to the following expected payoff for playing tactic j when facing tactic l from player k^o:

$$E[Y_j(k)|T_l(k^o)] = p_j \cdot [B_j(k)|T_l(k^o)] - (1 - p_j) \cdot [C_j(k)|T_l(k^o)] \tag{7}$$

Consider an example with two players and their choices of strategies and tactics as follows:

1. Available strategies:

   {Strategy A, Strategy B, Strategy C} $\in S(1)$

   {Strategy E, Strategy F} $\in S(2)$

2. Available tactics:

   {Tactic 1, Tactic 2, Tactic 3, Tactic 4} $\in T(1)$

   {Tactic 5, Tactic 6, Tactic 7, Tactic 8} $\in T(2)$

Given these strategies and tactics for each player, as well as the performance characteristics per tactic and performance levels of each player, the benefits and costs (*independent of the opponent's tactic choice*) are shown in Table 6. Note that player 1's choice of tactic 1 has a benefit and cost of 1 and 2.33, respectively. Player 2's choice of tactic 5 has a benefit and cost of 3 and 1, respectively. To determine the payoff for each player, we first determine the benefit and cost to play their chosen tactics, knowing what the other player will do: $B_1(1)|T_5(2) = 1 + 1 = 2$, $C_1(1)|T_5(2) = 2.33 + 3 = 5.33$, $B_5(2)|T_l(1) = 3 + 2.33 = 5.33$, and $C_5(2)|T_l(1) = 1 + 1 = 2$. Given a 95% success rate for player 1 and a 60% success rate for player 2, the payoffs will be

$$E[Y_1(1)|T_5(2)] = 0.95 \cdot 2 - 0.05 \cdot 5.33 = \mathbf{1.6} \tag{8}$$

$$E[Y_5(2)|T_1(1)] = 0.6 \cdot 5.33 - 0.4 \cdot 2 = \mathbf{2.4} \tag{9}$$

Using the same logic for all combinations, Table 6 provides the payoff summary by tactic for both players when considering the decision of the other player.

Table 6: Payoff summary for two players and their tactics.

			Player 1						
			Strategy A		Strategy B		Strategy C		
			Tactic 1	Tactic 2	Tactic 1	Tactic 3	Tactic 2	Tactic 3	Tactic 4
Player 2	Strategy E	Tactic 5	2.4 , 1.6	2.2 , -0.1	2.4 , 1.6	2.5 , 1.3	2.2 , -0.1	2.5 , 1.3	1.6 , -0.7
		Tactic 6	3.3 , 4.5	3 , 2	3.3 , 4.5	3.3 , 4.1	3 , 2	3.3 , 4.1	2.7 , 0.7
	Strategy F	Tactic 7	2.9 , 2.6	2.6 , 0.9	2.9 , 2.6	2.9 , 2.3	2.6 , 0.9	2.9 , 2.3	2.3 , 0.2
		Tactic 8	0.1 , 1.5	0 , -1	0.1 , 1.5	0.3 , 1.1	0 , -1	0.3 , 1.1	-1.2 , -2.2

In Table 6 we see that for each player there is a dominant tactic. For player 1, playing Tactic 1 will always produce the highest payoff (looking at the second column in each pair of columns across the table). For player 2, tactic 6 will always produce the biggest reward (looking at the first column in each pair of columns). It is also against the interest of player 2 if the players decide to play

both tactics with the highest payoff because ultimately player 2 will earn fewer points than player 1. If one of the players could have known what the other player is going to do (i.e, which tactic he is going to execute), then that player can always select his best response and eventually will be favored to win the game. In real life there is much uncertainty, thus our model will mitigate this by enabling the players to assign probabilities to the likelihood that their opponent will use various strategies and tactics over the course of a match. There are various levels of decision making and each level can reveal certain capabilities. Different capabilities for decision making is associated with different player positions in the game. In the next sections we will address each level and demonstrate how this frame work can impact recruiting assessments.

