BINOCULAR VISION'S PLAY ON BASEBALL

By

Adeline Bauer
Kimberly Reich

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Adeline Bauer
Kimberly Reich

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APPROVED

, Faculty Advisor

ACCEPTED:

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Faculty Course Supervisor

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ABSTRACT

Background: It is largely accepted that a good binocular vision system is critical to being successful in sports. In studies comparing high level baseball players to non-athletes, athletes have displayed exemplary binocular vision above and beyond the average person. Is their success based on innate above average levels of depth perception, or are these high levels trained through years of playing sports? We sought to discover if this correlation between stereopsis (depth perception) and success is true for the beginning levels of baseball. *Methods:* The following study tested the visual acuity, heterophoria, and stereopsis of children that participated in organized little league baseball teams and then compared these values to their batting averages. *Results:* Through the comparison of the patient data to their batting averages, we found that there is no correlation of the status of the binocular system and the batting averages. *Conclusion*: The athletes screened all had great visual acuity and stereopsis, regardless of how many years they had been playing. An innate superior visual system is found in athletes and from this research, it may begin in childhood. In comparison to the average population, athletes have superior stereopsis, but there is not a correlation between the success of the sport and the value of the athlete's stereopsis. Other skills contribute to the success of each athlete such as reaction time and experience.

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INTRODUCTION

Baseball is a fast paced sport that requires skills such as eye-hand coordination and quick thinking. Studies show that, in the general population, those with better stereopsis perform better than those with reduced or no stereopsis at tasks involving visual motor skills .[1] Visual motor skills can include simple things such as copying a sentence from a chalkboard to more sophisticated skills such as playing in a high pressured sport. Most professional athletes are known to have superior vision above and beyond the average person.[2] Specifically, studies done at the college and professional baseball levels have shown nearly uniform levels of depth perception that are better than the average population. However, it is unclear at this time whether these uniform above average levels are because the players that get to these high playing levels must have superior vision to compete at this level, or because these levels of visual acuity and stereopsis have been trained from years of playing the sport.

There have been some studies examining the ocular systems of novice and expert participants in certain sports. Fast paced sports such as table tennis and clay target shooting have both compared the visual systems of their novice and expert participants. These studies show that it is not the stereopsis that separates the good athletes from the superior ones, but simply reaction time and experience.

In this study, we examined the visual systems of relatively novice baseball players. Thirty-four children were screened during their 4 week indoor hitting league. Visual acuity and stereopsis were collected for each player then compared to their age and batting average for the season. These statistics were compared amongst the players, and also against previous studies of veteran players. By comparing these statistics, we

aim to determine if above average visual performance is present in these novice athletes, and if there any correlation to their success in the sport.

METHODS

Thirty-four athletes between the ages of seven and fifteen were randomly selected from a winter indoor hitting league. Subjects participated on different teams and were offered no compensation. They were told that they would undergo a short vision screening to determine their visual acuity and depth perception. The parents of the participants were required to sign an informed consent form and complete a short questionnaire. The questionnaire inquired about the participant's age and their previous participation in baseball (see Appendix A). The research and testing protocol was reviewed and approved by the Ferris State University Institutional Review Board.

Athlete screenings took place during the baseball teams' regular practice time. All tests were administered indoors and with each player's normal optical correction. Participants near local stereoacuity was measured with a Randot stereogram. Each subject held the test book at 40 cm and wore polarized glasses. The participant was asked to identify which circle in a set of three had crossed disparity, which made the circle appear to be coming towards the subject. The last correctly identified circle was recorded in seconds of arc. A supression check was also done using the R and L found in the test booklet. The subjects monocular visual acuity was tested with a Snellen chart placed at 20 feet. The participant was then instructed to cover one eye and read the lowest line they could. If the subject got all the letters correct, he was asked to read the next line down. Visual acuity was recorded as the last line the athlete got over 50% of the letters correct.

