

Article ► Peripheral Awareness and Visual Reaction Time in Professional Football Players in the National Football League (N.F.L.)

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ABSTRACT

Background: Athletes rely on more than visual acuity for optimal visual performance. As a constant surplus of visual information is presented, a player must identify relevant stimuli as rapidly and accurately as possible. This makes visual recognition, processing, and reaction time essential. This study will investigate peripheral awareness and reaction time abilities among players on the New York Jets professional football team.

Methods: Ninety players underwent visual examination, including visual acuity, hand and eye dominance testing, and Wayne Saccadic Fixator testing. Players were classified into one of two groups, skilled and non-skilled, based on field position. Skilled position players included quarterbacks, running backs, receivers, tight ends, safeties, defensive corner backs, punters, and place kickers. Non-skilled position players included offensive linemen, defensive linemen, and linebackers. Trial scores from multiple Wayne Saccadic Fixator programs were collected and analyzed.

Results: No significant difference was found between skilled and non-skilled professional football players on peripheral awareness programs. However, regarding reaction time, a significant difference was found between the two groups, where the skilled players showed faster times.

Conclusions: This study sought to investigate visual differences among professional athletes in the National Football League. Our study found players of all positions to have similar peripheral awareness and eye-hand coordination abilities. Players in skilled positions showed faster visual reaction times.

Keywords: athletic performance, peripheral awareness, reaction time, visual performance

Introduction

Visual Considerations for Athletes

Ideal athletic performance is reliant on several components, including physical condition, sport-specific skills, and visual skills. Physical condition and skill are obvious requirements, but the significance of others, such as an efficient and accurate visual system, can be underestimated. The visual skills needed are not necessarily superior vision on standard testing, but rather exemplary visual information processing of task-specific information and pattern recognition related to the sport in question.¹ As a whole, athletes tend to have superior recognition in more peripheral areas of vision than non-athletes, which allows for a more accurate assessment of surrounding movement and increased field awareness.²

Visual demands of a sport are contingent upon the demands of that particular game. Sports such as tennis and racquetball are considered more centrally focused, as compared to field sports,

which are considered more peripherally focused.² Field sports that involve catching also require excellent depth perception. A study analyzing visual abilities of soccer players found that they had stronger global, or peripheral, visual processing skills than they did local, or central, skills.³ The authors attributed this outcome to more valuable strategic information being gained through observation of field movement over observation of ball movement alone.

Visual reaction time, or the time required to respond to a visual stimulus, is another key aspect of athletic visual performance. Studies with badminton, tennis, and table tennis players have demonstrated that athletes have superior visual reaction time to non-athletes.⁴⁻⁶ According to Knudson, factors impacting visual reaction time include focusing of visual attention and visual anticipation.⁷ These skills may also vary by player position, though there has been conflicting evidence in this area. Bhanot and Sighu investigated position-dependent

visual skills with elite Indian field hockey players and found that defenders had faster reaction times than players in other positions.⁸ Wimshurst analyzed Olympic field hockey players on 11 different visual skills.⁹ Over a 10-week training period, the goalkeepers showed the most improvement, and this was attributed to the unique visual responsibilities of the goalie to follow the ball's quick movement constantly throughout the game. No significant differences were found among players of the other field positions.

The visual strategies used to read and to respond to stimuli may differ among athletes of varying experience levels. Bishop demonstrated that visual attention processing is more developed in subjects considered expert performers on a given task.³ Experts tend to focus on regions that have a higher probability of being information-rich. They also take less time to identify and to react to task-specific information when compared to novice competitors. This relationship was referred to as perception-action by Martell and Vickers and was used to describe the ability of field hockey players to read and to respond to offensive and defensive patterns on the field.¹⁰ Wood suggests that certain athletes are prevented from becoming experts, not because of visual system limitations, but rather due to inadequate visual attention and analysis ability.¹¹ According to Wood, the capabilities of selective attention, analysis, and decision-making based upon relevant visual information are what separate an expert from a novice.

