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REVIEW ARTICLE

Predicting Future Quarterback Performance in the National Football League: Effective Use of Cognitive Assessments

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Abstract

For years the National Football League (NFL) has been assessing the physical and mental abilities of NFL prospects through the NFL Scouting Combine. With football being one of the most popular sports in the world, significant amounts of money are on the line for NFL organizations to make the right pick when it is time for the annual NFL Draft, and the quarterback position is the most important selection. NFL organizations will use a variety of methods to scout NFL prospects to gather as much information as they can on their potential multimillion-dollar investment. However, there does not seem to be an exact formula for how NFL organizations can make the right pick based on past tests that have been administered. Due to the high stakes investments that NFL organizations make with drafting prospects, we hope to evaluate the different assessment tools that have been used to assess a quarterback's cognitive abilities and how they translate to on-field performance. We will do so by assessing current cognitive assessments that have been utilized by the NFL in their annual draft analysis, along with discussing new testing mechanisms that have been recently developed.

Keywords: Cognitive Assessment, Football Quarterbacks, Wonderlic Personnel Test, Athletic Intelligence Quotient.

1. Predicting Future Quarterback Performance in the National Football League: Effective Use of Cognitive Assessments

Professional sports in the United States are a multibillion-dollar industry, and the National Football League (NFL) is the most profitable (Stewart & Joyner-McGraw, 2019). The continued success of the league and its massive financial investment depends largely on the quality of the players on the field. As such, NFL teams spend considerable resources to evaluate players in an effort to predict who will be the most successful, while also attempting to avoid players who may have performed well previously (e.g., at the collegiate level) but are unlikely to perform at the professional level. This evaluation process is complex and multidimensional in nature, and it often includes physical evaluations, past performance accomplishments, emotional and psychological evaluations, and cognitive processing assessments, among other domains. Adding to the difficulty and complexity of the evaluation process, each position (e.g., linebacker, running back, quarterback) in the game of football requires different types of skills in each of these domains.

Across all the positions in football, the quarterback position is considered to be the most important (Berri & Simmons, 2011). And it is also considered the most difficult to evaluate. NFL teams make sizeable financial investment in the quarterback position, making quarterbacks the highest paid position in the league (Wolfson et al., 2011). Because of this, the evaluation of the quarterback position requires the highest level of attention. A high draft pick and a large financial

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investment in an ineffective quarterback can hurt the team not only for that season, but the multiyear success trajectory of a team can be negatively impacted by a bad investment at the quarterback position. While scouting departments for NFL teams have been reasonably effective in their evaluation of physical abilities of potential quarterbacks in the draft, the evaluation of the perceived intelligence of the NFL quarterback prospects has had a history of ineffective outcomes (Wolfson et al., 2011).

This manuscript will examine one element of the evaluation process: cognitive assessment. Specifically, we will examine the methods that NFL teams use to evaluate the intelligence of quarterbacks, with a focus on an assessment tool (i.e., Wonderlic Personnel Test) that has traditionally been used (Gill & Brajer, 2012). Because of the widespread criticism of the utility and validity of Wonderlic, we will then shift the focus onto an assessment tool (i.e., Athletic Intelligence Quotient) that is beginning to be used more widely (Hogan et al., 2023). In doing so, we hope to provide a critique of the tools the NFL uses for cognitive evaluation, while also offering suggestions for NFL teams to more effectively evaluate the cognitive functioning of the young men who play the most important position in their sport.

1.1 NFL Draft

Every year the NFL holds their annual draft which gives NFL teams the opportunity to draft amateur football players from the National Collegiate Athletic Association (NCAA) to join their organization. Along with the NCAA, there has been a recent emergence of minor league football leagues in the USA, Such as the United Football League (UFL), and NFL teams have the freedom to draft from this pool of players as well. Each year in the NFL Draft every team is given a pick in each of the seven rounds, and these picks are subject to being traded to another NFL team in exchange for players or other picks (NFL Football Operations, 2023). The most valued draft picks are the picks in the first round of the draft. As the draft proceeds through its seven rounds, the guaranteed money allocated to drafted players decreases. Subsequently, there is a substantial difference between being drafted in the first round and being drafted in the second. And with the highest salaries paid to the top first round picks, there is even greater financial separation between the first round and the seventh round (final) round of the NFL Draft.

The job security of NFL executives, coaches, and staff members within NFL franchises is often based on the production they find from their draft picks, and the earlier a player is drafted the bigger the investment-- and the bigger the risk-- the franchise has made with that individual (Quinn et al., 2007). The investments these NFL franchises make are often worth millions of dollars, so because of this substantial financial investment, teams will spend much of their offseason in advance of the draft allocating resources to find out everything there is to know about their perspective picks (Wolfson et al., 2011). Every team wants to find a good fit for their organization and collect as much information as possible through the different contacts that teams are allowed to have. In advance of the NFL Draft, there are numerous opportunities for NFL scouts, coaches, and general managers to contact a prospect. These contact points can occur at the prospect's pro day, at any of the all-star games held, (e.g., the senior bowl) and at private workouts where teams directly observe and formulate their opinions on a given pick. In addition to these events, the NFL holds its annual Scouting Combine where over 300 of the nation's top collegiate players are invited to attend; at this important event, these players will be analyzed and tested on a physical, athletic, and cognitive basis (NFL Football Operations, 2023). The combine is considered one of the most important job interviews a football player will ever have in his athletic career (Bowen, 2015).

