Sports Brain Laboratory for Measuring Athletic Competence and Performance

Masumi Yamaguchi

Abstract

Collaboration with athletes is essential for carrying out the Sports Brain Science project, a recent NTT initiative. This project aims to create novel insights into human science as well as to enhance athletic performance and thus benefit both researchers and athletes. The project is introduced in this article, focusing on the research facilities.

Keywords: hitoe, baseball, laboratory

1. A laboratory designed to attract athletes

The Sports Brain Science (SBS) project was initiated to create a novel research field by combining three of NTT's strengths: the human and brain science being studied at NTT Communication Science Laboratories; the vital sensing fabric called "hitoe," developed from bioscience research carried out at NTT Basic Research Laboratories and first commercialized as sportswear in 2014; and information and communication technology, a basic technology of NTT (**Fig. 1**).

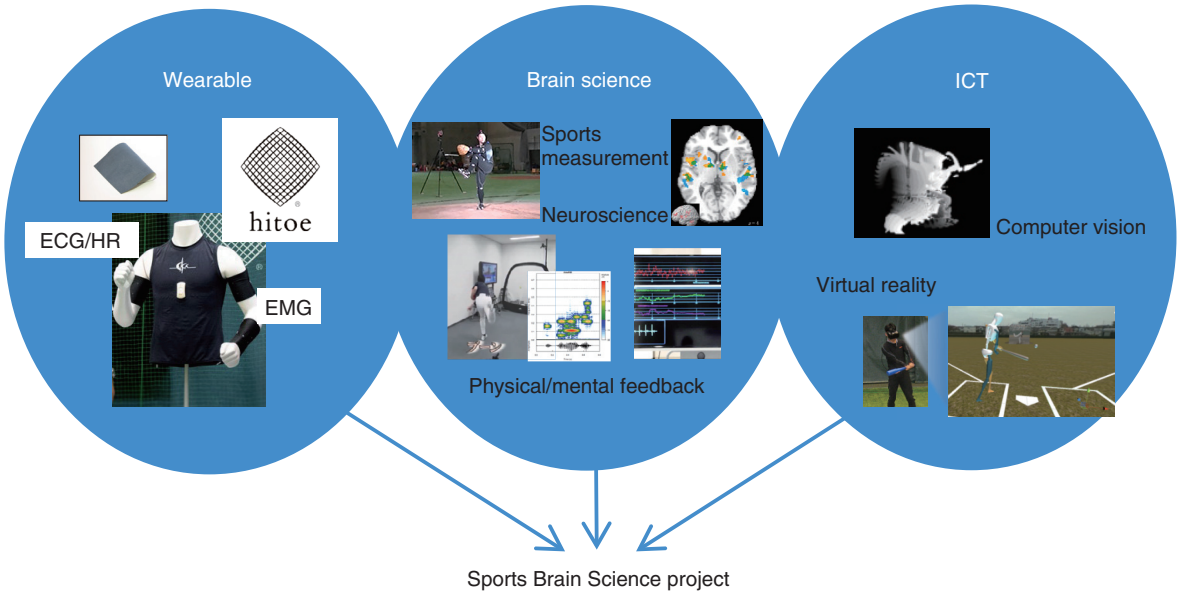
At the beginning of the project, researchers conducted simple experiments such as measuring electromyograms of men throwing balls to a batting tee net or putting golf balls on a pad in a small room. In 2015, we began work on a specialized facility dedicated to conducting authentic sports experiments. This facility was located in an empty space that used to be the synchrotron radiation (SOR) facility at the NTT Atsugi R&D Center [1].

The SOR equipment was moved out in 2015. The total area of the space is 20 m x 30 m with a ceiling height of 11 m for most of the space. Researchers first built a baseball pitching mound from clay and concrete blocks. A former professional baseball pitcher, who is collaborating with us in the project, came to the laboratory to throw balls from the mound. He acknowledged the researchers' construction effort but said that the mound was too small for throwing by professional players.

Although we realized that the mound should be extended, we were not up to the task of molding ten tons of clay into a real pitching mound. When we discussed this issue with the planning section, the laboratory director authorized the construction of a real pitching mound, adding that we should create a sports laboratory that athletes would want to visit again and again.

This meant that the laboratory should be planned not only to facilitate data collection but also to provide an attractive environment for athletes. Because athletes dedicate much of their lives to improving their performance, it was necessary to construct a facility enabling us to carry out experiments on athletes' performance without hindering their training.