4.7.1 Localized Decision Making Capability

The setting for localized view include the players performance characteristics relative advantage knowledge, execution capability and tactical selection. The application for this decision can be articulated in the next question setup when addressing Table 1:

- If player 1 knows that player 2 is going to play tactic 5 as well as his execution capability, what tactic should he select to play given his knowledge of the performance characteristics relative advantage and his execution capability when looking at his tactical selection in response

Isolating the localized decision making for player 1 regarding player 2's selection of tactic 5, we consider only the row of information from Table 6 containing tactic 5, which is shown below:

Table 7: Localized decision making - player 2 selects tactic 5

	Tactic 1	Tactic 2	Tactic 3	Tactic 4
Tactic 5	2.4 , **1.6**	2.2 , **-0.1**	2.5 , **1.3**	1.6 , **-0.7**

In this situation player 1 should select to play tactic 1, as it provides the highest payoff.

4.7.2 Short Term Decision Making Capability

Short term decision making builds on the result from localized decision making, and the question associated with this level of thinking is formulated as follows:

- What tactic should player 1 select when given a prediction for how player 2 will play between tactics over time?

The expected payoff of playing tactic j for player 1 will account for the proportion of time player 2 selects each of his tactics throughout the match (or specified time frame). The payoff of this short term decision can be denoted as:

$$E[Y_j^S(k)] = \sum_l P[T_l(k^o)] \cdot E[Y_j(k)|T_l(k^o)], \tag{10}$$

where $P[T_j(k)]$ represents the probability that player k will play tactic j' during the specified time frame.

For example, if player 1 estimates that player 2 will mix over time between tactics in this manner: $20\%, 30\%, 40\%, 10\%$ for tactics 5, 6, 7, and 8, respectively, then player 1's expected payoff from tactic 1, 2, 3, and 4 will be:

$$\begin{aligned}
E[Y_1^S(1)] &= 0.2 \cdot 1.6 + 0.3 \cdot 4.5 + 0.4 \cdot 2.6 + 0.1 \cdot 1.5 = 2.86 \\
E[Y_2^S(1)] &= 0.2 \cdot (-0.1) + 0.3 \cdot 2 + 0.4 \cdot 0.9 + 0.1 \cdot (-1) = 0.84 \\
E[Y_3^S(1)] &= 0.2 \cdot 1.3 + 0.3 \cdot 4.1 + 0.4 \cdot 2.3 + 0.1 \cdot 1.1 = 2.52 \\
E[Y_4^S(1)] &= 0.2 \cdot (-0.7) + 0.3 \cdot 0.7 + 0.4 \cdot 0.2 + 0.1 \cdot (-2.2) = -0.07
\end{aligned}$$

In this setting, player 1's best response selection will be to play tactic 1 as it demonstrates the highest payoff. We can also see that there is a minor difference between tactic 1 and tactic 3 but a large difference between tactics 1 and 3 to tactics 2 and 4. It should be important for a potential recruit to be able to recognize the most beneficial tactics to use, when given certain game scenarios.

When proposing a question like this, it is logical that some flexibility can be given if the recruit selects answers that contain tactic 1 and tactic 3, however if he selects answers containing tactics 2 and 4 we know that the player did not demonstrate a good ability in this question. Thus, his short term decision making score will reflect this in the evaluation report.

4.7.3 Long Term Decision Making Capability

We now consider how player 1 would react to knowing how player 2 might mix strategies as well as tactics over a match. The settings for long term decision making build directly from the distribution of tactical decisions presented in section 4.7.2. The question associated with this level is formulated in the next manner:

- Can player 1 identify a strong game plan when given a game plan that player 2 will follow?

A game plan implies a combination of strategy and tactic decisions being made throughout a match. In order to truly understand or predict the amount of time an opponent will use each tactic (as shown in section 4.7.2), the player must have a prediction for the amount of time the opponent will devote to each possible strategy, since each strategy leads to a choice of tactic. We are also acknowledging that a player will likely NOT remain in the same tactic forever, which is also implied from short term decision making. To account for this, we propose a game plan for the player to follow, and assess how well this game plan performs against a known game plan of the opponent. The equation to represent this game plan assessment is as follows:

$$E[Y_g^L(k)] = \sum_j P[T_j(k)]cdotE[Y_j^S(k)], \tag{11}$$

In other words, we take a game plan and determine the percent of time spent in each of the tactics. The probability of using each tactic is then combined with the expected payoff of that tactic. Consider player 2 having the following game plan. Strategy E will be played 80% and Strategy F will be played 20%. Within strategy E, tactics 5 and 6 will be used at 20% and 80%, respectively. Within strategy F, tactics 7 and 8 will be used at 80% and 20%, respectively. To simplify this from game plan into use of tactics, this data can be translated into $P[T_5(2)] = 0.16, P[T_6(2)] = 0.64, P[T_7(2)] = 0.16, P[T_8(2)] = 0.04$ for use in equations 10 and 11. To counter that game plan for player 2, player 1 has the following four options from which to select:

