The Effectiveness of Virtual Training: Comparing Virtual and In-person Sport-Specific Cognitive Training

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Abstract

The goal of the project is to outline the benefits of different types of cognitive training with physical or in-person training compared to a virtual training implementation specifically in the context of baseball pitch recognition. By doing this we are able to identify which aspects of pitch recognition are better trained by different types of training and allow athletes to train differently and more effectively. The participants were 21 undergraduate students at Bard College who have not played at a competitive level of baseball. Participants were assigned to two conditions either in-person cognitive training or similar but virtual training. Participants were tested on both their pitch type accuracy and strike accuracy in order to compare possible differences between the training implements. articipants' ability to identify the correct aspects of pitch type and strike accuracy within three seconds of viewing the pitch was assessed both in person and virtually. The hypothesis is that the virtual training group will outperform the in-person group in pitch type accuracy but the in-person group will outperform the virtual group in strike accuracy. The results showed that there was no significant difference in performance for strike zone accuracy between the virtual and in-person groups but there was a marginally significant difference between the virtual and in-person training groups for pitch type accuracy.

Introduction

The way we perceive the world around us is inherently based on a few main processes that occur continuously during the day as we travel through life. Visual perception and decision-making drive everything that we do in every aspect of our life. We perceive our own unique version of the world and what our brain does with that information informs how we act upon it. In the context of sport and athletic ability, everything about an athlete can be trained whether it is their muscular strength, agility, or even their cognitive ability to process information.(Wang et Al.) In a sport-specific context, the ability to visually perceive the world around us and make split-second decisions correctly is a vital aspect of sports that is under-recognized and under-trained.

How cognitive abilities are trained has evolved over the recent years. In sports such as baseball, hockey, tennis, and softball where athletes must make a decision and reaction in under 1 second the training has gone beyond just practicing the task physically. With advancements in technology as well as software, sport-specific cognitive training has moved virtually. It began with reaction time training in very basic software to sport-specific virtual settings allowing athletes to practice their sport without the physical drain of doing it in person. Training virtually extends the hours athletes can train and makes advanced training more attainable for a higher percentage of athletes. In a study by Broadbent et Al.(2017) researchers looked at the ability of tennis players to predict an opponent's shot through a virtual implement and then test it in a sport-specific task. The virtual implementation of tennis players with both sequenced and randomized tennis shots was used and tested as training or similar in-person testing of actual physically playing tennis after being exposed to the virtual implement. The use of this sport-specific virtual training is an advancement in sports psychology and further pushes for the use of virtual implements in the training of athletes. This study showed the use of virtual training improves tennis players abilities to predict a tennis shot and improve reaction and decision making time.

The visual system is complicated in itself but it allows us to perceive the world around us and make decisions and memories about what we perceive. Our brain, in specific our frontal lobe is directly involved in directing our visual attention in specific to goal-oriented tasks (Wang et Al. 2019). Also shown in visual processing is the activation of the supplementary motor area when linking visual perceptual input to perceived actions. This is directly related to how virtual implements in sport-specific ways can be used as effective training implements as they not only train an athlete's cognitive ability to make decisions but also have some carry-over into the motor cortex improving and linking this training with physical actions. (Broadbent et Al.)

Creating carryover, imrpovemnet in a task creating improvement direction in the desired sport, from virtual cognitive training to sport-specific tasks has proved to be one of the most common things struggled with as a training implement has to correctly mimic the cognitive processes perceived when physically playing the sport. In baseball training, this has been done by a few companies but in specific Applied Vision Baseball has taken it and made it publicly accessible for a low cost and allows athletes to use their prerecorded virtual implements on devices such as laptops, projects, and mobile devices. Athletes are shown different pitchers pre-recorded and cut off as the ball leaves their hand. Depending on the task and difficulty or velocity of the pitch different cut-offs are used. Athletes are then given 3 seconds to answer what type of pitch was being thrown and whether that pitch was heading for the strike zone or not. This compresses the decision-making and processing of the visual stimuli into a simple task. The question remaining is whether this window of decision-making creates enough of a parallel to actually hitting to have a carry-over. We can improve athletes' abilities in any sort of cognitive task as much as possible but if the task they are improving at doesn't have significant carry-over to their sport athletes do not benefit from implementing it into their training regiment. A study by Liu et al. (2020) focused on two collegiate baseball teams, Duke and Indiana University, and utilized cognitive training tasks and measured success in terms of baseball performance. Players that participated in the study had their prior season statistics compared to post-training season statistics as well as their performance in batting practice pre and post-training.

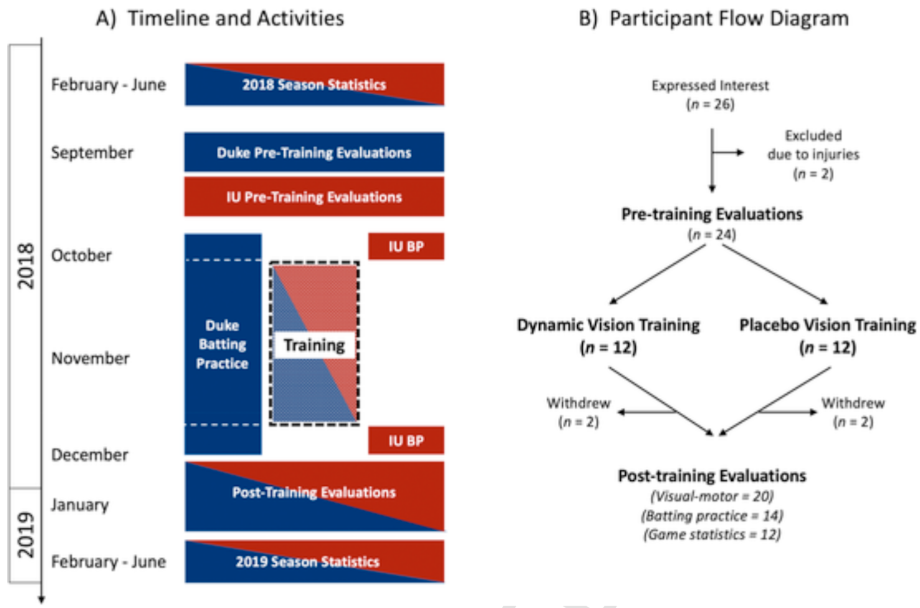

Figure One

This image shows the timeline of the study by Liu et Al.(2020). The impact of the training failed to show statistically significant improvements in season statistics but players improved in both the cognitive tasks and in batting practice performance.