At the combine, NFL teams attempt to analyze prospects' physical, emotional, psychological, and cognitive talent to help inform the decisions they hope to make in the upcoming NFL Draft. Physical tests in the NFL combine include the 40-meter dash, broad jump, and the vertical jump, in addition to on-field tests with specific football drills (NFL Football Operations, 2023). The NFL combine is a great opportunity for prospects to raise their draft value, but a poor performance could also lower their value. In addition to these physical evaluations the NFL Scouting Combine also incorporates cognitive evaluations. NFL teams want to determine how smart a player is in an effort to assess the player's capacity to handle the multiple mental tasks that football players face. In this manuscript we will examine the cognitive assessments processes utilized by NFL organizations in their draft preparation. We will examine traditional measures used (i.e., Wonderlic Personnel Test; WPT) in addition to emerging measures that are being used (i.e., Athletic Intelligence Quotient; AIQ) to assess

football players' cognitive abilities. Getting a better understanding of the different cognitive testing methods that are used will then help us gain insight into the future of talent assessment in professional sports, with a focus on the most important position in the game of football, the quarterback.

2. The Quarterback Position

By the time of the NFL Draft, each NFL organization has collected all performance statistics available on each quarterback. This will range from the number of games the player has won in college, down to the exact number of completions, touchdowns, and interceptions thrown. Due to there being multiple quarterbacks throughout the NCAA that have potential to be drafted into the NFL, there will be constant speculation as to who will be the first quarterback drafted to the team that is in need of a franchise quarterback. Keep in mind, teams whose draft pick is early in the first round either received their pick from a trade, or more likely are in that spot due to an unsuccessful season where they won fewer games than most other teams in the NFL. Within the game of football, the quarterback is the only player on the field who is consistently credited with the teams wins and losses, and because of the weight put on a quarterback's shoulders, NFL organizations will go to great lengths to make sure they pick the right quarterback with their draft picks (Berri & Simmons, 2011).

Quarterbacks who are picked early in the NFL Draft take home the largest contracts. Due to the high stakes that are put into these decisions, NFL organizations are under high stress to predict future performance of the quarterbacks they draft (Wolfson et al., 2011). If an NFL organization is to then predict wrong and pick a quarterback early in the draft that does not produce (e.g., becomes a bust), this can then keep that team out of playoff contention for several years and often becomes a primary explanation for failure within an NFL organization (Lavoie & Berger, 2015). Therefore, draft experts, fans, and NFL organizations will discuss a player's "bust potential," which refers to the possibility of a player that is picked early in the NFL Draft is unable to play at a high level in the NFL. Due to the difficulty of being a successful NFL quarterback, many quarterbacks that enter the league will have a high possibility of becoming a bust, and why NFL organizations will do everything they can to make the best selection possible (Wolfson et al., 2011).

2.1 Routine Quarterback Play

Playing quarterback is considered the hardest job in the game of football due to the multitude of tasks that are placed on a quarterback---these tasks are both physically and mentally challenging to do (Berri & Simmons, 2011). Before the game has even begun, a quarterback must know the nuances of the entire playbook in order for his offense to find success on the field. This means knowing on each play the assignment for each of the ten other players on the field for that play and being able to quickly recall those assignments on each play. Quarterbacks are considered the coach on the field, so if a teammate does not know what to do, it is the quarterback's job to correct him. Each play a quarterback needs to be in control of his offense, and from there he must then be able to operate and make the correct decision on the field. An illustrative example is a routine passing play, where there can be multiple factors that a quarterback must analyze and eventually decide on. In addition to knowing what all his teammates should do on any given play, the quarterback also must determine what the defense will do to try to stop the offensive play. This process can be defined as reading the defense, and that is a common term used for how a quarterback sees the defense in relation to his offense and the play his team has called.

The quarterback then must decide what to do based on what he has seen and remembers from his pre-snap read to help him with his post-snap read, (i.e., which is the decision he will make once the ball has been snapped). What a quarterback remembers from one play he can then use to help him later in the game. Storing information that he has seen early in the game can prove to benefit a quarterback's production later in the game. From here, quarterbacks must rely on their ability to find their receivers in a crowded field of defenders, and quickly make a decision on whether to throw the ball or not, and where to throw it. During this time of reading the defense and making a decision on where to throw the football, the quarterback is in the pocket moving behind and between his offensive linemen so that he is not sacked or hit by a defensive lineman, who is working hard to physically hit the quarterback. These processes will then be repeated throughout the game and each play can bring about a different obstacle that the quarterback must maneuver to find success on the field.

The tasks that we have illustrated are extremely difficult and require a tremendous amount of cognitive ability, yet these tasks are expected to be routine for quarterbacks: efficiently and consistently being able to read defenses and make the right decisions with the football ultimately leads to a quarterback's success.

And it is these cognitive skills that are necessary for success that NFL organizations are trying to evaluate to determine if a prospective QB has sufficient skills to perform these tasks. Routine plays for the quarterback position include much more than just throwing the ball to the receiver; quarterbacks must be able to retain information, see the field, and make quick and accurate decisions with the football. The NFL understands that it is not simply a quarterback's physical capabilities that can bring them success, but a combination of both physical and cognitive ability that plays a significant role in a quarterback's performance. And for many years the NFL has tried to quantify intelligence by consistently using a specific cognitive assessment at the NFL Scouting Combine (i.e., Wonderlic Personnel Test).