1. $P[T_1(1)] = 0.72, P[T_2(1)] = 0.03, P[T_3(1)] = 0.24, P[T_4(1)] = 0.01$
2. $P[T_1(1)] = 0.04, P[T_2(1)] = 0.24, P[T_3(1)] = 0.24, P[T_4(1)] = 0.47$
3. $P[T_1(1)] = 0.48, P[T_2(1)] = 0.1, P[T_3(1)] = 0.3, P[T_4(1)] = 0.12$
4. $P[T_1(1)] = 0.16, P[T_2(1)] = 0.18, P[T_3(1)] = 0.5, P[T_4(1)] = 0.16$

A similar method can be used to simplify these game plans into a probability of using tactic j within each game plan. This can be fed into equation 11 in order to find a game plan payoff for each case. Each game plan expected value among the four possibilities that the recruit will have to select from given his opponent game plan.

Figure 3: The expected payoff from game plan possibilities

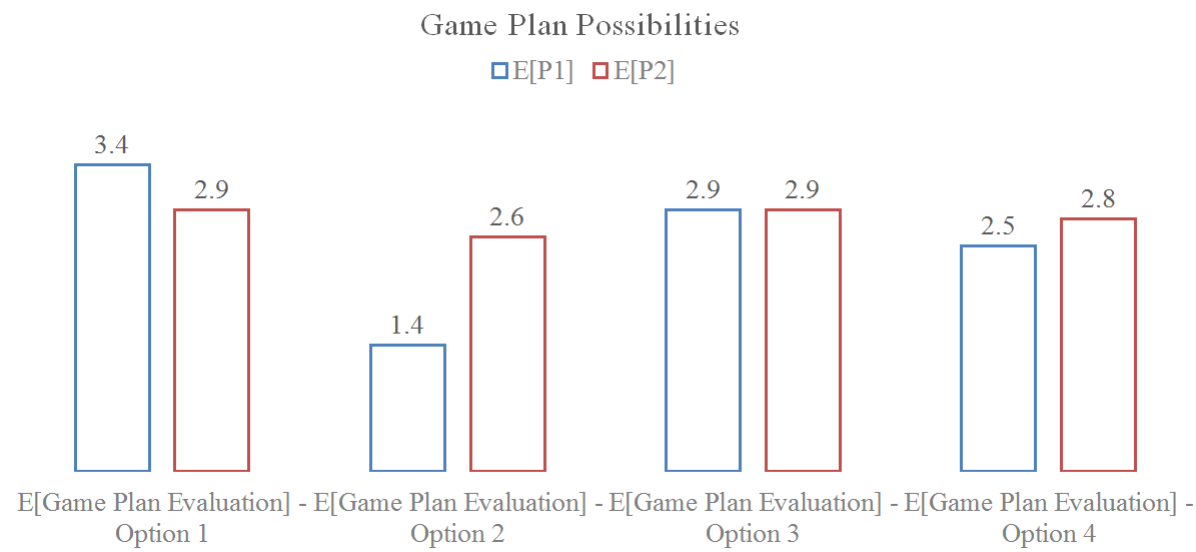


Figure 3 demonstrate that option 1 is the best game plan setup for player 1. This decision is the most difficult to make as the recruit need to understand how performance characteristics establishes tactical benefits and costs which determine critical features when playing a certain mix of tactics over time.