The results were recorded as a Snellen fraction and later converted to LogMAR for analysis purposes. Eye alignment was assessed by having the athlete fixate on a distance letter on the Snellen acuity chart at 20 feet away, then performing a unilateral and alternating cover test. The results were recorded as either orthophoric, esotropic, or exotropic. All tests were untimed

A batting average was obtained from the director of the hitting league after completion of the league. The hitting league consisted of four weeks, with one session a week. The participants received 50 pitches during each session, with ten pitches per at bat before rotating with another player, for a total of 200 pitches during the course of the hitting league. The pitches were presented in a batting cage with a pitching simulator, which mimics an actual pitcher's wind up before a pitching machine delivered the pitch. The pitching machine is located 46 feet from the batter, which is the regulation distance for all Little League fields.

Batting averages were determined based on whether the ball would have been a hit or an out on an actual baseball field. In order to determine this, the batting cages were marked with different zones that correspond to where the ball would land on a real Little League field. Foul balls were counted as outs, as were balls that landed within zones that a player should be able to field. Balls that would land in the outfield were counted as hits. If a player swung and missed, it was counted as an out. Not swinging at a pitch did not count against a batter and was not included in the total 50 pitches given to each player during a session. A neutral observer was charged with recording the hits and outs for each team. The final scores at the end of the four week period were used to calculate a batting average. These averages were obtained from the league coordinator for this study.

Statistical analysis was done to determine if any of the data yielded significant results. Descriptive and inferential statistics were accomplished using SPSS for Windows version 21. The mean and standard deviation were produced for all variables. Correlation coefficients were produced for all variable combinations. Stereopsis was divided into two groups with one group having 20 seconds of arc or better and the other group having greater than 20 seconds of arc. Number of years playing was also divided into two groups with one group having four years experience or less and the other group having more than four years experience. Participants were also grouped by age with one group being 10 years old or younger and the other group being over 10 years old. Independent Samples T-Tests were accomplished on the Stereopsis Groups, Experience Groups, and Age Groups.

Averages with standard deviations are provided for all data sets, as well as broken down between groups.

RESULTS

The 34 participants in this study had an average age of 10.8 years old. These players had an average experience level of 4.97 years. On the Randot stereogram, the participants had an average stereoacuity of 24.7±8.48 seconds of arc. The mean visual acuity for these players was 20/19.3 for the right eye and 20/18.8 for the left eye. Batting averages provided by the league coordinator showed an average of 0.543 for all participants.

Age of Player	Number of Players
7	1
8	2
9	4
10	8
11	8
12	7
13	2
14	1
15	1
	34

Table 1 describing the number of players in each age range

From the data that was collected the average local stereopsis score was found to be 24 seconds of arc. A study by Boden, et al, shows that the average, non baseball playing individual, has an average stereopsis of 56.2 seconds of arc[2]. A list of the stereopsis scores of each player can be found in Table 2.

From the data collected 94% of the athletes had a visual acuity better than 20/30 and 97% had a stereopsis score better than 30 seconds of arc.

After statistical analysis, it was concluded that there is no statistically significant correlation between stereopsis and batting average. In addition, there is no significant between years of experience and better batting average. Finally, there is no correlation between years playing and better stereopsis. The only statistically significant finding was the correlation between age and the number of years playing experience.

To further break down the data, stereopsis, playing experience, and age were divided into two groups and compared between these groups. Stereopsis was broken down into players who had 20 arc seconds or better versus those with greater than 20 seconds of arc. There was no statistical significant difference between the age, years of experience, nor batting average in this group. Playing experience was further broken