Improving aspects of training also carried over to increased performance in batting practice measurables but not in season statistics. The timeline athletes were put through is shown in *Figure 1.* Specifically, athletes improved in the aspect of launch angle and peak distance. Both are highly valued aspects of a hitter. Quantifying what measurables to improve such as peak distance and average launch angle is at the center of an athlete's goal for off-season and in-season training. The higher the launch angle of a batted ball the higher the expected batting average will be. With some exceptions due to exceptionally high launch angles but in most cases as the launch angle increases so does the expected batting average (xba) (Bailey et al., 2020). The way new stats such as xba is calculated in Major League Baseball (MLB) is due to new software and cameras installed in every MLB park and cited in Bailey et al (2020) as the new system of Statcast. XBA is a stat that uses the new Statcast technology to create an expected batting average based on how constantly hard a player hits the ball compared to a league average. Statcast is an advanced system of cameras that capture the speed, spin, and physical traits of every ball thrown or hit as well the metrics of every player on the field. New technologies such as this allow for average exit velocity, average thrown velocity for pitchers and position players, as well as sprint speed of hitters and defenders are able to be tracked. Due to the abundance of new data collected, new statistics are able to be collected such as xba, catch probability, average launch angle, barrel percentages, and many others all due to the Statcast system. With many new ways of measurables and cognitive visual training being shown as one of the ways to improve them, it would make sense that many MLB teams are implementing such practices into their training regimens.

Previous research including the study by Liu shows the positive effects of cognitive visual training in a sport-specific setting as well as the study by Broadbent shows how specializing in cognitive visual training to mimic sport-specific tasks can be even more beneficial in creating carryover from training to sports performance. The idea of training virtually is something that has come about more recently than the idea of training cognitive functions. Specifically in the sport of baseball athletes have hit things smaller than baseballs as a form of training and whether or not they are aware of how they were doing it they were training their brain cognitively to function at a higher level. What is left unanswered by previous research in this field is not how does virtual training affectssports performance, , but how does virtual training compare to training cognitive functions in a physical setting. That is what this study seeks to answer as it will compare very similar training mechanisms in pitch recognition in the physical sense seeing the pitch in person as well as in the virtual environment with a virtual pitch thrown. I hypothesize that in the physical training strike zone recognition will be better than the virtual training but in comparison, I hypothesize that the pitch type recognition will be significantly better in the virtual training group.

Methods:

Participants:

Participants for the study include 21 Bard undergrad students who were recruited for the study using fliers and emails distributed through campus. Each participant went through a questionnaire screening process and has had zero prior experience playing baseball beyond a high school level and has had no experience with cognitive visual training methods. Each participant was given informed consent to what they were about to participate in and each participant was coded with a participant number and their data was anonymized in the analysis. Each participant was given $5 to complete the 45-minute task.

Participants will be randomly assigned to either the physical cognitive training condition or the virtual cognitive training condition. Those assigned to the virtual training group were asked to arrive at the lab 5 minutes prior to their scheduled time in order to be properly informed of the task before beginning. Prior to the testing participants were familiarized with the software and the idea of pitch recognition through the use of Figure 2.

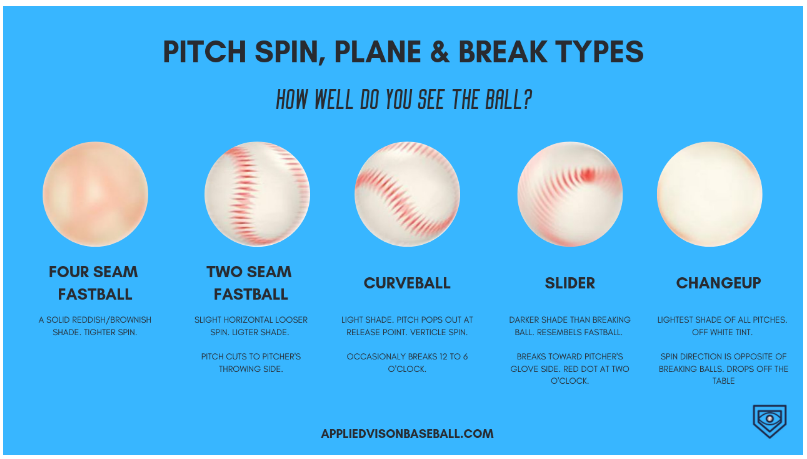

Figure Two

This contains the diagram presented to participants for recognizing pitch type. The Figure is from Applied Vision Baseball.

One familiarized with what participants were looking for in the task they were put through a trial run prior to the actual task. The task was completed at a desk in the lab setting with the participant seated directly in front of the monitor and using a mouse to click their responses in the software. In the experiment participants saw a randomized sequence of twenty pitches and were asked to identify each pitch for its pitch type and if it is a strike or not. This was recorded via the software by clicking the pitch type under strike or ball boxes. This is shown in image 2.

Figure Three

This is a snapshot of the software used and is what the participants see when completing the task. This is a screenshot from the software used in the study from Applied Vision Baseball.

Participants after seeing the pitch on the screen are prompted to answer what type of pitch they saw and whether that pitch was inside the box shown that is the strike zone or not. Participants are required to make this decision within three seconds of the pitch presentation or their data for that pitch is excluded from the results. The strike zone shown in Figure 3 disappears as the pitcher goes into their motion. Participants will go through one practice round of 10 pitches to familiarize themselves with followed by the experiment trial which will contain 20 pitches of either fastballs or breaking balls.