4.8 Decision making attributes

In this research we have demonstrated how we can work through a frame work and build a questionnaire based on given scenarios. Our case study refers to a set of parameters that are static in time, however, we know that real time decision making is dynamic. Dynamic decision making brings about a higher level of complexity when considering two main attributes that affect the expected payoff over time. The first one refers to the sequence or the order in which decisions are executed as there is an effect from one decision to the next one. Each decision has a consequence that changes the values of the critical performance characteristics, which play a role in quantifying the expected payoff of a certain decision in the game. A change in the performance characteristics could relate

to physical, mental (logical) or emotional aspects. For example, a sequence of decisions have led to win points back to back. This might change the confidence level of the player (emotional aspect). Another example would be that a sequence of decisions have exhausted the players, resulting in a low level of performance (physical aspect). The sequencing attribute needs to be accounted for when considering dynamics in the game. The second attribute that needs to be considered is the response learning curve to a certain type of decision in the game. The nature of the players is to maximize their performance thus they are constantly looking for the best response to a certain situation. The opponent will always learn to adapt and perform better based on the frequency of decisions and the types of decisions being made. The more an opponent will encounter the same play the better his response will be over time, thus the player's expected payoff will decrease over time as well. This logic brings about the motivation for mixing strategies and tactics as there is a balance to determine when a certain play is profitable or not. These dynamics can be further examined with a simulation software and a look into the architecture of decision making over time.

4.9 Frame work summary

The research frame work demonstrates how to analyze decisions in the game, overcome uncertainty and maintain relativity throughout the subjective assessment of specialist in the field. Once this frame work is utilized any change to the analysis setup will demonstrate the effects at each level of decision making. This flexibility can prove to be quit significant in the recruitment process when evaluating the decision making capabilities based on a determined scenario. In the following section we have applied the research frame work to analyze the decision making capabilities of tennis players in order to improve the Clemson Tennis Club team to have the best chance of winning. The objective of this collaboration is to understand how to match players with their opponents based on their decision making capabilities in order to achieve the highest relative advantage. This case study resulted in elevating the players awareness, improving the players training program and providing a logical reasoning for creating a certain lineup.

5 Case Study: Decision Making Evaluation of College Tennis Players

Now, we would like to examine if a potential recruit is able to reach this logical reasoning when challenged to make a decision in a specific game scenario. We have created an appropriate survey using six tennis game scenarios. Each player was introduced to the evaluation logical reasoning with a consent form, as well as a response/survey form to complete at certain points during the evaluation. This research and survey received institutional review board approval under protocol # IRB2015-365 at Clemson University, named "Human Performance Engineering and Decisions". The only identifiers were the department name and position title. The individual staff names were not recorded. Following the evaluation, each participant received a full analysis of the evaluation findings. Each participant also received a set of recommendations for improving his decision making capabilities in the future.

5.1 Creating evaluation questions

An evaluation question should contain a structure that imitates the actual player environment. In the introduction to the question (or series of questions), the recruit is first familiarized with the

scenario. All performance characteristics of the players in the scenario are also described to the recruit. At this point, the recruit activates his imagination while he embeds himself in the described scenario. He imagines his opponent and the field of play, and he establishes a set of goals with which he is already familiar. From this point, the question should expose the available alternatives or possible decisions that the player could make in this scenario. The last part of this section is the question itself, where the recruiter can tailor to examine specific decision and its considerations of the potential recruit. This enables the recruiter to evaluate a player's ability to:

1. Identify performance characteristics that provide a relative advantage and their effect on the physical and mental aspect of the player's performance capability
2. Understand the relationship between performance characteristics, tactics and strategies in the game
3. Differentiate between successful tactics when considering player execution capabilities

Differentiation between executions of tactics could be addressed as localized decision-making. Successful execution of a certain tactic relies on the ability to control certain performance characteristics, resulting in less resistance from the opponent. These types of players can assess a specific situation and make a decision based on current capability. These players can make good decisions in a short time span, having exceptional execution abilities so that they can reach high level of performance.

A successful relationship between performance characteristics to tactics or strategies in the game could be addressed as short-term decision-making. These types of players can look at more than localized situations and make a decision according to a larger set of information. They can put together a game plan and be more effective in preserving energy than localized decision-making players. Players with an effective short-term decision-making capability have a strong ability to tune themselves to certain situations and specialize in several skills. In high levels of performance, these players can potentially win any type of match.

Successful selection of game strategy reflects on the long-term decision-making capability. These player's are usually very consistent during high levels of performance and can play the game with a wide variety of skills. They can determine when and how to employ a strategy; thus, they can adapt to any type of situation and can predict many outcomes in the game. Such players may demonstrate the highest level of analytical thinking as they can look closely at specifics as well as considering the larger scheme in the game progression. Strategic players have the inert capability to make localized decision and short-term decision as well.