Visual Considerations in Football

Football players rely heavily on the visual system to provide accurate information regarding the location and movement of multiple targets simultaneously. Since players in different positions have different responsibilities, the visual skills required for such will vary.¹² For example, the visual strengths of a quarterback will include acuity and depth perception. Robust visual attention and rapid visual reaction time are imperative. For linemen, peripheral awareness and reaction time are also essential but with less reliance on visual acuity and more reliance on physical attributes such as strength. In this study, our objective is to investigate and to highlight these differences.

The Wayne Saccadic Fixator

The Wayne Saccadic Fixator (WSF) is an apparatus used to analyze saccadic eye movement, peripheral awareness, hand-eye coordination, visual reaction time, and speed of recognition (Saccadic Fixator, Wayne Engineering Orthoptic Division, Skokie, IL). The WSF has historically been used to measure and to improve saccadic eye movement ability and peripheral field awareness in vision training and rehabilitation. These skills are essential during athletics and can therefore be used to predict and to analyze sports-related visual proficiency.

Vogel and Hale used this apparatus to compare abilities among adolescent athletes and non-athletes between the ages of 8 and 13.^{13,14} The results demonstrated significantly better

performance in hand-eye coordination in the former. The WSF can be used to assess both athlete-driven and stimulus-driven reaction times, referred to as proaction and reaction, respectively. Sherman used this WSF data to calculate an entity referred to as the Sports Vision Average (SVA).¹⁵ The SVA is calculated by dividing the proaction test time by the reaction test time and converting this number to a percentage. Sherman postulated that the SVA would differ among specific sports and positions and proposed that it be used to establish standards among professional athletes.

In our study, the WSF was utilized to investigate reaction time as well as proaction and reaction peripheral awareness of players on the New York Jets professional football team.

Methods

Statistical Considerations

The outcome variables of the study were all the measurements obtained during visual assessment. The measures were compared between skilled and non-skilled players using the Mann-Whitney test for continuous-type measurements; the Fischer's exact test was used to compare categorical variables. Due to the exploratory nature of the study, no adjustment for multiple comparisons was planned a priori. SAS v9.3 (Cary, NC) was used to analyze the data.

Subjects

The sample size in this study was a sample size of convenience and was not based on any formal statistical calculations. It was based on the number of participants who consented to the study.

Data obtained from the visual examination of all available members of the New York Jets professional football team who attended pre-season training camp at the Atlantic Health Jets Training Center were included in the analysis (n=90). Testing equipment and conditions were kept consistent throughout the evaluations. All testing was performed on the same day by the same operator to minimize variability. The subjects were classified into two categories: skilled and non-skilled. Skilled players included quarterbacks, running backs, receivers, tight ends, safeties, defensive corner backs, punters, and place kickers. Non-skilled position players included offensive linemen, defensive linemen, and linebackers.

Institutional Review Board approval was obtained from the Northwell Health System in Manhasset, New York. Research followed the tenets of the Declaration of Helsinki, and informed consent was obtained from participants. Approval of the National Football League (NFL) was also obtained.

Wayne Saccadic Fixator Testing

The WSF test involves an apparatus with LED buttons at various locations in the subject's peripheral vision. Once a button is pressed, an auditory tone is produced to confirm

Table 1. Sample Characteristics: Age, Hand/Eye Dominance, & Best-Corrected Visual Acuity Data

	OVERALL N=90	SKILLED N=64	NON-SKILLED N=26	p-value
Age (mean ± SD) (median; min-max)	25.3 ± 2.9 (24.5; 21-34)	25.14 ± 2.84 (24; 21-34)	25.81 ± 3.06 (25; 21-33)	p<0.26
Hand Dominance (%(n)) Left Right	11.11% (10/90) 88.89% (80/90)	12.5% (8/64) 87.5% (56/64)	7.69% (2/26) 92.31% (24/26)	p<0.72
Eye Dominance (%(n)) Left Right Codominant	36.67% (33/90) 61.11% (55/90) 2.22% (2/90)	40.63% (36/64) 56.25% (26/64) 3.13% (2/64)	26.92% (7/26) 73.08% (19/26) 0.00% (0/26)	p<0.29
Best LOGMAR VA OD (mean ± SD) (median; min-max)	-0.08 ± 0.08 (-0.12; -0.3-0.10)	-0.09 ± 0.08 (-0.12; -0.3-0.10)	-0.07 ± 0.07 (-0.12; -0.12- 0.10)	p<0.367
Best LOGMAR VA OS (mean ± SD) (median; min-max)	-0.07 ± 0.10 (-0.12; -0.3-0.30)	-0.08 ± 0.10 (-0.12; -0.3-0.30)	-0.04 ± 0.10 (0; -0.30- 0.18)	p<0.063

feedback of the selection. The number of correct stimuli is recorded on the display window.