The in-person training group completes their testing in the batting cage of the Stevenson gymnasium. They saw pitches thrown from 60 ft 6 inches, the same distance used in a baseball game, and be asked to respond to whether the pitch fed through the machine was a strike or ball and if the pitch was a fastball or breaking ball. The strike zone will be defined as a pre-measured strike zone which is defined by major league baseball as the width of home plate, 17 inches, and the height is determined by the batter being between the knees of the batter to the midpoint of the top of the shoulders and bottom of the uniform top (Strike Zone | Glossary, n.d.). The height of the strike zone used in this study was averaged based on the average heights of current MLB players. Participants stood outside of the cage, to ensure their safety, and saw the pitch from a slight side angle similar to that of a batter hitting a baseball. They will be asked by the researchers within three seconds of the pitch to report its pitch type and if it is a strike or not. Participants will each get 10 practice pitches and then will see 20 pitches as the experimental trial.

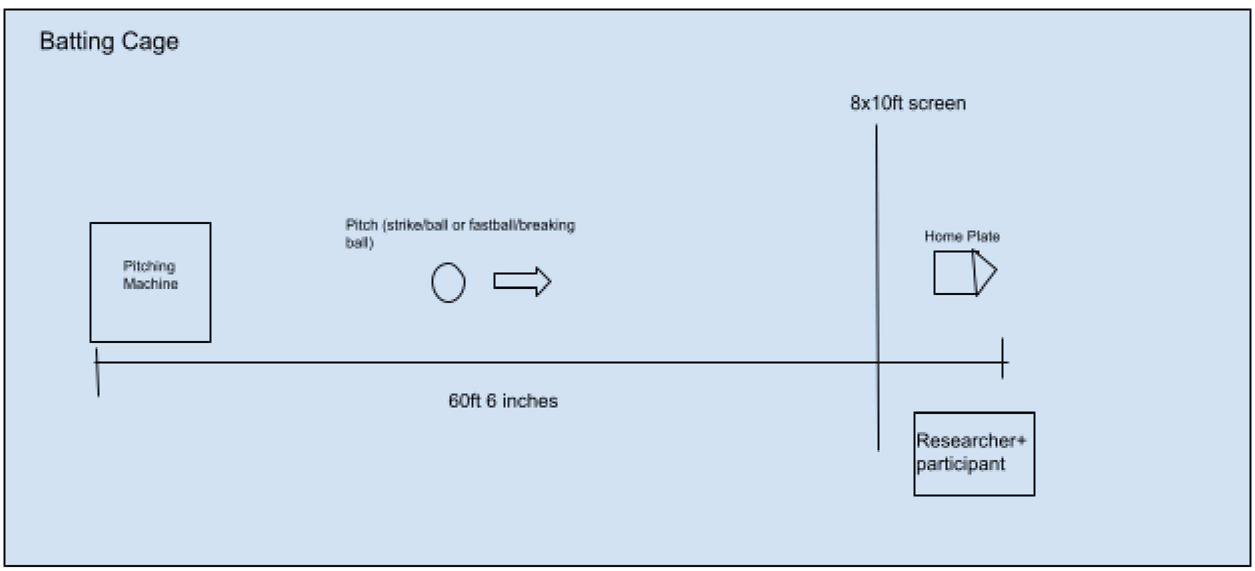

Figure Four

This shows the setup that will be used in the in-person implement

Results

The study consisted of 21 participants total and these participants were either assigned to the in-person group who saw live baseball thrown from a pitching machine. The virtual group was tested using Applied Vision Baseball, a virtual software that allows people to train and test pitch recognition skills through computer software.
All participants were recruited through convenience sampling and recruitment on the campus of Bard College. All participants were current undergraduate students at Bard College who reported no collegiate or professional baseball experience and having a twenty-twenty vision or corrected to twenty-twenty with glasses or contact lenses. All eligible participants either partook in the virtual implementation or the in-person manipulation. Overall 12 participants completed the virtual task while 9 participants completed the in-person task.

The results were calculated using Jamovi software running a T-test that compared strike zone accuracy and pitch type accuracy between the in-person group and the virtual implement group.

Descriptives

	Group	PT	SA
N	V	12	12
	P	9	9
Missing	V	0	0
	P	0	0
Mean	V	9.92	11.9
	P	12.0	13.1
Median	V	10.0	12.0
	P	12	13
Standard deviation	V	2.27	2.50
	P	2.35	2.26
Minimum	V	7	8
	P	8	9
Maximum	V	14	15
	P	15	17

Figure 5

The calculations of Mean, Median, Minimum, Maximum, and Standard deviation from the data set collected

The data collected comparing the virtual group to the in-person group in two aspects. It compared them on their pitch type accuracy (PT) as well as their strike zone accuracy (SA). The number collected for each participant was their total number correct for each aspect out of the 20 pitches they saw in each implement. For the virtual pitch type accuracy the mean was 9.92 with a standard deviation of 2.27. The virtual strike zone accuracy had a mean of 11.9 with a standard deviation of 2.5. For the in-person implement, the mean of the pitch type accuracy was 12 with a standard deviation of 2.35 and the strike zone accuracy had a mean of 13.1 with a standard deviation of 2.26.

Running the T-test comparing the two different kinds of accuracy across the two groups, in-person and virtual, gives us the ability to compare and look for possible differences or similarities in the groups.