3. Past Cognitive Assessments: Wonderlic Personnel Test (WPT)

For decades now the WPT has been used to assess quarterbacks and their mental capabilities at the NFL Scouting Combine (Lyons et al., 2009). Due to the importance of drafting a quarterback who will have the mental and physical capabilities to perform at a high level, there has been significant weight placed on the correlations between quarterback draft status and the Wonderlic scores (Berri & Simmons, 2011). Given the heavy focus that NFL organizations put on the score a quarterback might receive on the WPT, there should be empirical evidence regarding the validity of these scores and intended transferability to on-field performance (Gill & Brajerl, 2012). However, researchers have cast doubts on how successful the WPT is at predicting success in the NFL, especially for the quarterback position (Wolfson et al., 2021).

3.1 Background of the WPT

In 1937, industrial psychologist Eldon F. Wonderlic created the WPT, and this test consists of 50 questions that are to be answered within 12 minutes (Berri & Simmons, 2011). Dr. Wonderlic examined predictors of job performance as methods to quantify intelligence; he first used the Otis Self-Administering Test of Mental ability to predict performance on the job, specifically analyzing personality, intelligence, and supervisor ratings for these non-athletes (Hicks et al., 2015). What Dr. Wonderlic found from this test was that the Otis Self-Administering Test did not accurately predict cognitive performance, and so he shortened the Otis Self-Administering Test because there were multiple items within the test that did not accurately measure extremes. Once the items were cut, the Otis Self-Administering Test became the Wonderlic Personnel Test (Hicks et al., 2015).

From the early 1970's to 2022, the NFL Scouting Combine administered the WPT to NFL Draft prospects to assess their cognitive abilities to help predict future performance of these NFL prospects in the NFL (Rapp, 2022). The WPT has been used to measure an individual's verbal, numerical, general, analytical, and spatial relations ability, but the score an individual receives will only reflect their total score on the test (Lyons et al., 2009). That is, although the WPT assesses different cognitive abilities, the individual score will not reflect how well an individual did on each of these specific cognitive abilities (Hicks et a., 2015). This is attributed to the uncertainty regarding what each item on the WPT specifically measures, and so when individuals are given a general score instead of a cumulative score, it is difficult to know how well they did in each sub-area (Hicks et al., 2015).

Despite the usage of the WPT in the NFL Scouting Combine, it has been asserted that cognitive assessments have been an under-utilized form of measurement when considering the talent and potential of an athlete (Bowman et al., 2021). One of the most essential questions to ask when considering the WPT and its usage in the NFL Scouting Combine is the test's validity. Breaking aspects of validity down, it is important to determine if the WPT has criterion validity, meaning do the answers on this test help predict real life job performance, and specifically, do the answers on the WPT translate onto the football field (Hicks et al., 2015)? Along with criterion validity, it is important to ask if the WPT has construct validity, meaning does the test correctly measure the targeted variable that is being measured (O'Leary-Kelly & Vokurka, 1998)? Finally, does the test have cross-cultural validity, meaning does the test objectively compare when administered to individuals across different backgrounds (Küçükdeveci et al., 2004)? Beyond attempts to answer these validity questions, perhaps the most salient critique is that even though the WPT has been utilized by the NFL Scouting Combine to test the mental abilities of draft prospects for over 5 decades, it was a test that was normed on and created to measure job performance for non-athletes (Hicks et al., 2015).

3.2 Validity of the WPT

A study by Tymins and Fraga (2014) ran multiple correlations tests with the WPT and different forms of quarterback efficiency measurements such as Total

Quarterback Rating (QBR), Sack Percentage, Passer Rating, and Interception per Attempt. Results of this study reported negligible correlations between the WPT and quarterback performance across each factor (Tymins & Fraga, 2014). These findings illustrate some of the shortcomings the WPT has with predicting future performance amongst NFL quarterbacks in specific areas of the game. Due to WPT not being able to specifically label which cognitive abilities an athlete performed well or poorly on; you then are unable to predict how these scores will translate to on-field performance. Which alludes to some of the questions we have directed at the validity of the WPT and the tests' ability to effectively measure and predict future performance amongst athletes.

For a test to accurately quantify intelligence amongst high level athletes, it is necessary for the test to be significantly correlated with the different cognitive abilities that athletes use to perform at this level (Clark & Watson, 2019). However, the WPT does not distinctly measure specific cognitive abilities, and the final score an individual receives will not reflect which cognitive abilities an individual scored well on (Hicks et al., 2015). This could be a key limitation of the WPT that Hicks et al. (2015) highlighted: When an individual has completed the WPT, they only receive a singular score for the 50 items they have answered. Due to this, we may also question if the WPT could effectively give a comprehensive score of specific cognitive abilities due to the lack of depth and questions focused specifically on the different cognitive abilities that the test is aiming to quantify.

Thus, the lack of specificity regarding what cognitive abilities the test is measuring should be considered a potential limitation. Furthermore, research done to assess correlations between on-field performance and WPT scores has lacked to show transferability between the test and on-field performance. As we continue to highlight the shortcomings of the WPT, we must also assess how the test has established cross-cultural validity with its development. Due to growing diversity amongst NFL quarterbacks, tests administered to these athletes must not only translate to on-field performance but properly translate across cultures and ethnic backgrounds.