In this study, the apparatus was used to investigate both proaction (self-paced performance) and reaction (program-paced performance). It was also used to measure both horizontal and vertical reaction time. The programs used for the study were 9.1, 9.11, 9.18, and 9.34. A brief description of each is provided below and can be found in more detail within the product manual.

For all tests, the subject stood facing the apparatus with height adjusted to eye level. All buttons on the apparatus were within arm's length of the subject. The subject was wearing his habitual refractive correction. Once the program was set, the subject was asked to press the buttons as quickly as possible as they lit up. Unless otherwise specified under the program description, the subject was asked to use his dominant hand to complete the task. Each player was given a 10-second practice trial to familiarize himself with the test that was being administered. Three trials each were performed on programs 9.18 and 9.34; the "best" trial time was designated.

Programs

9.1-Self Pacing Timed For 30 Seconds

32 lights move in a random pattern. Once the subject depresses the light button, the next button will light up. The number correctly achieved in a 30-second window is displayed and recorded.

9.11-Automatic Pacing Timed For 30 Seconds

A random array of lights is presented at a constant speed of one light per second. The number correctly achieved in 30 seconds is displayed and recorded.

9.18-Reaction Time Eye Hand Activity

The subject presses the light in the nine o'clock position, immediately followed by the light in the three o'clock position. The activity measures the time it takes to depress

two buttons in sequence from opposite ends of the fixator. Reaction time required to follow the sequence is recorded in hundredths of a second. This test was performed for three trials with the right hand, followed by three trials with the left.

9.34-Eye Hand Reaction Time

The subject presses the button in the twelve o'clock position, immediately followed by the button in the six o'clock position. Reaction time required to follow the sequence is recorded in hundredths of a second. This test was performed for three trials with the right hand, followed by three trials with the left.

Hand and Eye Dominance Testing

The player's own personal account of hand dominance was obtained and recorded. Ocular dominance was recorded using the hole-in-the-card test. The player was given a 12 x 16 cm black card with a 12 mm hole in the center. The subject was instructed to view a small distant object through a hole in the card, holding the card away from himself with outstretched arms and with both eyes open. Using both arms, the player then was instructed to pull the card back toward his eyes gently, keeping fixation at all times on the distant object. The eye that had the opening in front of it, while still viewing the object, was recorded as the dominant eye. The test was repeated twice, and in-between trials, the subject was asked to place the card down on his lap before picking it up for the next sighting. If the results from the first and second trials were identical, that concluded the ocular dominance test. If the results differed, third and fourth trials were obtained. The examiner also tested by alternately occluding each of the subject's eyes while he was fixated on the target, keeping the hole in the card at arm's length with arms outstretched centrally. The subject was asked when the target remained visible.