Independent Samples T-Test

Independent Samples T-Test

		Statistic	df	p
PT	Student's t	-2.05	19.0	0.054
SA	Student's t	-1.13	19.0	0.274

Note. H_a $\mu_V \neq \mu_P$

Figure 6

A table showing the results of two independent sample T-tests run through Jamovi statistics software

The results of the two independent sample T-tests performed show the comparisons of pitch type accuracy and strike zone accuracy in both in-person implementations as well as virtual implementations. An independent samples t-test revealed that in our sample of participants, there was no difference between the in-person strike zone accuracy and the virtual groups' strike zone accuracy. Virtual (M=11.9 SD=2.5) Compared to In-person (M=13.1 SD=2.26), t(20)=.274. However, in pitch type accuracy, an independent sample t-test revealed that the virtual group (M=9.92 SD=2.27) compared to the in-person group (M=12 SD=2.35) was marginally significantly different with t(20)=.05. Showing a slight difference between the two groups.

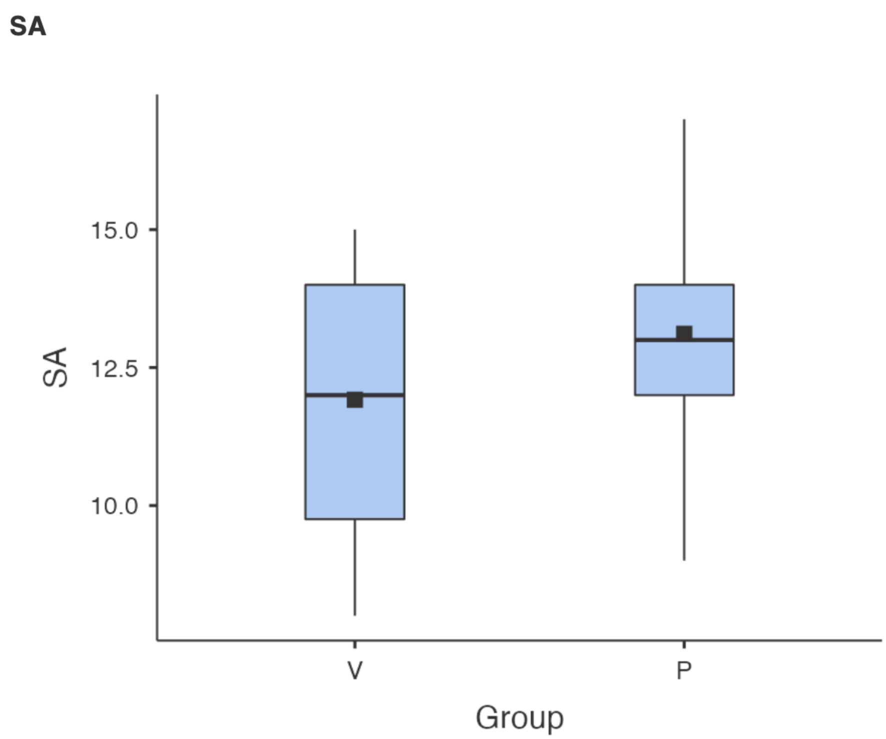

Figure 7

The box plot showing the results for strike zone accuracy

The above figure shows the box plot comparing the results for strike zone accuracy in the two groups. Showing the similarity of the box plots and the closeness of the mean lines confirms what we previously saw in the T-test that there is no significant difference between the two groupings. Conversely, if we look at the box plot below, figure 8, it shows the data for the pitch type accuracy where we see the means and data sets further separated confirming what we saw in that T-test showing significant results. This means that the in-person group performed better when it comes to pitch type accuracy and there was no difference between the groups when it comes to strike zone accuracy.