down to two groups that consisted of those 10 years old or younger and those over 10 years old. Among this group, there was no statistically significant difference between their stereopsis or batting average. The population was also broken down into a group with four years of less experience versus those with more than four years experience. There was no statistical significant difference between batting average or stereopsis between this group.
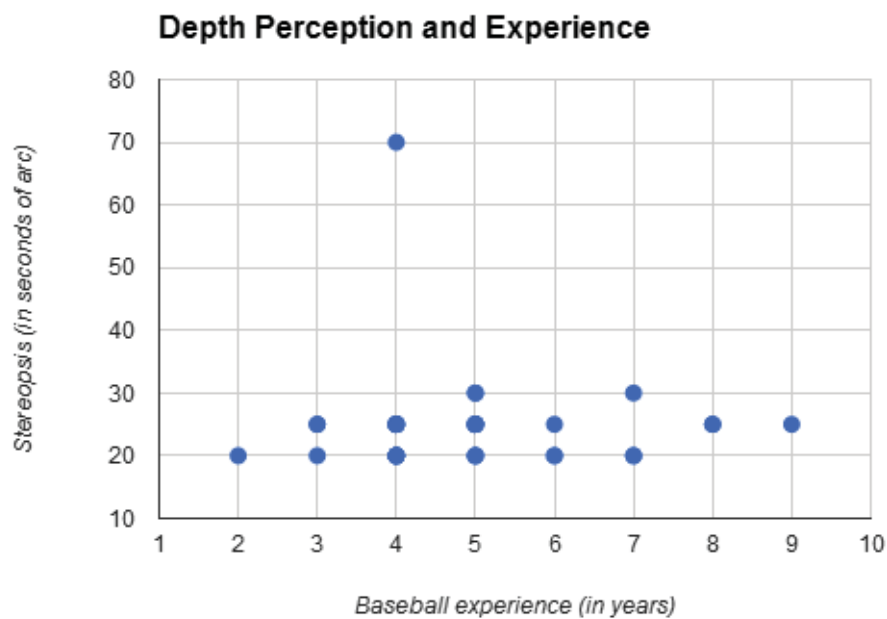
Depth Perception and Experience

Figure 1. A depiction of the relationship between the numbers of years each player has been playing baseball versus the stereopsis of the players that have been playing that specific year.

DISCUSSION

Several studies have shown that those who participate in baseball have a higher level of depth perception than non-participants. A study by Boden et al found that high school age youth who participate in baseball or softball had better depth perception than people who did not participate in these sports[2]. Laby et al. also found a difference between stereoacuity of professional ball players and the general population.[6] These studies both show a statistically significant higher level of stereopsis than those found in the general population. The stereopsis levels measured in the little league players in this study are comparable to those found in the two previously mentioned studies, and the study by Molia et al. Comparison of the mean stereopsis levels are illustrated in TABLE 3 below.

Study	Age of Players	Mean Stereo± std dev
Current Study	Little League	24.7±8.4
Boden et al.	Youth Ages 10-18	25.5±11.9
Molia et al.	College	51.4±39.1
Laby et al.	Major League Year 1993 Year 1994 Year 1995	29±25 23± 10 37±83

Table 3. Comparisons of the athletes' mean stereopsis between the current study and those previously done

Instead of studying players statistics from actual game situations, batting cages were used for the setting of this study to provide more consistent playing conditions, as suggested in Molia et al. In this situation, batting average is a measure of pure hitting skill. Therefore, the data is not obscured by coaches calling for sacrifice plays, such as bunting, where the player hits the ball intentionally trying to get out so as to move other players around the bases. Having participants in the batting cages also eliminates increased batting averages due to fielding errors by the opposing team. Additionally, having a pitching machine deliver the pitches eliminates intentional walks and players getting on base by getting hit by a pitch. The scoring for the indoor hitting league attempts to make the batting averages as close to real field averages as possible, by consistently scoring hits based on location the ball hits the net in the batting cage.

Even with this more controlled environment, there was no appreciable correlation between stereopsis and depth perception. Nor was stereopsis correlated with years of experience. This agrees with the findings in the population of college players found in Molia et al. Their conclusion from this information was that players with better stereopsis were "self-selecting." In other words, only players with exceptional stereopsis were successful in baseball, and continued onto the next level. However, both their study and this study show no correlation between success as it relates to hitting and a higher level of stereopsis. There then becomes three different explanations for the high levels of stereopsis among all levels of baseball players.