3.3 Cross-Cultural Validity of the WPT

The research that has been done to find correlations between on-field performance amongst NFL quarterbacks and their scores on the WPT is proving to be inadequate (Gill & Brajer, 2012). However, while Gill and Brajer (2012) did find correlations between WPT scores of White quarterbacks and their draft position, these WPT scores failed to maintain the same correlations with Black quarterbacks and their overall draft position. As a result of these findings, NFL teams can view scores from Black quarterbacks to be less valid than the scores from White quarterbacks (Gill & Brajer, 2012). Researchers have not been able to find cross cultural validity with the WPT and this can allude to the need for a cognitive test that not only translates to on-field performance but can be consistently used on individuals from varying culture and backgrounds. And when we think now of today's game of football and the emergence of Black quarterbacks finding success in the NFL, tests that are administered to these athletes must be culturally valid for the diverse populations that they will be administered to (Reid, 2022). Due to these findings, we can now see some of the potential issues with the cross-cultural validity within the WPT, which brings us to further question the utility of the WPT being administered to a diverse population of elite athletes.

Because of the growing diversity within the quarterback position in the NFL, we must also analyze how the design of the WPT can be a factor in lessening the tests cross-cultural validity. As forementioned, the WPT consists of 50 multiple choice and short answers questions, and each participant is given 12 minutes to take the test (Lyones et al., 2009). One could question if the 50 questions asked are general to the different cultural backgrounds of the individuals who take the WPT. The history of cognitive assessments highlights the lack of diversity regarding who these tools are designed and created for, and due to the underrepresentation of racial minorities in sampling and the development of these assessments, there has been consistent bias for those who take these assessments (Barrett, 2020). Because individuals from underrepresented backgrounds need to not only be able to answer the questions but have the cultural and linguistic knowledge to comprehend what the test is asking. These biases then lead to a lack of cross-cultural validity within cognitive assessments due to the lack of diversity with the sampling used to develop these assessments, a prominent factor in the shortcomings of the WPT with predicting future draft position of Black quarterbacks versus White quarterbacks that Gill and Bajer (2012) were able to highlight. However, such shortcomings are not exclusive to the WPT, since the early construction of cognitive ability tests, there has been discussions regarding whether a test

could be culturally free from bias or not (Cole, 2009). Although the goal for test developers is to create a test that is culturally free from bias and create an even playing field for those who take these cognitive ability assessments, Cole (2009) was able to highlight the inevitable fact regarding the influence of culture and experience playing a significant role in a test takers ability and understanding of the test's material. Due to an individual's experience and culture impacting their cognitive ability and understanding, this makes us question the cross-cultural validity of the WPT due to its development and format.

So far, we have been able to address the background of the WPT, along with its development, and the test's overall validity. And in each domain, we have been able to highlight limitations that make us question if the WPT is the right test for quantifying and predicting future performance amongst prospective NFL quarterbacks. Due to the many limitations we have been able to highlight, we want to also look at past participants of the WPT to track their scores to see how successful the WPT was at predicting each quarterback's career in the NFL. Doing so can give us insight into the predictive power of the WPT and see how this test has predicted NFL careers throughout its implementation in the NFL Scouting Combine.

3.4 Notable QB WPT Scores

In its history, the WPT has had an influential role in the selection of multimillion dollar NFL Draft picks each year, and so far, we have been able to highlight many of the shortcomings the WPT has in its development and validity. Throughout its usage in the NFL Scouting Combine, the WPT has been administered to Hall of Fame quarterbacks such as Terry Bradshaw, Dan Marino, and Jim Kelly (Brehman, 2023). These three NFL Quarterbacks are some of the most notable examples of quarterbacks who scored poorly on the WPT, as each received a score of 15 out of 50 on the WPT, which are some of the lowest WPT scores by a quarterback. Yet each of these quarterbacks ended up having some of the best careers that a quarterback can have in the NFL, despite their low WPT scores (Brehman, 2023). On the flip side, Greg McElroy received a score of 48 out of 50 on the WPT, and he ended up having an average NFL career (Brehan, 2023). It is interesting that quarterbacks like Peyton Manning, Dress Brees, and Russell Wilson who are all Super Bowl winning quarterbacks—all received a slightly above average score of a 28 out of 50, which is four points below Johnny Manziel's score of 32, yet Manziel had a short and underwhelming NFL career (Brehman, 2023). Comparing the scores of some of the most prominent NFL quarterbacks can help understand the ineffectiveness of the WPT in predicting future NFL quarterback performance. Because the WPT is a test that neither normed upon nor designed for athletes, WPT may not be considered an effective tool to quantify an athlete's specific cognitive abilities, nor can it effectively predict how these cognitive skills translate to on-field performance. Thus, it would be useful to find other assessments to measure an athlete's cognitive abilities that were created for athletes, that are cross culturally valid, and that are empirically supported.

Due to the high pressure that NFL organizations are under to pick the right prospects in the NFL Draft, NFL organizations might need to consider branching out to different ways to quantify intelligence. More importantly, we believe the NFL should use cognitive tests that were created specifically for athletes to help aid their chances of selecting a prospect who will prove to be successful in the NFL. What we will now discuss is the emergence of the Athletic Intelligence Quotient (AIQ), developed by Dr. Scott Goldman and Dr. James Bowman, two psychologists that studied clinical and school psychology.

