Women's Softball × Sports Brain Science

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Abstract

In the world of sports, the key to success is often the ability to make snap decisions and act instinctively faster than making conscious decisions. The Kashino Diverse Brain Research Laboratory at NTT Communication Science Laboratories is researching the implicit brain functions that are exhibited by athletes under these special conditions. Together with the Japan women's national softball team, which won the gold medal at the 2021 international sporting event held in Tokyo, NTT has been working on practical initiatives in parallel with academic research to apply the findings of this research to improving the team's chances of winning.

Keywords: sports brain science, softball, pitching machine

1. Background of the initiative

The key to success in sports matches is the implicit brain functions that even the athlete himself or herself is unaware of, such as the instantaneous decisions that must be made when batting in a game of softball. The Sports Brain Science Project was launched at NTT Communication Science Laboratories in January 2017 (in July 2019 it changed its name to the Kashino Diverse Brain Research Laboratory). Its mission is to push forward with research that improves the performance of athletes on the basis of clarification of the superior implicit brain functions of top athletes and identification of the factors that help them win [1] (**Fig. 1**). We have received the cooperation of US and Japanese professional baseball teams, Japanese semi-professional baseball teams, university baseball teams, the Japan Softball Association (Japan women's national softball team), and corporate teams belonging to the Japan Women's Softball League. Therefore, we were able to clarify the special abilities and characteristics of athletes who compete at the topmost levels.

In October 2017, we signed a joint experimental agreement with the Japan Softball Association to carry out experimental and practical measurements of top and up-and-coming softball players. On August 3, 2016, before we entered into this agreement, the decision was made to reintroduce women's softball to the international sporting event to be held three years later in Tokyo. Alongside our academic research, we were engaged in practical initiatives with the Japanese national team to devise a strategy for turning brain training into success at softball with the aim of winning the gold medal at the event [2]. This article focuses on the efforts we made with the Japan women's national softball team to achieve this goal.

2. Working with the Japanese national softball team

In August 2016, Shinsuke Yabata, the then deputy training manager at the Japan Softball Association, paid his first visit to the Sports Brain Science Laboratory at the NTT Atsugi Research and Development (R&D) Center. The first time we met him, he told us that Japan's biggest challenge in winning the gold medal would be dealing with fast and changing balls thrown by US pitchers.

In September 2016, the Japan Cup was held in Takasaki City, Gunma Prefecture. This provided us with the opportunity to watch international matches

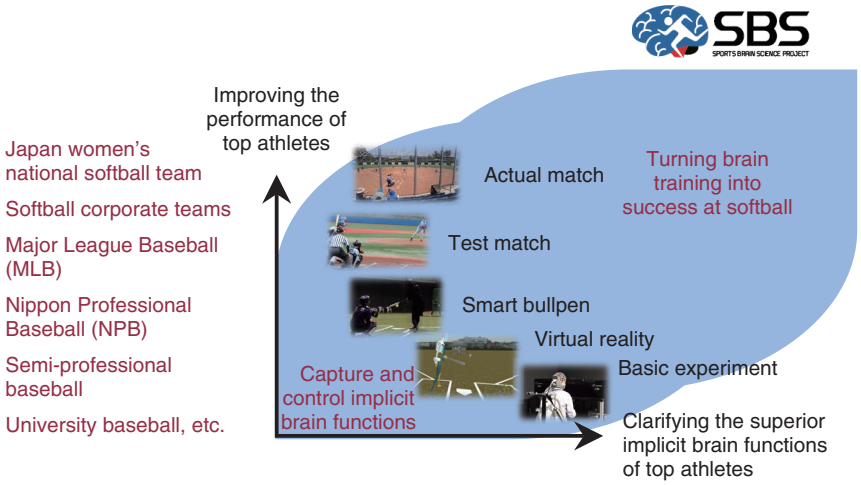

Fig. 1. Sports Brain Science Project.

Fig. 2. International matches and training camps.

among four national teams, including those of the US and Japan. We then attended most of Japan's international matches and obtained video footage of the teams as a member of the national team's information squad (**Fig. 2**). Our main purpose in obtaining this material was to understand the characteristics of the pitchers on opposing teams. We took videos of their pitching styles from various angles to analyze pitchers' habits. We also used a high-speed camera behind the back net to identify the characteristics of the balls thrown by pitchers and conducted ball-quality analysis to extract the ball's rotation axis and number of rotations.