First, it could be that self-selection occurs at a younger age than these studies examine. This self-selection could occur within the first year of participation in baseball,

causing all players that make it past the first year to have excellent stereopsis. Yet this makes the assumption that self-selection only happens at a discrete point in time; within the first year of play. If there was a selective power behind stereopsis, it should be evident as a gradual increasing level of stereopsis over time. Therefore, higher levels of stereopsis would be apparent at higher levels of playing. For example, college players should have better stereopsis than high school players and Major league players should have better stereopsis than college players. Players with the lowest levels of stereopsis amongst these groups (little league, high school, college, and major leagues) would theoretically not make it to the next level, because they cannot compete amongst players with better depth perception. Yet all studies done up to this point show that stereopsis levels among these groups are not statistically significant, leading to the conclusion that self-selection is not the mechanism behind the higher levels of stereopsis in baseball players.

Second, it is possible that stereopsis is behind a self-selection process that occurs between these groups, but that it is not associated with hitting. There are several different skills involved in being successful in baseball. Players have to field as well as hit the ball. While there is no correlation between hitting and stereopsis, it is possible that higher levels of stereopsis are required for fielding accurately. Yet, the problem remains that there is no appreciable difference between the stereopsis of little league players and major league players. If stereopsis were important in advancement of skill level, there should be a difference of stereopsis measurements between these skill levels.

The third possibility can explain better stereopsis levels in baseball players than the general population and the overall homogeneity of stereopsis levels among the

baseball players. It is possible that playing a sport such as baseball can effectively act like vision therapy, causing an optimization in many different areas of visual function. This explains the excellent visual skills found among ball players like those noted in Laby et al, and also explains why no correlation has been found between these skills and success in the sport. Tracking activities, hand-eye coordination, and oculomotor skills are being constantly practiced as baseball practices all over the country. They are also a major component of most vision therapy sessions. It is likely that practicing these skills for hours a day, and five days a week at baseball practice is even more effective at optimizing the visual system than once a week in-office vision therapy. If these excellent visual skills are trained through practice, we would expect an improvement of visual skills in a roughly sigmoid function, with major gains in stereopsis levels being made in early years of playing, and then slowly tapering off after optimum levels have been achieved. This explains why little league players have levels of depth perception similar to that of major league players, yet better than the general population.

Baseball is not the only sport in which visual skills have been examined in relation to a successful athletic performance. One study by Abernethy and Neal compared the visual skills of novice and veteran clay target shooters. In their study, they found that visual skills, such as stereopsis and acuity, had no correlation between success hitting the moving targets. Instead, they cite experience and the ability to quickly process visual information as the biggest difference between the levels of participants.[8] Another study done by Hughes et al. found that the difference between elite and novice table tennis players was their level of psychomotor performance, or reaction time. Both these studies

agree that the ability to quickly process information regarding target speed, direction, and spin; then reacting quickly are more important factors for success than visual function.[7]

In order to more accurately determine the factors that determine success in baseball, future studies should focus on the area of why stereopsis is better in ball players, but has no correlation to hitting performance. Examining the difference between stereopsis before their first year of playing then subsequently after their first year of playing would lead to a better understanding of how depth perception changes as players gain experience. Comparing stereopsis of those who continued playing versus those who dropped out of the sport would lead to determining whether self-selection was occurring between the different levels of play. Another interesting area of study involves comparing the changes to the visual system of those who play baseball to a similar matched group of those who underwent vision therapy to determine if playing a sport can function like in-office therapy. Reaction time and batting statistics should also be examined further, potentially leading to an effective regimen to improve player's chances of participating at elite levels.

APPENDIX A

PRE TESTING SURVEY

Player Survey

1. Age of the Player _____

2. Years playing baseball _____

3. Has the player ever had an eye exam? Y/N

APPENDIX B

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