4. Future Cognitive Assessments: AIQ

To get a better understanding of the AIQ, it is important to see the test's development just like we explored the WPT and its creation. The AIQ is based on the Cattell-Horn-Carroll (CHC) theory, which is the theory of intelligence with the most supportive evidence (Flanagan et al., 2012). CHC is an integrated theory combining seminal research conducted by John Carrol, and separately, John Horn and Raymond Cattell (Alfonso et al., 2005). The three researchers consolidated their ideas to include short-term memory acquisition, broad and narrow cognitive abilities, and dichotomous and deductive reasoning in their effort to create the CHC theory. (Alfonso et al., 2005). This theory provides a robust empirical foundation for how cognitive strengths and weaknesses can be interpreted across a variety of specialized fields (Bowman et al., 2021).

The AIQ was explicitly designed based on the tenets of CHC theory, in a three-phase standardization process (Bowman et al., 2021). The process began with consideration of which cognitive abilities outlined in CHC theory to include in the assessment. Consultation with experts in intellectual ability assessment and

sport psychology informed this process, as did review of existing research in related fields (e.g., military). Great care was taken to include cognitive abilities that would be impactful in elite sports, while excluding those cognitive abilities that would be unimportant and potentially involve cultural/racial biases (e.g., crystallized intelligence). Ultimately, they chose to include the four broad cognitive abilities of Visual Spatial Processing, Reaction Time, Decision-Making, and Learning Efficiency. The subtests themselves were then created following best practices in non-discriminatory assessment, including use of the Cultural Linguistic Interpretive Matrix (CLIM) (Flanagan et al., 2012).

Once Bowman et al. (2021) produced their initial version, they then administered it to a sample population of adults who went through the test using paper and pencil; once the software program for the AIQ was created, they tested a population of athletes to assess the validity of their test. This pilot sample helped Bowman et al. (2021) modify their test based off the score participants received on each item, and this modified version was then sent to the 2012 NFL Scouting Combine where NFL prospects were administered the AIQ. Once the test was administered and results were collected, the final phase of this process included conducting reliability and factor analyses on each item. If subtests of the AIQ were found to not be reliable, they were removed from the test, and subtests that showed exceedingly high reliability were then adjusted by either shortening the time limit or including fewer items (Bowman et al., 2021).

Creating the AIQ with this three-phase process boosted the construct and criterion validity of the test. The three-phase process worked to establish validity by targeting multiple age groups and individuals outside of the game of football, while also shortening the test by starting with a large pool of subtests that were then edited to make the standardized AIQ. Clark and Watson (2019) highlighted multiple key criteria in creating construct validity with a cognitive test, and some of those factors are: (a) clear conceptualization of target constructs, (b) an overinclusive initial item pool, (c) testing the pool against closely relation constructs, (d) choosing validations samples thoughtfully... (e) and "orphan," and "interstitial" constructs, which do not fit neatly within these structures. These factors can be seen in the three-phase process that Bowman et al. (2021) used to construct the AIQ.

Within this three-phase process, the AIQ's development was also in line with American Psychological Association's (APA) Tests Construction guidelines, which again emphasizes the structure and precise creation of the AIQ (AIQ, 2023). The APA implemented 17 guidelines for how tests should be constructed in their creation of the AIQ, and the APA describes these guidelines as suggestions or recommendations that provide psychologists a form of ethical guidance that they can consider when creating different forms of assessment (APA, 2020). Some of the guidelines that the APA (2020) listed include: (a) developing and maintaining competence with findings, (b) seeking training and or supervision within assessment, (c) showing sufficient validity and appropriateness for the usage of their assessment, using multiple relevant and reliable sources, (d) strive for cultural competence, (e) understand relational differences, (f) and testing instruments that are designed for a specific population but are tested with a diverse population. The APA guidelines for psychological assessment and evaluation are very thorough, but again only offers the guidelines for assessment as suggestions and ethical guidelines; you can see from the three-phase process that the creators of the AIQ were in alignment with multiple of APA's guidelines for assessment and evaluation (APA, 2020).

The usage of the three-phase process can be considered a key foundation to the validity of the AIQ. As Clark and Watson (2017) mention, the large-scale lack of efforts to generate construct validity within tests is either a misunderstanding or simply ignoring the concept completely. Thus, the validity of the AIQ was strengthened by abiding by guidelines put in place by the APA Guidelines for Assessment and Evaluation. Throughout its development it seems that the AIQ took the proper steps in making sure that this assessment was developed ethically. After highlighting the development and background of the AIQ, we now look to dive into the core of the AIQ and discuss the different cognitive abilities that this test uses to measure and predict future performance amongst NFL prospects.

4.1 Cognitive Abilities and Application within the AIQ

The AIQ specifically tests for different cognitive abilities an athlete uses when performing, so the results can more specifically predict the relationship between the athlete's cognitive abilities and how these cognitive abilities impact their performance. The four

broad abilities that the AIQ assesses for are **Visual Spatial Processing** (Gv), **Learning Efficiency** (Glr), **Reaction Time** (Gt) and **Decision Making** (Gs) (Bowman et al., 2021). Each broad ability within the AIQ then will have subtests that we will outline below. A key developmental point of the AIQ is that this test does not focus on cognitive abilities that can't be directly related to sport, and so the more academic cognitive abilities such as verbal knowledge and quantitative reasoning have been left out in the creation of this cognitive test (Bowman et al., 2021). The AIQ assesses a certain set of CHC abilities, but with the four broad factors that were selected, there are then ten total subtests of each of the four broad abilities. These ten subtests include: **Manipulation rotation** (Shape Rotation), **Navigation** (Route Finding), **Visual Retention** (Memory for Shapes), **Spatial Awareness** (Design Matching), **Reaction Time – Simple** (Simple Reaction Time), **Reaction Time – Distract** (Choice Reaction Time), **Multiple Target Search** (Object Scanning), **Target Comparison** (Number Matching), **Acquisition** (Paired-Associative Learning), **Recall** (Paired-Associative Learning – Delayed), (AIQ, 2023).