While we were analyzing the other teams in this manner, we also attended the Japanese team's training camps to take videos and assess the players. To help the players improve their performance, we provided them with video feedback showing their

pitching and batting actions after a delay of a few seconds and analyzed the performance of the pitchers with the same high-speed camera technology that we used in the international matches. While providing this support, we also conducted measurements for research purposes with the help of the players. At the Okinawa training camp in December 2017, the top national team who would compete at the target international sporting event and the national teams in other age groups (under-19, under-16, and under-14) got together. We measured the hitting decisions of players of each team during actual gameplay by using virtual reality (VR). In June 2019, just before entering a long-term training camp, nineteen players from the top national team spent two days at the NTT Atsugi R&D Center, where we conducted various measurements including batting gaze, movement, and cognitive tasks. We analyzed the measured results as research data and provided feedback to the players.

3. Special abilities of top players

In women's softball, the pitcher delivers the ball to the batter from a distance of 13.11 m, which is about two thirds the pitching distance in baseball. US pitchers pitch the ball at speeds ranging from 72 to 118 km/h with various pitch types, such as riseball, dropball, curveball, and screwball, and the timing of the ball to reach the batter can also be adjusted using techniques such as change-up pitches. For some pitchers, the difference between a riseball and dropball can be as much as 80 cm. However, the time taken for a pitched ball to reach the batter is only about 0.4 seconds. This only gives the batter a short window of opportunity in which to respond by striking the ball. No matter how fast the batter can swing, there is a limit to the batter's ability to respond. It has been found that good batters can adapt to this particular environment [3, 4].

There are several measures that batters can take to deal with these fast and varied balls. The first is to read the pitch sequencing. Although it varies from person to person, batters are generally able to read pitch sequencing and narrow down the possible pitch types to some extent before the pitcher throws the ball. The second is to determine the pitcher's habits. For example, if a batter knows in advance that the pitcher sets the ball with the wrist in a different position when delivering a riseball, then she will be better able to focus the strike on the position of this ball. These pitching habits can be shared with the rest of the team through speaking and video.

However, not all pitchers are quite so easy to read. We heard an interesting story about Eri Yamada, the captain of the Japan women's national softball team. She is widely recognized as a batter with the ability to read a pitcher's pitch sequencing, and unlike other players, she seems to have the ability to identify different pitch types while sitting on the bench. However, it is not clear how she manages to do this. Apparently, there are many things that she somehow manages to understand. Even if she does not know where or what the difference is, she can somehow guess what type of pitch is coming and adjust her striking accordingly.

Even more interestingly, experiments with VR suggest that even if she does not aware of what type of pitch is coming, she can still sometimes react to it. The VR experiments incorporated motion captured from real pitches, and the batters were tasked with swinging a bat to strike randomly thrown change-up and fastball deliveries. A sensor was attached to the batter's waist to measure the timing of the swing. Using VR makes it possible to switch the correspondence between fastball and change-up of pitching styles and ball deliveries. As a result of carrying out switches in this manner, we found that the batters could swing their bats with the correct timing when the correspondence between the pitching style and ball delivery was correct, but could not with the correct timing more often when the correspondence was switched [5]. What is interesting is that the batters said they could not tell the difference between different pitching styles and did not know what type of pitch was coming from these pitching styles. Even after the experiment, they were completely unaware that the pitching styles had been switched. This means that even if a batter is not aware of what she is doing, she may be unknowingly using information from the pitcher's pitching style when striking a ball.

These types of predictions cannot be shared with the team because they cannot be explained to others, even when using video or data. However, if more players can acquire these abilities, the team's hitting ability will improve.

4. Honing skills

As a member of the Japanese team at the 2000 international sporting event in Sydney, Reika Utsugi, head coach of the current Japanese team, conducted image training by watching videos of opposing pitchers hundreds of times. Since visiting the NTT Atsugi

R&D Center in May 2017 and experiencing VR batting simulations, she became very interested in the use of this technology to defeat US pitchers.