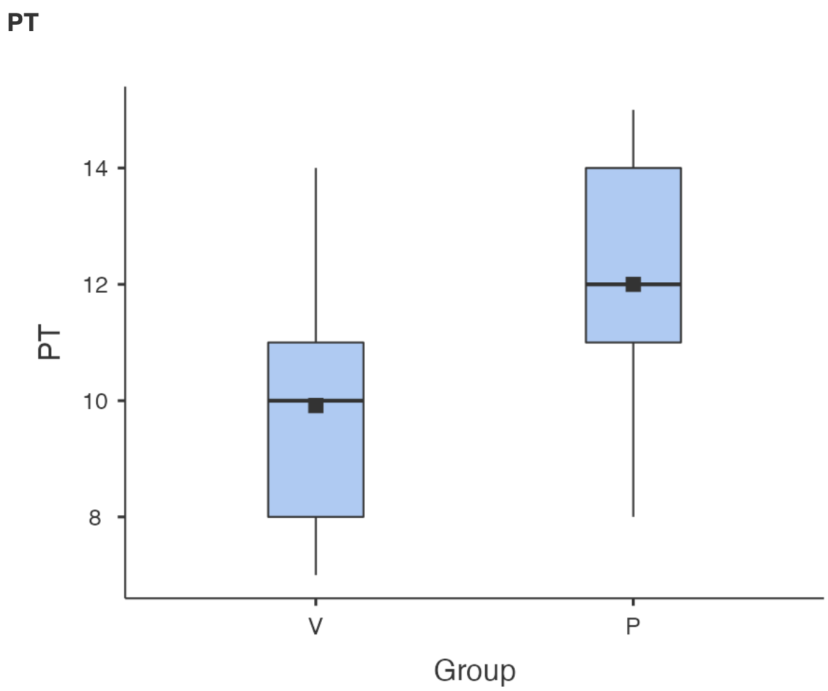

Figure 8

The box plot showing the data from pitch type accuracy

Discussion

The main objective of this study was to determine how new methods, particularly virtual, of pitch recognition and vision training differ from their physical and in-person counterparts. To do this I had two groups perform a similar task of baseball pitch recognition in both an in-person physical setting as well as a laptop-based virtual setting. It was through these two methods that I split pitch recognition into two different categories that they would be tested on. The first is strike zone recognition which, simply put, defines the batter or participant's ability to correctly determine if the pitch delivered was in the defined strike zone or not. Testing and training this ability is vitally important in the sport of baseball as it is one of the most difficult and important parts of hitting. In order to effectively play the game of baseball a batter must be able to determine if the incoming pitch is a strike or not as quickly as possible to give them a better chance of making solid contact with their swing or deciding not to swing at the baseball at all. An incorrect assessment of the pitch as a strike or not leads to swings outside of the strike zone as well as fewer swings at pitches that are hittable. In theory, a hitter with a better understanding of the strike zone will perform significantly better in the categories of on-base percentage, batting average, and on-base plus slugging, the three most commonly used statistics when assessing hitters' performance. The other half of pitch recognition is the ability to correctly identify the pitch type that is being thrown. Whether the pitch is a fastball, slider, curveball, or change-up is also vitally important to hitting as all the pitches are thrown differently in a few different identifying ways. The pitches will differ in spin rate, spin direction, spin efficiency, velocity, and movement shapes. Through these different identifiers, hitters are challenged with determining which pitch is being thrown so that they can adjust the timing of their swing as well as where they are swinging and expecting the ball to be when it crosses through the strike zone. Training to improve the ability of hitters to recognize pitches as early as possible gives them more time to process the information presented to the visual processing system and ultimately become better-performing hitters. The breakdown of pitch recognition into two categories and testing which method of training could be better at training each facet could be instrumental in determining how to improve players' performance most efficiently. A player may struggle with their ability to determine the strike zone but can recognize pitch type very well. This would cause a player to recognize a pitch as maybe a curveball early but swing at curveballs outside of the zone because they recognized which pitch it was but not if the pitch thrown was a strike. Making training more tailored to each specific player allows for the most growth.

Looking directly at the statistics for the strike zone accuracy we ran an independent sample t-test to determine if there was any difference between the virtual group and the in-person group. The p-value for the t-test came out to be $p=.274$ showing that there was no difference between the two groups when it comes to pitch type accuracy. The implications of this have to do with how the participants view the strike zone in different settings. The virtual and in-person setups are designed to mimic each other and be as similar as possible. It is because of this that we are able to compare each other on the independent variable, and testing method, and make assertions based on that. If there is no difference in performance because of the in-person and virtual then we can look at the benefits of each training method and see which may be better for the specific athlete. The time taken and put into the in-person group is larger as it requires either a cage setting or access to a field setting. It also required a pitching machine or a live arm to supply the pitches and with an in-person set up there may be inconsistencies in the pitchers thrown as machines aren't perfect and neither are live pitchers. The use of a laptop with a 13-inch screen makes the strike zone seem smaller than the compared in-person strike zone which is 17 inches wide and although the height is determined by the height of the batters for simplicities purposes we defined it as 24 inches which are about the average height of the strike zone based on the average height of MLB players. This data was found and utilized from Baseball Savant by MLB. The in-person strike zone was directly the same size as the average MLB strike zone while the virtual was proportionally similar but being on a smaller screen may have had an impact on the participant's ability to correctly identify pitches in or out of the strike zone. Compared to the virtual training method which, if attempting to train strike zone accuracy, has no significant difference in performance has several differences that may make it advantageous to use instead of in-person training. The first is its accessibility. The software, AppliedVision Baseball, is available to be used on mobile devices, laptops, desktops, and virtual reality devices making it far more accessible to the general public than the in-person method which requires a cage setting, pitching machine, or live arm, as well as a second person to assist with the training. The virtual training can be done alone in a private setting allowing for many more reps to be taken. The is no downtime spent to pitch up baseballs and refill the bucket so that allows for more repetitions to be taken in a much shorter amount of time. Another advantage is that the virtual method can be done any time of day and anywhere as it is portable and can be added to an athlete's jammed packed schedule in any downtime they may have. Maximizing efficiency and allowing for the most time-effective and cost-effective methods of training allow athletes of all ages and economic backgrounds to become the best players they can be and maximize their individual potential.

Looking at the other half of pitch recognition, pitch type recognition, the results of the experiment showed that when looking at pitch type recognition across virtual training and in-person training there was a marginally significant difference between the two groups. The in-person training group was marginally better at identifying pitch type than the virtual training group. When thought about critically the causes and resulting effects of this makes sense. Although set up to mimic each other the virtual training and in-person training do have some differences that may have caused participants to perform differently depending on the type of training. A possibility that could have caused the difference in performance between the two groups could be the perceived velocity of the different settings. In the virtual group, the goal of identifying the pitch is to determine which pitch type it is based on the pattern presented in the orientation of the spin of the baseball. This is determined by the different blurs, shapes, and dots presented by the spin of the seams of the baseball depending on the orientation of the ball spinning in the air during ball flight. In the virtual setting, this is accomplished quite well because of the smaller screen and the 2d nature of the screen making it more difficult to perceive the movement of the baseball forcing participants to rely on the training they received prior to the study to determine the pitch type based on the orientation of the seams of the baseball. This is the ultimate goal of training pitch recognition because it allows hitters to recognize spin earlier as they improve at it which gives them more information on the ball flight of the pitch and whether or not they will be able or have to be able to hit it. On the contrary, the in-person group did have access to some more information when making their decision on if the pitch was a fastball or an offspeed pitch. They did have the same training on seam and spin orientation and were told to try to identify the pitch based on these identifiers, but there were some other aspects present in the in-person group that was not present for the virtual training. The ability to see the ball flight of the baseball in a full 60ft 6-inch setting meant that if the pitch was a breaking ball, curveball, or slider, then they were able to see more of the shape on the baseball in a larger setting than the virtual group. Simply being able to the shape of the pitch gives even the untrained participant a leg up on identifying the pitch type. Participants may have been identifying pitches based on shape and not spin. Another thing that the in-person group that may have led to the difference in performance could be the perceived velocity of each pitch. The in-person group with the pitching machine has more of a sense of sight of the baseball and saw the ball for longer in the air compared to the virtual group which did have velocity changes between pitches but due to the nature of the software and screen shown on may have been perceived as a lesser gap than the in-person pitches. The gaps were physically similar in velocity but when scaled down to a smaller size for the virtual training the gaps in velocity between fastballs and off-speed pitches may have been perceived as smaller.