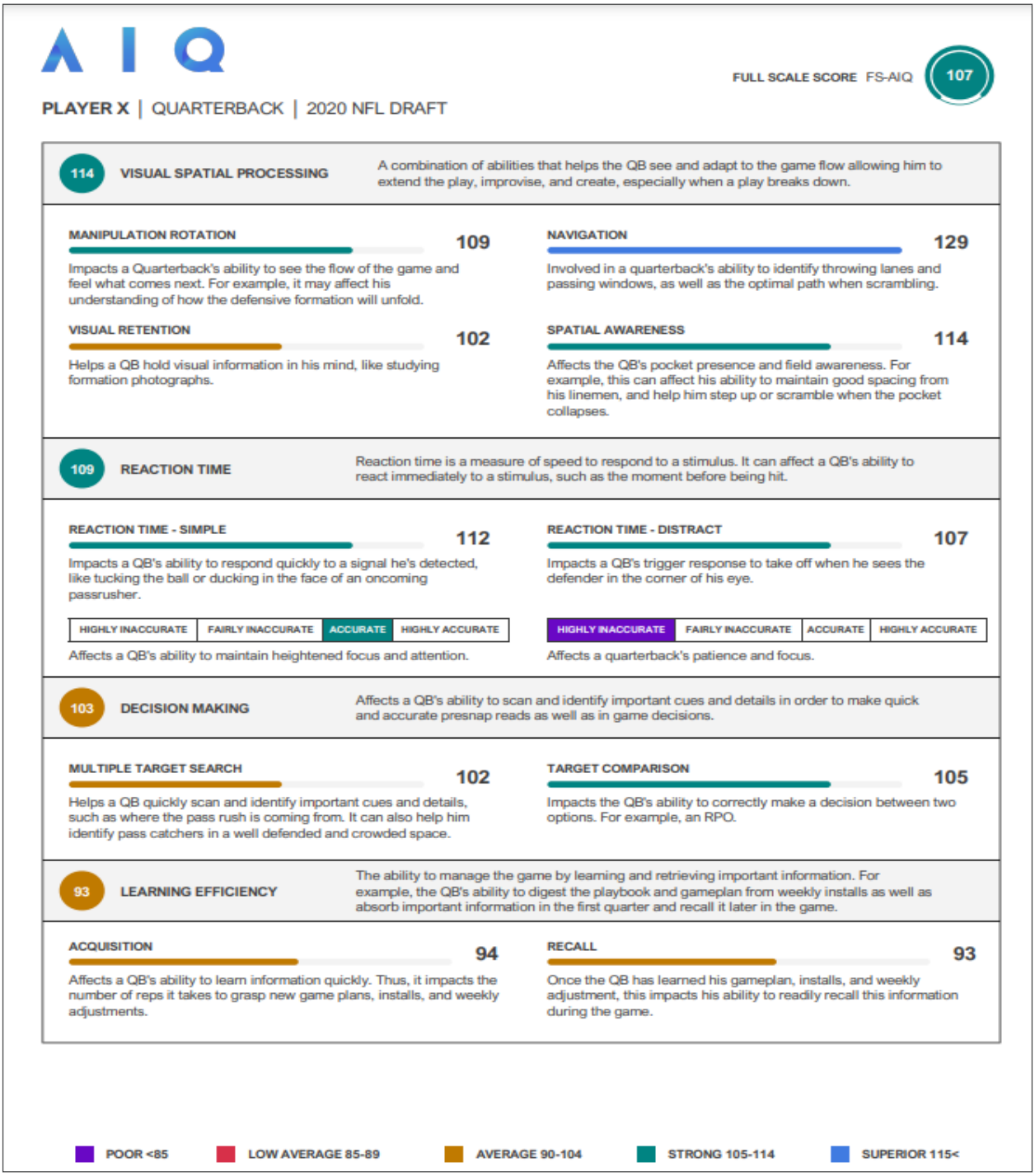

Figure 1. *AIQ Full Scale Score*

Figure 1 illustrates an AIQ Full-Scale Score and the strengths and weaknesses an individual will be tested on, but what is not noted are the specifics to each of the ten subtests scores and the AIQ's capacity to translate to the field. Therefore, to better understand the AIQ and the cognitive abilities that are measured, we must outline how these abilities can translate onto the field for a quarterback which can also be found in Figures 2 and 3. The first set of subtests fall under the broad ability of **Visual Spatial Processing** (GV), which looks at how visual memory, spatial scanning, and visual perception and organization play a role in an athlete's performance. The first subtest in Figure 1 is **Manipulation Rotation** (Shape Rotation), and this can be defined as an athlete's ability to visualize the field under altered conditions (AIQ, 2023). **Manipulation Rotation** for the quarterback position is then focused on a quarterback's ability to recognize the flow of the game and have a feel for what could come next (AIQ, 2023). The next subtest within **Visual Spatial Processing** (Gv) is **Navigation** (Route Finding), and this subtest is defined as an individual's ability to scan a visual field quickly to then determine the shortest route to a given destination (AIQ, 2023). Specifically, quarterbacks will use **Navigation** to find passing windows to throw the ball in and find the best path out of the pocket when scrambling (AIQ, 2023). The third subtest within **Visual Spatial Processing** (Gv) the AIQ measures is **Visual Retention** (Memory for Shapes), which focuses on mentally storing images such as formations or alignments and being able to recall them later on in a game (AIQ, 2023). For a quarterback **Visual Retention** will include remembering the different formations a defense has shown him and recognizing them later in the game (AIQ, 2023). The fourth subtest we will discuss is **Spatial Awareness** (Design Matching), which is described as an individual maintaining their orientation to other object in their space; for a quarterback this ability is used the most when a quarterback must move in and out of the pocket (AIQ, 2023). From these four subtests the AIQ then focuses on **Reaction Time** (GT) the second broad ability that can be defined as how fast and accurately an individual responds to a stimulus with and without distractions present (AIQ, 2023).

The two subtests within the broad ability of **Reaction Time** (GT) include **Reaction Time – Simple (Simple Reaction Time)** and **Reaction Time – Distract (Choice Reaction Time). Reaction Time – Simple** can be defined as an individual's ability to respond quickly and accurately to an immediate stimulus (AIQ, 2023). How this subtest then relates to a quarterback is **Reaction Time – Simple** can be how a quarterback can respond quickly to different stimuli presented during a play, such as tucking the ball away as a defender is getting ready to tackle him (AIQ, 2023). **Reaction Time – Distract** is then defined as an athlete's ability to respond quickly to stimuli while also processing other distractions, and an example of this for a quarterback scanning the field looking to throw the ball, but notices a defender is getting ready to tackle him, so he quickly escapes the pocket (AIQ, 2023). The final two broad domains of the AIQ include **Decision Making** (Gs) and **Learning Efficiency** (Glr), and both of these broad domains include two subtests.