Table 2. Wayne Saccadic Fixator (WSF) Program Analysis

Program	OVERALL N=90 (mean ± SD) (median; min-max)	SKILLED N=64 (mean ± SD) (median; min-max)	NON-SKILLED N=26	p-value
9.1	43.34 ± 5.71 (43.00; 31-55)	43.90 ± 5.68 (43; 33-55)	41.92 ± 5.65 (43.00; 31.00-51.00)	p<0.264
9.11	31.14 ± 6.49 (31; 15-43)	31.63 ± 6.30 (31; 15-43)	29.88 ± 6.89 (30.00; 15.00-41.00)	p<0.337
9.21	29.75 ± 4.32 (30; 18-39)	29.71 ± 4.27 (30; 18-39)	29.84 ± 4.52 (31.00; 20.00-36.00)	p<0.656
9.18 Trial 1 Right	0.41 ± 0.14 (0.38; 0.21-0.95)	0.40 ± 0.14 (0.38; 0.21-0.95)	0.44 ± 0.16 (0.38; 0.25- 0.83)	p<0.315
9.18 Trial 2 Right	0.38 ± 0.13 (0.35; 0.15-0.85)	0.37 ± 0.12 (0.34; 0.15-0.68)	0.41 ± 0.16 (0.38; 0.20- 0.85)	p<0.343
9.18 Trial 3 Right	0.36 ± 0.13 (0.35; 0.17-0.70)	0.35 ± 0.13 (0.32; 0.17-0.70)	0.38 ± 0.11 (0.38; 0.21- 0.57)	p<0.161
9.18 Best Trial Right	0.33 ± 0.11 (0.32; 0.15-0.62)	0.33 ± 0.11 (0.30; 0.15-0.62)	0.35 ± 0.11 (0.35; 0.20-0.56)	p<0.333
9.18 Trial 1 Left *	0.38 ± 0.14 (0.35; 0.15-0.82)	0.37 ± 0.14 (0.34; 0.15-0.82)	0.41 ± 0.12 (0.41; 0.19-0.69)	p<0.045
9.18 Trial 2 Left	0.38 ± 0.13 (0.35; 0.17-0.88)	0.37 ± 0.13 (0.34; 0.17-0.88)	0.39 ± 0.13 (0.36; 0.24-0.67)	p<0.576
9.18 Trial 3 Left	0.37 ± 0.15 (0.34; 0.18-0.94)	0.36 ± 0.15 (0.33; 0.18-0.94)	0.40 ± 0.14 (0.37; 0.22-0.77)	p<0.094
9.18 Best Trial Left	0.34 ± 0.12 (0.32; 0.15-0.76)	0.32 ± 0.12 (0.30; 0.15-0.76)	0.36 ± 0.11 (0.34; 0.19-0.62)	p<0.067
9.34 Trial 1 Right *	0.40 ± 0.15 (0.36; 0.17-0.84)	0.38 ± 0.15 (0.34; 0.17-0.84)	0.44 ± 0.15 (0.44; 0.22-0.82)	p<0.043
9.34 Trial 2 Right	0.38 ± 0.16 (0.34; 0.17-0.97)	0.37 ± 0.15 (0.33; 0.17-0.97)	0.38 ± 0.14 (0.36; 0.22-0.67)	p<0.208
9.34 Trial 3 Right	0.37 ± 0.16 (0.33; 0.15-0.83)	0.35 ± 0.13 (0.30; 0.15-0.75)	0.44 ± 0.20 (0.37; 0.22-0.83)	p<0.067
9.34 Best Trial Right	0.34 ± 0.13 (0.30; 0.15-0.71)	0.32 ± 0.13 (0.29; 0.15-0.71)	0.38 ± 0.14 (0.36; 0.22-0.67)	p<0.065
9.34 Trial 1 Left	0.39 ± 0.16 (0.35; 0.16-0.94)	0.37 ± 0.15 (0.35; 0.16-0.94)	0.44 ± 0.19 (0.37; 0.23-0.89)	p<0.166
9.34 Trial 2 Left	0.39 ± 0.16 (0.35; 0.14-0.99)	0.37 ± 0.14 (0.34; 0.16-0.88)	0.43 ± 0.19 (0.38; 0.14-0.99)	p<0.195
9.34 Trial 3 Left	0.39 ± 0.17 (0.34; 0.14-0.97)	0.38 ± 0.17 (0.32; 0.14-0.97)	0.42 ± 0.17 (0.40; 0.18-0.76)	p<0.202
9.34 Best Trial Left	0.34 ± 0.13 (0.31; 0.14-0.82)	0.32 ± 0.12 (0.30; 0.14-0.82)	0.38 ± 0.15 (0.31; 0.14-0.71)	p<0.109