At subsequent training camps, we brought in several times a VR system using footage and ball trajectories of pitchers from other countries that had been acquired thus far. However, there were issues with this system. At the level of a VR video game, it is possible to link the VR images with the swinging of a real bat, but there are still temporal and spatial discrepancies between the throwing of the ball in VR space and swinging of the real bat. It was therefore of limited value for player training because it was not possible to correctly assess whether the swings done by the players were actually appropriate. If we had pursued greater accuracy, we would have had to install many sensors and make the equipment much larger. This would have made it difficult to find a location to set up the equipment and placed more burden on the players; thus, making it difficult to use this approach for actual training. In 2017, most VR headsets had to be connected to a personal computer, but in 2019 stand-alone headsets became more widespread. With such equipment, it became possible for players to train individually in their hotel rooms. We began preparations to bring this system to the athletes' village during the international sporting event to be held in 2020. Although allowing players to access this system in their rooms removes constraints related to location, it reduces its interactivity to the point where the players can only watch footage and ball trajectories of pitchers. Being able to see ball trajectories in three dimensions is better than watching the video, but we were not sure how much this would benefit the players (**Fig. 3**).

Fig. 3. Our VR system.

5. The team's secret weapon: the "Nasu Machine"

In addition to the VR system, we also provided the players with a pitching machine for use in batting practice. We called this the "Nasu Machine," after Dr. Daiki Nasu, one of the authors of this article. Besides being able to deliver various types of breaking balls, this pitching machine also displays images of a pitcher, giving it the same appearance as a pitching machine at a batting cage that shows an image of a pitcher. At the Kashino Diverse Brain Research Laboratory, we are using this machine to experimentally investigate the perceptions of baseball batters under conditions that cannot be achieved with actual pitchers, such as switching them between left- and right-handedness [6]. To conduct similar experiments with softball batters, we had a pitching machine that could reproduce various pitching speeds and ball rotation speeds with softballs as well as baseballs. We decided to try combining this softball-pitching machine with the images of pitchers used in the VR system to create a practice machine with which players can actually hit balls. At the end of the 2019 Atsugi visits, we showed the players a prototype of this softball-pitching machine we had built in the laboratory and observed that it could be useful in practice (**Fig. 4**).

However, we had a few issues with this machine when it was used for actual training. Our biggest concern was that the equipment would be much larger than the VR-only equipment, so it could be difficult to find somewhere to install it. Since the pitcher's image is displayed using a projector, it had to be very bright for outdoor use. Furthermore, steps had to be taken to protect the machine from rain if used outdoors. Since the team's training involved other activities besides practicing with the pitching machine, it was important to ensure access from the ground where all the rest of training is conducted. If we set up the machine at our laboratory in Atsugi, it would be of no use because it is far from the training camp, and the players would not have time to visit us before the start of the target event.

In 2019, the Utsugi Stadium was built in Takasaki City as a dedicated softball venue, and it was decided that the Japanese team would hold a training camp

The Japanese team checking out the prototype

Survey of pitching machine installation location

Pre-event training camp

Fig. 4. Pitching machine.

there just before the target event. A covered practice area for use in rainy weather was set up in one corner of this facility. This was our preferred location for installing the pitching machine, but since the sides of this area are just covered by netting and semi-exposed to the outside, we were concerned that daylight coming in from the sides might make it hard to see the pitcher images. On a more practical note, we feared that this machine might not be allowed to occupy a part of the training area that plays an important role in wet weather. At the time, we had no idea how useful this machine would be.

Due to the novel coronavirus (COVID-19), the 2020 international sporting event was postponed for a year. As a result, we adjusted our schedule and moved the preview of our machine from April 2020 to November 2020 when we finally loaded the projector into a car and took it out for a field test. On this occasion, the machine was trialed by head coach Reika Utsugi and some players, Yutaka Miyake (president of the Japan Softball Association), Taeko Utsugi (vice president of the Japan Softball Association), Shinsuke Yabata (training manager), and Noriko Yamaji (coach), who were able to see how the video images looked, and were confident that the machine would work fine in this location.