Decision Making (Gs) can be defined as the ability to scan and identify important cues and make a quick and accurate decision (AIQ, 2023). Within this broad ability, the first subtest is **Multiple Target Search** (Object Scanning), which can be defined as an athlete's ability to quickly search for information in a visual field, and this subtest translates to a quarterback seeing a crowded field of defenders and finding his receiver in this space (AIQ, 2023). The second subtest of **Decision Making** (Gs) is then **Target Comparison** (Number Matching) which is the quarterback's ability to compare information in a crowded field, which for a quarterback this could be reading a defender and deciding which receiver to throw to based off the defenders' actions (AIQ, 2023). The final two subtests we will discuss fall under the broad ability of **Learning Efficiency** (Glr), which is an athlete's ability to learn and retrieve important information (AIQ, 2023). The two subtests of **Learning Efficiency** (Glr) are **Acquisition (**Paired-Associative Learning**)** and **Recall (**Paired-Associative Learning – Delayed). **Acquisition** can be defined as an athlete's ability to store and recall information, and for a quarterback this is their ability to learn their playbook quickly and efficiently (AIQ, 2023). The final subtest is then **Recall**, which is defined as an athlete's ability to recall previous learned information and use it quickly and accurately, and for a quarterback this is the ability to remember the ins and outs of a playbook and use it to their advantage throughout a game (AIQ, 2023). Defining each of the subtests and how they connect to a quarterback's play is important to note and is a foundational aspect of the AIQ. We will now look to discuss how the AIQ broad abilities, and their subtests connect to our example of a routine passing play, but

also note some of the research that has already been done on the AIQ and the cognitive abilities the test measures.

4.2 AIQ Cognitive Abilities Related to On-Field Performance

As mentioned earlier in our example of what a quarterback sees and must know on each given play is defined in Figure 2. A great example can be in **Visual Spatial Processing** (Gv) and the subtest of **Spatial awareness** because **Visual Spatial Processing** is described as a combination of abilities that help the QB see and the adapt to the game flow, and **Spatial Awareness** is then what affects the QB's pocket presence and field awareness (AIQ, 2023). This means that a quarterback who scores high on **Spatial Awareness** should then find success moving in and out of the pocket while avoiding defenders. Our example earlier alluded to the different cognitive abilities that are used in each play, and the AIQ and the Full-Scale Score does a great job of not only listing out the abilities but defining each and how they will translate to an athlete's performance on the field.