Talking about how we put the data collected into practice, training baseball athletes, how does the in-person training group performing better at pitch type recognition impact the way we train? The goal of training is identifying what specifically the athlete needs to improve upon and finding the most effective and efficient way to improve this aspect of the game. The aspect we are talking about here is pitch type recognition which is a very specific skill within the larger scheme of the game of baseball, but it is incredibly important to be a good hitter at any level of the game. With the collected data showing that untrained individuals perform marginally better at pitch type accuracy in an in-person setting then the best way for baseball players to improve their abilities of pitch recognition would be to train in person off of the machine or a live arm as often as possible. Simply because the data says they're likely to perform better at it and the increased number of pitches they are able to identify correctly will not only improve their ability to identify pitch type but will also improve their confidence in the skill which is a huge part of being successful. The benefits of in-person training for pitch type recognition are shown in the data but also include more similarity to a live game and therefore possibly more crossover of skill development as well as the ability for multiple people to train at the same time. The setting for in-person training is large and multiple people are able to track the ball's flight and spin at the same time. Using the virtual implement may be difficult as the screen can only accommodate one person at a time and only one person can input a response into the software. The possible advantages of training virtually include a similar list as in the strike zone accuracy but the following has to be taken into account. If training pitch type accuracy is better in an in-person setting but the use of virtual implementation is more available and easier to implement, what is the trade-off you are willing to make for ease of training and accessibility? Depending on the situation the athlete is in physically, financially, and what level of the game they are at the type of training they receive should be based on the data as well as the individual needs of the athlete.

Another influence on pitch recognition pertains directly to the individual's perception of the baseball and the mindset they go into the task or at bat with. In pitch type recognition what pitch is thrown can be an important factor in the accuracy of pitch type recognition but also strike zone recognition. Certain pitches come in at similar velocities but some pitches are one of few or the only pitch that comes in at that velocity making it more of an identifiable pitch. For example, a curveball and slider can both be thrown at similar velocities, although sliders tend to be thrown slightly harder, and have a somewhat similar movement pattern, but the key identifier between the two pitches is the spin pattern made by the seams. Due to seam orientation, a curveball has a blur of white but the axis of spin on a slider creates a key red dot due to the seams of the baseball. This allows for it to be identified by a hitter when the movement and speed of a slider are similar to a curveball. A pitch that is an outlier here and identified easily by a hitter is a splitter. Thrown at a variety of speeds by different pitchers a splitter is used as a secondary fastball but also as an alternative to a changeup by many pitchers. It has a very low spin rate and an unpredictable spin pattern meaning the seams are visible to the hitter and struggle to fly cleanly through the air. As a result, a splitter will sink or drop unpredictably and have to be identified by the seams. As a result of a different combination of identifiers of each pitch as well as different pitches commonly being thrown in the same velocity ranges the pitch type thrown is vitally important and they all will have different accuracy levels of identification by hitters. Within the study, participants were tasked with identifying the pitch type and strike zone accuracy when pitch type was asked where different pitches were identified correctly more often. In both the virtual and in-person settings offspeed pitches were identifying more often correctly in pitch type accuracy when compared to fastballs were identifying correctly less often. Statistics on this were not run to show if the difference was significant this is just from looking at the numbers but it is something to take into account and discuss why this may be the case. In the virtual and in-person settings, the participants only had two choices for pitch type so as not to complicate the study and make it increasingly difficult for participants who lacked in baseball experience. A hitter's mindset of looking fastball adjust breaking ball is a common saying in baseball but in the setting of the experiment, I do not believe that was present. With participants of nonbaseball players, they were simply trying their best to identify whatever they perceived the pitch to be. With the choices for answers being a fastball or slider then a fastball or curveball the options never ranged between slider or curveball. Due to this, I believe that curveballs and sliders are slower than fastballs combined with the fact that they have a more distinctive movement pattern compared to a fastball led them to be more easily identifiable.

Using the data collected in the study to build off of previous research such as the study done by Liu et Al. simply improving the way we train baseball players can significantly improve hitters' abilities in key aspects of the game. In the study by Liu hitters improving in nonbaseball-specific cognitive tasks allowed them to increase not only their in-season statistics such as OPS, AVG, and SLG but it also improved their metric-based stats like launch angle, avg exit velocity, and average distance. This combined with direct baseball-specific cognitive training tailored to the athlete's specific cognitive weaknesses, strike zone accuracy or pitch type accuracy, and it's possible that these metrics could be even further increased. It was already shown by Liu that cognitive training has carryover into the world of baseball and other reaction-based sports but tailing the training to the sport and athlete specifically could be the key to vastly improving each athlete and improving the sport as a whole.

Further improvements and directions to the study are necessary as the work to improve in the world of sports and sports psychology is never done. The field just like athletes is constantly changing and improving. New training methods and new technology allow for more and more improvements to be made to the way athletes go about their training. Just 30-40 years ago strength training was thought to be detrimental to performance and now every athlete in the world is on a high-level program to be as strong as possible. I truly believe that in the future cognitive training will be just as common and as highly researched as strength training. Every athlete can benefit from improving their cognitive decision-making abilities as well as improving their perception abilities to the fullest level. As the field advances and becomes more common new technology will become widely available to more and more athletes worldwide. The first thing that with more time and funding I would at to the study would be the implementation of virtual reality in the virtual sections of the study. The use of a laptop and the Applied Vision Baseball was incredibly useful and practical for my study and the setting it was done in but with more resources virtual reality can better simulate a baseball game and allow for more gamelike situations to be created. The laptop setup made perception somewhat more challenging due to the smaller nature of the screen and may have impacted the results due to the size. With a virtual reality set up the scaling of size can be the same as an in-person implementation but would allow for the same benefits found in the laptop-based virtual implementation. Newer virtual reality devices configured with software such as Win Reality even allow for at-bats to be had and hitting results and feedback to be given based on swings and timing. Something like this could allow for even more carryover while maintaining the same and even more accessibility and maneuverability benefits that come with training virtually. The creation of success based on actual baseball outcomes in virtual reality training allows for the data collected to be compared to even more things such as actual in-game statistics. If facing comparable pitches in virtual reality training then the performance could be compared to in-game statistics and if found similar enough the results from virtual reality training could become good predictors of in-game performance.