An evaluation form containing 42 scenario-based questions is created in order to examine the traits that are required to fill a certain position in the game. As we mention earlier, these traits might depend on a subjective evaluation in order to establish the best fit for that position. Once the potential recruit has completed the evaluation form, quantitative and qualitative methodologies will be used.

The quantitative analysis section requires a system that would reveal the difference between a good decision maker and a superb one. In order to create this feature in the analysis, we need to be able to quantify each answer in a high variate scaling system. For example, for a multiple-choice answer, an exponential scoring response could be used in order to increase variability between the possible answers. Assuming we have a question to which we select an answer among five possibilities, each possibility will contain different level of descriptive information. An answer that is selected

and contains irrelevant information will be of poor or inferior quality, thus its score should be the lowest. The range of answers contains many types of information and the scoring difference should be substantial in order to identify the player who considers the right type of information in the questioned scenario.

We propose the following scheme - the response's answers are assigned a quality level from inferior to superior, with a total of five possibilities. They are considered equally (spaced on a log_2 scale, with the information score being given a value. Then, the difference between the remaining quality levels is expressed as 2 to the power of 1,2,3 and 4, thus the difference between the inferior level and the superior level is 30 points (see 8). This scale would generate a wider range of scores among the answers, thus providing an easier mechanism for detecting differences between the decision making levels among the players.

Table 8: Sample Grading Scale With Five Possible Answers

Answer Quality	
Inferior	0
Low	2
Average	6
High	14
Superior	30

The qualitative section of the questionnaire asks the players to explain their reasoning behind their answers. This aspect allows the recruiter to extract more details about the way the potential recruit thinks. The recruiter can identify certain processing patterns and can evaluate the player's knowledge of the game.

From a current pilot study that is conducted with the Clemson Tennis Club team, college tennis players are presented an evaluation form. The form includes scenario-based expertise from former professional tennis players and tennis coaches, including an author of this paper. In this study the decision making capability of the players is challenged in an effort to identify strengths and weaknesses. Presented below are four players that demonstrate different decision making capabilities.

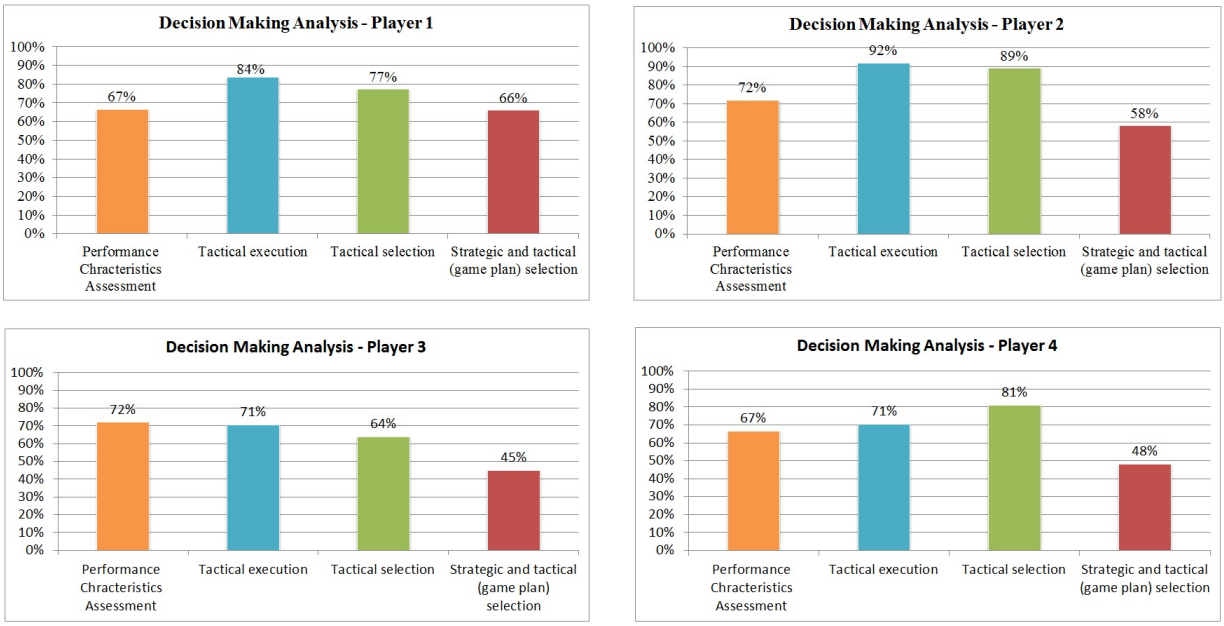
5.2 Analyzing the responses of a recruit - A Case Study