Another interesting point that translates from our quarterback example to the AIQ full-scale score is described by the broad ability of **Learning Efficiency** (Glr), and the subtest **Recall**. As mentioned in our example, quarterbacks must know the ins and outs of their playbook, and be able to recall this during real time, and be able to assist a player who forgets his assignment. We highlight this subtest within the QB example and its connection to the AIQ to highlight how this test can translate to the field and can be a phenomenal tool for not only NFL organizations, but also for a variety of professional and collegiate sports teams such as the MLB, NBA, NHL, MLS, and Olympics teams. What is even more impressive about this tool is that the broad abilities that I discussed earlier have already been proven to correlate with on-field performance for players in the NFL. Specifically scores with **Visual Spatial Processing** (Gv), **Reaction Time** (Gt), **Decision Making** (Gs), and **Learning Efficiency** (Glr) all proved to correlate significantly with higher NFL career approximate value (CAV), and NFL playing time (AIQ, 2023). And to dive deeper into the correlations the AIQ has found, they also have reported correlations with NFL running backs and rushing yards, interceptions for defensive backs, and fewer false starts for NFL tackles (AIQ, 2023). For linebackers and defensive linemen, reaction time was also significantly and positively correlated with tackles per game (Bowman et al., 2020). Finally, Bowman et al., (2020) found that AIQ factors explained over 17.5% of variance regarding CAV, and when they controlled for draft pick, the AIQ factors explained an additional 6% of variance. Because the AIQ has shown correlations between their test results and NFL performance, NFL organizations should continue to consider the role that the AIQ can play in their organizations scouting processes and beyond. What can come from this test are various advantages for NFL organizations while they are in the process of drafting prospects, but also how they develop these prospects and even game plan against individuals who have taken the test.

4.3 Next Steps for the AIQ

The AIQ is emerging as a valid and effective cognitive test that can be used across multiple sport platforms and even beyond sport due to how it was built on theory and backed by empirical data (Bowman et al., 2020). As we were able to discuss the AIQ and its development, we were able to find positive correlations with on-field performance for draft prospects who have taken the AIQ. Which opens the door for finding out what all the AIQ can predict when considering correlations between the AIQ factors and on-field performance. As reported, the AIQ found positive correlations between their four broad abilities within different NFL positions (Bowman et al., 2020). Specifically, we suggest that researchers expand the research on the quarterback position because of its importance not only to the NFL but the game of football. The franchise quarterback of a football team is the face of a multimillion-dollar and sometimes multibillion dollar organization; and with the different findings the AIQ has on specific positions, we believe researchers should dive deeper into the AIQ.

Further research should assess the subtests of the AIQ, and its impact with on-field performance in the NFL. The ten subtests of the AIQ should all be tested against the major passing statistical categories the NFL holds, such as yards per attempt, completion percentage, passing touchdowns, interceptions, and passer rating (NFL, 2023). Other intriguing statistics that could be related to the NFL subtests could be analyzing relationships between game winning drives, and overtime wins; as these are two critical situations that NFL quarterbacks will be judged based off how they perform in these key moments. Other areas of focus due to the potential of the AIQ could be diving into player development. Due to the AIQ providing a full-scale score on an individual, one could possibly build off this score and work specifically with an individual

who struggles with a specific cognitive area. For instance, if a player struggles in learning efficiency, it suggests that they may require additional coaching/learning/memory strategies (e.g., mnemonic devices, multiple modalities, weekly quizzes, etc.) And conversely, teams could gain a competitive advantage when using the scores from the AIQ when scouting their opponents and their shortcomings. There is still much more to be researched, but the AIQ has proven to be a test that can successfully contribute a piece of the puzzle when forecasting the future performance of NFL prospects.

5. Conclusion and Future Research

Throughout this manuscript we have discussed the importance of the evaluation process the NFL has implemented to assess talent amongst NFL draft prospects. The NFL Scouting Combine along with pro days, all-star games, and different meetings NFL organizations will have with draft prospects all play a role in the final decision made on draft night. We have also questioned the evaluation process by diving into the WPT to get a better understanding of this cognitive assessment tool that the NFL administered on NFL prospects for decades. Because of the questions we were able to bring up regarding the WPT, we believe that NFL organizations, and researchers in the field should assess better ways to quantify intelligence amongst some of the top athletes in the country. Specifically, investigating which cognitive assessment tools are most effective in predicting future performance of NFL quarterbacks.

Throughout this manuscript we have been able to investigate the AIQ to get an understanding of its foundation and see how it has been shown to be a valid tool for measuring athletic-based intelligence. But there is still much more research to be done regarding the AIQ, and based on its foundation, we have confidence that it would be beneficial to further the understanding of the AIQ as a cognitive assessment tool that can be utilized to assess NFL prospects. Researchers should further investigate the critical areas of the game of football and how they correlate with the most important position on the field, the quarterback. For example, we believe researchers should assess the different key situations that quarterbacks are judged on such as game winning drives, overtime wins, and 3rd down efficiency. Along with routine statistics held for quarterbacks such as yards per attempt, completion percentage, passing touchdowns, interceptions, and passer rating. Because there is constant speculation regarding how quarterbacks will perform in these areas of the game of football, it is important that researchers assess these major areas of the game with the AIQ and its subtests. Doing so can give us a better understanding of how effective the AIQ can be at predicting on-field performance of NFL quarterbacks.

Having this information could lead to lessening the bust potential of NFL quarterbacks and be an asset to NFL organizations who utilize the AIQ in their draft process. Further research could also prove to benefit talent development within the NFL, as information from the AIQ can help teams focus their development efforts on some of the cognitive and physical skills an athlete could be lacking in. And while NFL organizations can use AIQ Scores to develop their own players, they could also use these scores to scout against their future opponents. Moving forward, we encourage researchers to answer some of the questions we have brought up throughout this manuscript regarding the AIQ and its ability to predict future performance amongst NFL quarterbacks in the draft process. Due to many shortcomings that we have highlighted regarding the Wonderlic Personnel Test, it is vital that researchers further assess the AIQ as an assessment tool to be used amongst a wide variety of athletes, but specifically focusing on the game of football and the quarterback position.

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