For the pitcher images, we were able to use the same images that we had prepared for the VR system. Unlike the VR system, we were not able to perfectly reproduce the ball trajectories with the pitching machine. Specifically, the three-roller mechanism used in this pitching machine is physically unable to reproduce gyro spin components. It also varies the trajectory and rotation from one pitch to the next. Bearing in mind the performance limits of this pitching machine and how it would be used in actual training, we decided to label pitching styles with different pitch types and associate these labels with the ball trajectories set in accordance with each pitch type.

As mentioned above, the characteristics of the pitching machine made it impossible to impart gyro spin to the ball, so it was not possible to exactly reproduce the rotation of balls thrown by actual pitchers. Therefore, under the guidance of team analyst Minori Ota, we adjusted the pitching machine to produce the trajectories closer to those of deliveries made by a real pitcher by using the vertical and horizontal rotations that the pitching machine was capable of producing. Ms. Ota watches every game from behind the back net and is familiar with the data that have been gathered in relation to individual characteristics of pitchers. This enabled her to provide us with very detailed instructions on the variation of each pitcher.

We installed the pitching machine at the indoor training ground in Takasaki City on May 17, 2021, which was the first day of the team's first training camp just before the target event. When we did so, we found that the players (including head coach Reika Utsugi) were more interested in it than we had imagined. Our initial plan was to spend about a week

setting up the pitching trajectories, but on the following day, the players decided to start practicing with it straight away. The first training camp was followed by the second training camp after a one-week break, and the machine stayed in place until the end of this second camp on July 14. Throughout both camps, the players took turns on the machine on visits from the main training ground. During this period, we also added video footage of other pitchers, thus were able to prepare content for six pitchers from three different countries.

When the players came to the practice field where the machine was installed, they told the operators which pitchers and pitch types they were going to practice and practiced not only striking the ball but also bunts and hit and run. One team member (Yu Yamamoto) said that when facing an actual pitcher, she experiences various emotions such as a desire to strike the ball, but practicing on the machine was better because she could observe the pitcher's pitching styles and ball trajectory more calmly. The players also seemed to enjoy playing against virtual pitchers and were keen to try out new video images and pitch types as soon as we added them.

Since the team's policy was not to disclose any information about practicing with this machine until after the finals at the target event, it was described as the team's "secret weapon" in newspapers and television reports until after they had won the gold medal.

6. Japan brings home the gold medal

Throughout the tournament, the Japanese team batted well. We cannot tell how much they were helped in this achievement by being able to practice with their secret weapon. In addition to coaching each player in preparation for the event, the top pitchers from the Japanese men's softball team acted as batting pitchers to prepare the players for fastball deliveries from the US team. The team was also assisted by analysts, but since they were unable to work onsite due to the COVID-19 pandemic, they instead used the Internet and other sources to obtain information about opposing pitchers and analyzed their habits, pitch types, and pitch sequencing. The team also took part in other efforts, initiatives, and actions that cannot be described here, and the team won the gold medal through the combined effect of all these efforts.

Our pitching machine not only helped players learn about the combination of ball trajectories and pitching styles of opposing pitchers but helped them get used to the timing and the trajectories of balls thrown by opposing pitchers. It could also have positive psychological effects by making players better prepared. Although it is impossible to identify exactly how our machine benefited the players and to what extent, we are confident that it did have a positive effect. At the very least, it seemed that the players enjoyed using this machine and had a positive attitude toward using it as a practice tool. As mentioned by training manager Shinsuke Yabata in the October 2021 issue of Softball Magazine, a player called Saki Yamazaki, who had thrown no-hitters in previous games, hit a double in the final with a dropball thrown by Cat Osterman of the US team. He commented that the practice sessions with our machine may have contributed to this achievement.

It is not easy to pursue academic research and the improvement of sporting performance at the same time. In the initiatives introduced in this article, we were probably more focused on improving performance than on conducting research. However, the fact that our research tools played a role in this successful bid for the gold medal proves that our experimental environment is properly connected to actual matches. We will continue conducting research to elucidate and train the special abilities that athletes demonstrate in actual matches.

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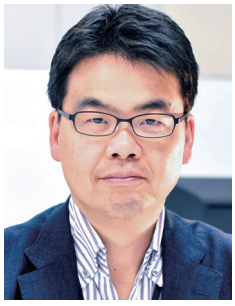

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