Reflecting on the study there are a few things that I would like to be able to change or do differently but that will have to wait for future research. The first being the addition of a more gamelike setting for the virtual implementation wether that be virtual reality or a larger screen or project to be used. I want to make the virtual method as close to game like as possible so as to ensure the most carry over to in game performance from the training. The next thing I would like to do is to be able to manipulate the sample and the sample size. The study being on a small college campus was limited in the pool of participants to draw from and did not quite have the sample size I had hoped for. And with the data collected showing marginally significant results perhaps if there was a larger sample size I would have more statistical power to be sure of what I observed in the study. I would also like there to have been a sample of competitive baseball players in both implements to see if experience plays a roll in the results and maybe even causes competitive baseball players to be significantly better at certain aspects of pitch recognition. Lastly I would like to have changed the in person implement to an outdoor setting on a baseball field. The ability to have used a field with a real home plate and pitchers machine set from a real mound could increase the carryover to in game performance as well as better simulate a real game setting. Overall the study was successful as I was able to find out more about the game I love and in the process learn more about how we see what we see when it comes to pitch recognition. The ability to split pitch recognition into two parts, strike zone accuracy and pitch type accuracy, is incredibly important when testing and training athletes because its two separate parts that make a whole. As shown by the data in-person training is marginally better than virtual when it comes to pitch type accuracy. Overall more research is needed to better improve the way we cognitively train baseball players but starting by splitting up pitch recognition is a step in the right direction.

References

Broadbent, D. P., Ford, P. R., O'Hara, D. A., Williams, A. M., & Causer, J. (2017). The effect of a sequential structure of practice for the training of perceptual-cognitive skills in tennis. *PLOS ONE*, *12*(3), e0174311. https://doi.org/10.1371/journal.pone.0174311

-This source shows the effect of sequencing of training as well as the impact virtual training can have in a sport-specific setting. It shows background info for my project as well showing the benefits of virtual cognitive training in a sport besides baseball.

Fadde, P. J., & Zaichkowsky, L. (2018). Training perceptual-cognitive skills in sports using technology. *Journal of Sport Psychology in Action*, *9*(4), 239–248. https://doi.org/10.1080/21520704.2018.1509162

-This study brings background information on how training cognitive perceptual skills can be done using technology and allow for us to talk further about how this training can be manipulated to fit different sports cognitive needs.

Liu, S., Ferris, L. M., Hilbig, S., Asamoa, E., LaRue, J. L., Lyon, D., Connolly, K., Port, N., & Appelbaum, L. G. (2020). Dynamic vision training transfers positively to batting practice performance among collegiate baseball batters. *Psychology of Sport and Exercise*, *51*, 101759. https://doi.org/10.1016/j.psychsport.2020.101759

-The project by Liu shows a timeline of training over the course of a season in college baseball and compares the implementation of training but also allows it to be measured in different ways. Comparing batting practice success and season statistic success shows different ways the training impacts performance.

Takeuchi, T., & Inomata, K. (2009). Visual search strategies and decision-making in baseball batting. *Perceptual and Motor Skills*, *108*(3), 971-980E. https://doi.org/10.2466/pms.108.3.971-980

-This study shows the importance of the frontal lobe in decision-making but also highlights the way the visual search and the visual process are vital to making quick impactful decisions. This is not allowed to be applied to sports but in this context, particularly baseball, it requires an insanely quick decision-making process followed by a difficult bodily response.

Wang, S., Mamelak, A. N., Adolphs, R., & Rutishauser, U. (2019). Abstract goal representation in visual search by neurons in the human pre-supplementary motor area. *Brain: A Journal of Neurology*, *142*(11), 3530–3549. https://doi.org/10.1093/brain/awz279

-The pre-supplementary motor cortex activates with the goal-oriented search mimicking movement in the brain similar to that of the searching task showing possible similarities in vision training to physical sports training.

Strike zone | *glossary*. (n.d.). MLB.Com. Retrieved November 17, 2022, from https://www.mlb.com/glossary/rules/strike-zone

-Provided the definition for the current rules of the Major League Baseball Association strike zone.

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Bailey, S. R., Loeppky, J., & Swartz, T. B. (2020). The prediction of batting averages in major league baseball. *Stats*, *3*(2), 84–93. https://doi.org/10.3390/stats3020008

-Provided statistics and terminology for looking at advanced statistics in baseball expanding on the Liu results.

The Ultimate Guide to Baseball Pitch Recognition & Vision training. Applied Vision Baseball. (2022, October 7). Retrieved May 2, 2023, from https://appliedvisionbaseball.com/the-ultimate-guide-to-baseball-pitch-recognition-vision-training/

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Mducondi. (2017, April 28). *The 2016 strike zone and the umpires who control it*. Community Blog. Retrieved May 2, 2023, from https://community.fangraphs.com/the-2016-strike-zone-and-the-umpires-who-control-it/

Appendix

Name: Jared Toby
Email: jt5078@bard.edu
Academic Program: Psychology
Status: Undergraduate
Advisor: Tom Hutcheon
Advisors email: thutcheo@bard.edu

Please list all individuals (full name and status, i.e. faculty, staff, student) involved in this project that will be working with human subjects. Note: Everyone listed must have completed Human Subject Research Training within the past three years.

Jared Toby

Do you have external funding for this research?

No

What is the title of your project?