The 42 questions were divided into four grading sections: Performance Characteristics Assessment (PCA), Tactical Execution (TE), Tactical Selection (TS) and Strategic and Tactical Selection (STS). The percentage represents the success rate of the possible points earn from the available points in each section. Each player worked through the questionnaire at their own pace, and the graphs are the quantitative assessments of the questionnaire. When looking at each player's decision making analysis, generic trends were captured. For player 3, we see how performance deteriorates as different aspects of decision making are being exposed. Player 1 presents the highest success in strategic decisions. Player 2 has the highest capability in tactical decisions. Player 3 understands performance characteristics but has a low level of strategic thinking. Player 4 excels in tactical decision making but poor strategic decision making. The meaning of these trends is very important as we conclude this section. Player 1 is an all around player, with high capabilities in every aspect

of decision making. His average success is 73.5%. This player is consistent in his performance in the game. Player 2 has similar features as player one only he demonstrate higher level of capability. His average success is 77.7%. When compare to player 1 there are certain features of strength and weaknesses especially when considering game plan creation. Player 3 demonstrate lower level of performance then player's 1 and 2. He present the lowest success average with 63%. Player 4 present a better performance then player 3 but still lower then player 1 and 2. His success rate stands on 67.7%.

The qualitative aspect of the questionnaire reveals more subjective thinking when analyzing and

Figure 4: Summarized results from four different players



selecting a certain type of decision in a specific game scenario. This section of the analysis can signal out character features in a player. The focus of the evaluation is to classify the ability of a player to interpret certain situations while providing reasoning for the selection decisions. From across the decision making sections, certain patterns of reasoning emerged. For example, player one's decision making capabilities are challenged when he needs to evaluate his opponent's reactions based on his own decision. His reasoning for his mistakes underlined this. Player two's reasoning is primarily based on response rather than initiative. This pattern might explain the gap between strategic thinking and tactical thinking. Difference in decision capabilities in the decision making space might suggest emotional constraints, especially when looking at confidence and consistent performance. Player 3 demonstrates a difficulty in identifying the relative advantage in the game, which is the essence of structuring a game plan. This is supported nicely in the quantitative data, such that when the challenge require different verity of cognitive logic from section 1 to 4, performance is decreasing and the player cannot adapt. Lastly, player 4 has difficulty in recognizing how performance characteristics affect the decision making space. This aspect means that this player will have the highest challenge with an opponent of high level of skill in his performance

capabilities.

As a team manager, player profiling would aid in order to create the highest relative advantage in the game when considering which opponent to play with. When considering the quantitative results and the qualitative information, matching of players with opponents should follow these guidelines. Player 1 should be matched with a player that has a few tactical alternatives and his game style should be very transparent. Player 2 should be matched with an opponent who demonstrates the same level of play or higher but does not hold high levels of strategic capabilities. Player 3 should be matched with an opponent with low tactical capabilities and who takes many risky shots in the game. Player 4 should be matched with an opponent who demonstrates low levels of skills and transparent physical and technical capabilities that would allow for specific tactical alternatives to be dominant.

6 Conclusions and Future Research

With many athletes possessing similar physical abilities that enable them to perform at a high level, the relative advantage can be found with the player's decision making capabilities. In this research we present a method to improve recruiting by evaluating decision-making in a potential candidate. Our framework creates a systematic way to form a recruitment evaluation, which could be tailored to any player position in the game. Using the results from the analysis of players on the Clemson Club Tennis team, we are enabling the recruiter to look at the decision-making capabilities of the player within his decision-making space. These findings give rise to a more analytic thinking when managing a sport team in order to achieve the highest relative advantage in the game.

Professional recruiters in the field have many issues to consider in a relatively short amount of time. Thus, this tool can help promote the recruitment process as it will create a structured framework that will sharpen the recruiter's ability to find the right player for the right position. The recruiter's ability to assess the decision-making type of the player will reduces the coach's uncertainty when he consider the player's performance in a certain game scenario.