*Significant test

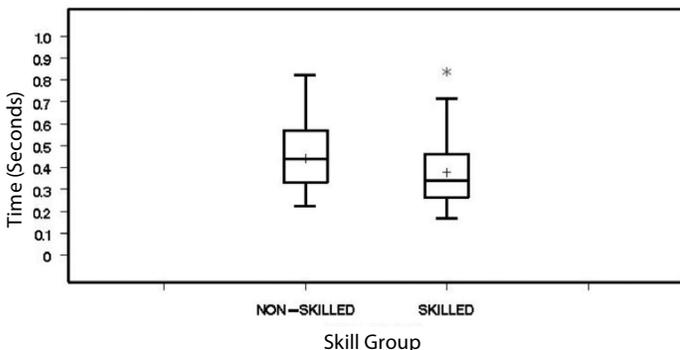


Figure 1. 9.18 Trial 1 Left *Faster reaction time
N=25; Median=0.41; Mean=0.41; SD=0.12; Q1=0.32; Q3=0.5



Figure 2. 9.34 Trial 1 Right *Faster reaction time
N=25; Median=0.44; Mean=0.44; SD=0.15; Q1=0.33; Q3=0.57

Visual Acuity Testing

Monocular uncorrected and best-corrected visual acuity of each player was tested using the standard LogMAR acuity chart at a distance of 6 meters.

Room Luminance

Previous studies have found room illumination to be an important factor in WSF performance. Appler and Quimby

suggested improved performance with dimmer room illumination.¹⁶ The authors attributed this relationship to increased contrast between the light on the buttons and the ambient lighting. In our study, the testing room had halogen overhead lights, and the illumination was kept constant for all testing. The level of illumination for our testing area was calculated to be 12 foot-candles, which is comparable to the 15 foot-candle level used by Vogel and Hale.¹⁴

Results

Sample Characteristics

Results on 88 of the 90 players were obtained. Two players did not wish to participate and were therefore excluded from all analyses. The tables still indicate 90 players as the total sample size (64 skilled players; 26 non-skilled players).

All subjects were male and between the ages of 21 and 34, with a mean of 25.3 years old (SD: 2.91). The two skill groups did not differ with respect to age ($p < 0.26$). They also did not differ with respect to hand dominance ($p < 0.72$) or ocular dominance ($p < 0.29$). There was no significant difference between the two skills groups with respect to best-corrected visual acuity. Table 1 presents demographic data for age, hand/eye dominance, and visual acuity for the two groups.

WSF Program Analysis

No significant differences were found on programs 9.1 or 9.11 between the groups.

There was a significant difference between the skill groups for trials of both tests related to visual reaction time: namely, the 9.18 Trial 1: Left and the 9.34 Trial 1: Right. Skilled players had a statistically significantly lower Side-to-Side 9.18 Trial 1 Left scores than non-skilled players (0.37 ± 0.14 , median=0.34 vs. 0.41 ± 0.12 , median=0.41; $p < 0.045$). This suggests that skilled players have a faster reaction time on this test. Similarly, skilled players scored significantly lower on the Top-to-Bottom 9.34 Trial 1 Right relative to non-skilled players (0.38 ± 0.15 , median=0.34 vs. 0.44 ± 0.15 , median=0.44; $p < 0.0432$). Again, this is indicative of skilled players having a faster reaction time on this test.

Data for the tested WSF programs along with statistical results can be found in Table 2. Graphical representations of the significant findings can be found in boxplot form as Figure 1 and Figure 2, respectively. The differences on both tests were significant at the 0.05 level but not at the 0.01 level.

Discussion

According to Erickson, peripheral eye-hand response and response speed are two of the most important visual-perceptual skills in optimal athletic performance.¹⁷ Other essential skills include static and dynamic visual acuities, contrast sensitivity, stereopsis, and accommodative and vergence abilities.