The Effectiveness of Virtual Training: Comparing Virtual and In person Sport Specific Cognitive Training

When do you plan to begin this project? (Start date):

March 15th, 2023

Describe your research project:

My research project is diving into how new methods of training cognitive abilities in sports, specifically baseball, compare to previously used in person methods of training these cognitive abilities. Determining how comparable these methods are and where differences may be in these two training methods will allow athletes to have access to more information on how effective their training is and allow them to train more efficiently and more effectively. This will be done by using a virtual implementation of simulated baseball training and comparing scores to a similarly situated in person baseball training situation. Each implementation will produce a score for pitch type accuracy and strike zone accuracy.

Describe the population(s) you plan to recruit and how you plan to recruit participants.

Participants will be recruited from the Bard Undergraduate population through flyers placed around campus with a link to a google form to determine eligibility. Participants who fill out the form and are eligible will be contacted through Bard email about participants and consent forms.

Approximately how many individuals do you expect to participate in your study?

32 participants

Describe the procedures you will be using to conduct your research. Include descriptions of what tasks your participants will be asked to do, and about how much time will be expected of each individual

Participants will be randomly assigned to either the physical cognitive training condition or the virtual cognitive training condition. Those assigned to the virtual training group were asked to arrive at the lab 5 minutes prior to their scheduled time in order to be properly informed of the task before beginning. Prior to the testing participants will be familiarized with the software and the idea of pitch recognition through instruction and demonstration from the researcher. Once familiarized with what participants are looking for in the task they are put through a trial run prior to the actual task. The task is completed at a desk in the lab setting with the participant seated directly in front of the monitor. It will use a mouse to choose their responses in the software. In the experiment participants will see a randomized sequence of twenty pitches and are asked to identify each pitch for its pitch type and if it is a strike or not. This is recorded via the software by clicking the pitch type under strike or ball boxes. This is shown in image 2. Participants after seeing the pitch on the screen are prompted to answer what type of pitch they saw and whether that pitch was inside the box shown that is the strike zone or not. Participants are required to make this decision within three seconds of the pitch presentation or their data for that pitch is excluded from the results. Participants will go through one practice round of 10 pitches to familiarize them with followed by the experiment trail which will contain 30 pitches.

The in person training group will complete their testing in the batting cage of the Stevenson gymnasium. They will see pitches thrown from 60 ft 6 inches, the same distance used in a baseball game, and be asked to respond to whether the pitch fed through the machine was a strike or ball and if the pitch was a fastball or breaking ball. The strike zone will be defined as a pre measured box which is defined by major league baseball as the width of homeplate, 17 inches, and the height is determined by the batter being between the batters knees to the midpoint of the top of the shoulders and bottom of the uniform top (Strike Zone | Glossary, n.d.). Participants will stand outside of the cage, to ensure their safety, and they will see the pitch from a slight side angle similar to that of a batter hitting a baseball. They will be asked by the researchers within three seconds of the pitch to report its pitch type and if it is a strike or not. Participants will each get 10 practice pitches and then will see 30 pitches as the experimental trial. This is done so that the in person method most accuratly mimics the virtual setting make the two implements as comparable as possible while keeping the independent variable the type of training.

Describe any risks and/or benefits your research may have for your participants.

The virtual group poses what I believe to be no risk as they will be in a secure setting completing a cognitive task on a laptop. The in person group poses more risk due to the nature of observing a moving baseball but this risk be mitigated as much as possible and they will be required to sign a consent form prior to participation. The particpant is behind two seperate layers of screens and netting and the baseballs used differ from regulation baseballs in that they are softer and pose a much lower risk of injury.

Describe how you plan to mitigate (if possible) any risks the participants may encounter.

Risks will be reduced by placing the participant outside of the batting cage where the ball cannot get to as well as using screens inside the cage to control the flight of the baseball. The typical hard five ounce baseball is replaced for a softer mock baseball used in tee ball and young children baseball games that looks identical and has a similar ball flight but significantly reduces risk of injury.

Describe the consent process (i.e., how you will explain the consent form and the consent process to your participants):

The consent form will be distributed prior to the arrival of the participant but will also be read prior to any involvement in the experiment. Emphasis will be placed that the participant can stop at anytime and is under no obligation to complete the task as well as the privation of data collect and the anonymous nature of the data once it is collected. Participants will be informed of the last day to withdraw from the study but if they are uncomfortable at any point in the study they will be permitted to leave.

What procedures will you use to ensure that the information your participants provide will remain confidential and safeguarded against improper access or dissemination?

Data will be stored on a secure folder on my password protected laptop. The data once collected and assigned to a participant number will have no link to the participants name.

For all projects, please include your debriefing statement. (This is information you provide to the participant at the end of your study to explain your research question more fully than you may have been able to do at the beginning of the study.) All studies must include a debriefing statement. Be sure to give participants the opportunity to ask any additional questions they may have about the study.

Thank you for participating in my study of virtual implements of cognitive training. The data collected will be anonymous and not tied to you in any way. We are seeking to identify what aspects of cognitive training can be better done in person or better virtually and your input today helps us get closer to understanding and answering our question. If you have any follow-up questions or would like to hear about the completion of the study please email me at jt5078@bard.edu or contact my advisor Professor Tom Hutcheon at thutcheo@bard.edu Thank you again for your participation.

Bard College Institutional Review Board

Date: 3/18/2023
To: Jared Toby
Cc: Frank Scalzo; Nazir Nazari
From: Ziad M. Abu-Rish, IRB Chair
Re: The Effectiveness of Virtual Training: Comparing Virtual and In person Sport Specific Cognitive Training

DECISION: APPROVAL

Dear Jared Toby,

The Bard IRB committee has reviewed your revised proposal. Your application is approved through March 18, 2024. Your case number is 2023MAR18-TOB.

Please notify the IRB if your methodology changes or unexpected events arise.

We wish you the best of luck with your research.

Ziad Abu-Rish, Ph.D.
IRB Chair
Associate Professor of Human Rights and Middle Eastern Studies
Bard College
zaburish@bard.edu