This line of research can open the door for more examination of how performance characteristics take part in the decision-making capability of a player in the hope of achieving a higher level of performance. As we know how to scale a level of characteristics and evaluate the relative advantage, we can test these concepts further to quantify performance characteristics. Using computer simulation or similar tools, our approach in this research can help shape management setup and structure of an athletic program as its implementation will require a process of identifying, classifying and comprehending all aspects of human performance.

7 References

A. Arad (2012), 'The Tennis Coach Problem: A Game-Theoretic and Experimental Study', The B.E. Journal of Theoretical Economics: Vol. 12 No. 1

A. Linhares, A. Elizabeth, T. A. Freitas, A. Mendes, J. S. Silva (2012), 'Entanglement of perception and reasoning in the combinatorial game of chess: Differential errors of strategic reconstruction', Cognitive Systems Research, Vol 13, No 1, pp 72-86.

A. Patil, M. S. Pasodi (2012), 'Responsibility and Difficulty of Coaches in Selection of Athletes for Sports Meet', International Journal of Sports Sciences and Fitness, Vol 2, No 1.

A. Petersen, K. Wagner & T. Greener 2012, 'Recruiting', Strength & Conditioning Journal (Lippincott Williams & Wilkins), vol. 34, no. 1, pp. 87-88.
B. Moore 2014, 'What Makes a Recruitable Athlete?', Texas Coach, vol. 58, no. 8, pp. 34-37.
B. Risk 2000, 'Visual skill and pole vaulting. / Aptitudes visuelles et saut a la perche', Track Coach, no. 150, pp. 4784-4788.
D. Basco & M. Davies 2010, 'The many flavors of DIPS: a history and an overview', The Baseball Research Journal, vol. 39, no. 2, pp. 41.
D. M. Nelson (1994), 'The Anatomy of a Game', Cranbury, NJ: Associated University Presses, Scouts Inc.
D. Montgomery (2013), 'Introduction to Statistical Quality Control', 7th edition, John Wiley and Sons, Inc.
D. Shvorin, K. Taaffe (2014), 'Improving tennis player performance using system development interpretations methodology', International Journal of Quality Engineering and Technology (IJQET), Vol. 4, No. 3
F. Lauterbur (2000), 'Defense Against a Strong Passing Team', Defensive Football Strategies, Champaign, IL: Human Kinetics, pp 176-177.
G. Nyberg 2014, 'Exploring knowings in human movement: The practical knowledge of pole-vaulters', European Physical Education Review, vol. 20, no. 1, pp. 72-89.
J. Ilundin-Agurruza 2015, 'From clumsy failure to skillful fluency: a phenomenological analysis of and Eastern solution to sports choking effect', Phenomenology and the Cognitive Sciences, vol. 14, no. 2, pp. 397-421.
J. L. Park, M. M. Fairweather & D. I. Donaldson 2015, 'Making the case for mobile cognition: EEG and sports performance', Neuroscience and biobehavioral reviews, vol. 52, pp. 117-130.
J. Niednagel(1992), 'Your key to Sport success', Laguna Press: Laguna Niguel, CA.
J. M. Dumond, A. K. Lynch & J. Platania, 2008, 'An Economic Model of the College Football Recruiting Process', Journal of Sports Economics, vol. 9, no. 1, pp. 67-87.
L. T. Huffman & C .G. Cooper 2012, 'I'm Taking my Talents to...An Examination of Hometown Socio-Economic Status on the College-Choice Factors of Football Student-Athletes at a Southeastern University', Journal of Issues in Intercollegiate Athletics, vol. 5, pp. 225-246.
M. McCormick (2010), 'Soaring to New Heights: The Evolution of Pole Vaulting and Pole Materials', Illumin. Online. ¡http://illumin.usc.edu/printer/143/soaring-to-new-heights-the-evolution-of-pole-vaulting-and-pole- (Accessed 19 Oct. 2015).
M. Miller (2013), 'How do Scouts Break Down NFL Cornerback Prospects?', [online] Copyright 2015 Bleacher Report, Inc. Turner Broadcasting System, Inc. All Rights Reserved. Bleacher-Report.com is part of Bleacher Report Turner Sports Network, part of the Turner Sports and Entertainment Network. Certain photos copyright 2015 Getty Images. Any commercial use or distribution without the express written consent of Getty Images is strictly prohibited. AdChoice, http://bleacherreport.com/articles/1686545-how-do-scouts-break-down-nfl-cornerback-prospects .
M. Spieler, D. R. Czech, A. B. Joyner, B. Munkasy, N. G. J. Long (2007), 'Predicting Athletic Success: Factors Contributing to the Success of NCAA Division I AA Collegiate Football Players', The online journal of sport psychology, vol 9, No 2.
S. Baker 1996, 'The four A's in recruiting college baseball', Coach & Athletic Director, vol. 65, no. 10, pp. 90.
S. Ibrahim & A. Kanniyan 2013, 'Effect of Selected Physical, Technical and Motor Fitness Variables on the Prediction of Pole Vaulting Performance of Men', British journal of sports medicine, vol.