There has been little research into specific differences in visual skills between athletes of different field positions within the same sport. In our study, no significant difference was found among players of skilled and non-skilled positions on peripheral awareness task performance. In football, movement of peripheral stimuli on the field, whether other players or the ball, will determine the next movement of every player on some level. For this reason, we believe that all of the elite football players likely have superior abilities in this area and thus performed similarly on the peripheral awareness programs. While Vogel found adolescent athletes to have better WSF performance than their counterparts,

and Christenson found athletes to have superior peripheral awareness than non-athletes, a more accurate comparison of our elite athletes to the general population is precluded by the current lack of normalized adult WSF data.^{14,18}

This study did show that visual reaction time to a peripheral stimulus was faster in skilled football players than non-skilled football players. Of the two trials that presented as statistically significant, one was a vertical reaction time test, and the other was a horizontal reaction time test. One was on a right-hand trial, and one was a left-hand trial. Therefore, our data does not provide any correlation between the skill groups and abilities with vertical versus horizontal reaction time, nor does it demonstrate a right- versus left-hand advantage between the skill groups.

We hypothesize that skilled players have faster reaction times to peripheral visual targets not as a learned characteristic but as an inherent one. All elite athletes are able to perform at such high skill levels due to extremely efficient physical and visual systems. Why a particular athlete excels at one position over another is dependent on physical and visual potential on a more specific level. For example, a player with sharp dynamic acuity and reaction time to peripheral stimuli would be more apt to excel while utilizing these skills to anticipate field movement to plan out passing plays down the field. Such a player would excel as a quarterback, receiver, or other skilled position. These situations, during which a millisecond's delay in reaction time to catch or throw the football can be detrimental, require intense visual attention and rapid and precise reactions. Optimal performance of skilled players also requires a specific coordination of the visual, cognitive, and musculoskeletal systems. Only certain players possess this at such an advanced level.¹⁹

Our data is consistent with the 42-study meta-analysis by Mann et al., which found more skilled athletic participants to have superior abilities anticipating movement of the opponent, which led to quicker response time.²⁰ It is also consistent with Abernathy and Neal's results regarding peripheral response time on the WSF and reaction time.¹ They found no significant difference among skilled and non-skilled clay target shooters on peripheral WSF testing but a significant difference in reaction time between the two.

Limitations

This study was limited to the sample size of only one professional football team. It was also limited to the WSF programs selected by the examiners and to the testing environment characteristics, which are not as dynamic as and cannot directly correlate to player actions on the field. The results of testing off the field may also not be exactly representative of player abilities on the field, where motivation and competition play a greater role.

Future Areas for Investigation

Multiple studies have found athletes to have better saccades, peripheral awareness, and reaction time than non-athletes.^{13,21}

It has yet to be determined whether those skills develop due to athletic experience or rather if innate talents in those areas allow the player to excel in the athletic arena.²²

The WSF may be a valuable asset to test and/or train peripheral awareness and reaction time in Sports Vision Training.²² Wood demonstrated a significant improvement in skills on the WSF over a 4-week training period.¹¹ Other computer-based visual programs have shown similarly promising results.

Poltavski and Biberdorf investigated visual perception in collegiate hockey players and found that certain factors on the Nike Sensory Training Station were predictive of performance and goal scoring.²³ The four tests shown to have correlations were Go/No-Go, Perceptual span, Average reaction time, and Near-far quickness. Erickson monitored changes in performance on the Nike Sensory Station over multiple sessions and found that adult subjects had significant improvement in the hand-eye coordination program.²⁴ The Nike Sensory Station uses a similar procedure as the WSF by utilizing a 42-inch touch-screen display with equally spaced circular targets.

With regard to both tests, more supportive research is needed to determine improvement based on test familiarity versus improved skills, which may carry over with an athlete onto the field. Additionally, these tests may have practicality in screening athletes to determine visual strengths and thus to predict potential athletic strengths.

Conclusions

Football is a dynamic game that requires constant balance of central focus, peripheral awareness, and rapid reaction to movements of the ball and other players. The aforementioned skills can be investigated using the WSF, as utilized in this study. Our results demonstrate that while peripheral awareness and hand-eye coordination were consistent between players of different football positions, visual reaction time was fastest in players who held skilled field positions.

While this study was limited to professional football players, all athletes should have routine ocular health examinations as well as visual skills evaluations. By considering all aspects of the visual system, eye care providers can ensure that athletes of all ages have the tools needed for success.

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Conflicts of Interest

The authors have no financial interests or conflicts of interest to disclose.

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