47, no. 10, pp. 35-35.
S. Tadelis (2013), Game Theory: an introduction, Princeton University Press, UK.
T. Foster (2013), 'Managing Quality: Integrating the Supply Chain', 5th edition, Pearson Education, Inc.
T. Jordan (2014), 'Track and Field', Scholastic. online ¡http://www.scholastic.com/teachers/article/track-and-field¿ (Accessed 17 October 2015).
T. Morgan & M. Martin 2007, 'Student Recruiting: Implications for Athletic Training Education Programs', Athletic Therapy Today, vol. 12, no. 6, pp. 29-32.
W. J. Hopp, M. C. Spearman(2011), Factory Physics Third Edition, Waceland Press, Inc. IL.

8 Appendix

Expected tactical payoff for player 1

$$E[T_1] = \frac{0.4}{2} \cdot 1.6 + \frac{0.6}{2} \cdot 4.5 + \frac{0.8}{2} \cdot 2.6 + \frac{0.2}{2} \cdot 1.5 = 2.86$$
$$E[T_2] = \frac{0.4}{2} \cdot (-0.1) + \frac{0.6}{2} \cdot 2 + \frac{0.8}{2} \cdot 0.9 + \frac{0.2}{2} \cdot (-1) = 0.84$$
$$E[T_3] = \frac{0.4}{2} \cdot 1.3 + \frac{0.6}{2} \cdot 4.1 + \frac{0.8}{2} \cdot 2.3 + \frac{0.2}{2} \cdot 1.1 = 2.52$$
$$E[T_4] = \frac{0.4}{2} \cdot (-0.7) + \frac{0.6}{2} \cdot 0.7 + \frac{0.8}{2} \cdot 0.2 + \frac{0.2}{2} \cdot (-2.2) = -0.07$$

Table 9: Tactical Data

Tactic	Benefit	Cost	Success Rate
1	1	2.35	0.95
2	1	2	0.7
3	0.67	2.35	0.95
4	2.5	2	0.5
5	3	1	0.6
6	3	4	0.8
7	2	2	0.8
8	6	1.35	0.2

Table 10: Tactical data when in play and its expected payoff

	Player 1			Player 2		
Tactic	Benefit	Cost	E[v]	Benefit	Cost	E[v]
T1—T5	2	5.33	1.6335	5.33	2	2.398
T2—T5	2	5	-0.1	5	2	2.2
T3—T5	1.67	5.33	1.32	5.33	1.67	2.53
T4—T5	3.5	5	-0.75	5	3.5	1.6
T1—T6	5	5.33	4.4835	5.33	5	3.264
T2—T6	5	5	2	5	5	3
T3—T6	4.67	5.33	4.17	5.33	4.67	3.33
T4—T6	6.5	5	0.75	5	6.5	2.7
T1—T7	3	4.33	2.6335	4.33	3	2.864
T2—T7	3	4	0.9	4	3	2.6
T3—T7	2.67	4.33	2.32	4.33	2.67	2.93
T4—T7	4.5	4	0.25	4	4.5	2.3
T1—T8	2	8.33	1.4835	8.33	2	0.066
T2—T8	2	8	-1	8	2	0
T3—T8	1.67	8.33	1.17	8.33	1.67	0.33
T4—T8	3.5	8	-2.25	8	3.5	-1.2

* Expected Payoff is calculated using equation 4 as well as Table 6