From a basic research point of view, we wanted our experiments to have long-term benefits for athletic events, but we also thought it was important to generate short-term benefits for the athletes participating in our experiments. The idea of a laboratory that athletes would want to visit repeatedly was the guiding principle in designing the laboratory and also in planning and conducting the research. The Sports Brain Laboratory (SBL) was completed in March 2016 (**Fig. 2**), and we are continuously improving the facilities



ECG: electrocardiogram
EMG: electromyogram
HR: heart rate
ICT: information and communication technology

Fig. 1. Elements of the Sports Brain Science project.

Handmade mound | Smart bullpen

Manipulandum | Lighting

Fig. 2. Sports Brain Laboratory.

Fig. 3. Displaying the performance and multi-angle videos.

while using them for various experiments.

2. Smart bullpen

Of particular importance in designing the bullpen was achieving one that would enable the players—the pitcher and batter—to play seriously. One of the skills we are focusing on is batting, where we are seeking to understand the implicit brain function within the 0.5 seconds before the ball arrives at the home plate after the pitcher releases it. The best way to study this is to take measurements during real games. However, this is impractical because of the game's regulations and field rules. Therefore, we prepared a smart bullpen where the pitcher and batter can play as if on a real field, and many kinds of data can be collected. High-speed video, pitching speeds, trajectories, and spins of balls obtained by radar, as well as video from the front, sides, and top are taken as players play realistically in the smart bullpen (**Fig. 3**). In addition, when players wear a motion-sensing suit and "hitoe" shirt, motion data and biological data such as heart rate can be measured.

Live video with a delay of a couple of seconds, as well as pitching performance such as speed and spin, can be displayed on a large monitor installed in front of the mound on the left. Normally, such data are not shown to subjects during experiments because their actions—and thus the experimental results—may be affected. In our laboratory, however, athletes use the monitor to check their own motion and performance during breaks between and after experiments. The video and measured data are used not only for research data but are also provided as feedback to the athletes, enabling them to review their motion and performance.

3. Facilities of SBL

The SBL includes measurement equipment for use in research on other sports and activities such as golf and walking. The space within the SBL is limited, so the configuration of equipment was determined on the basis of input from every researcher involved. For example, the golf tee, where two force plates are used to measure shifts in weight, is located at the right corner from the bullpen in order to obtain the longest shot distance. The area where the ceiling is lower is used as a gym floor for virtual reality experiments (**Fig. 4**) and for basic biomechanical experiments done with a treadmill and manipulandum system.

Although the SBL was expertly designed for various experiments, we initially overlooked the importance of lighting. Since the laboratory was already bright enough for normal activity, and taking video was not emphasized, no one recognized the need to enhance the brightness of the room. The importance of lighting was pointed out by an expert in sports broadcast lighting who happened to visit our lab with the designer we consulted. He said that lighting is of

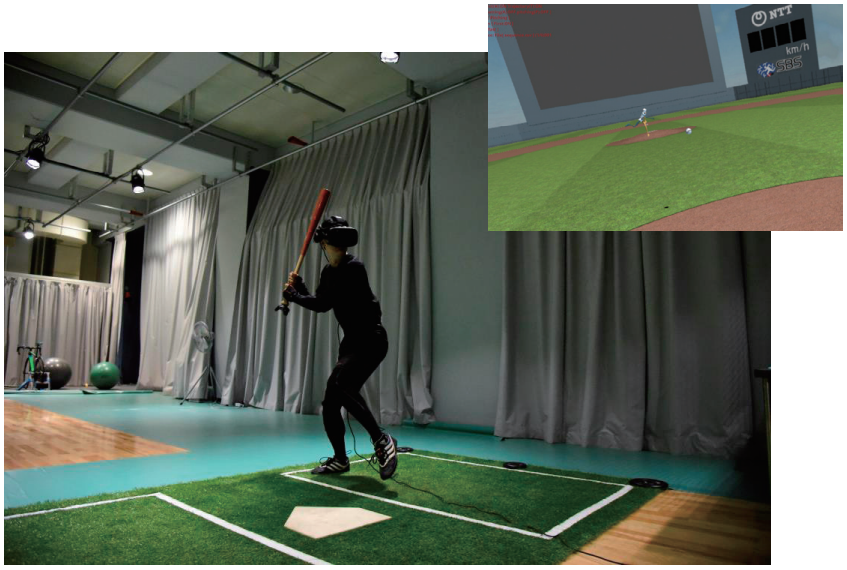


Fig. 4. Batting experiment using virtual reality.

fundamental importance for the laboratory. This became evident when we faced a flicker problem when using the high-speed camera. In most cases, it was difficult to add support lighting around the bullpen because the balls that are hit fly around the bullpen during experiments. Therefore, we used light emitting diodes (LEDs) to increase the brightness of the laboratory light. The LEDs are compatible with the high-speed camera and make the SBL as bright as the infield during a professional night baseball game.

We later found that the lighting was important not only for obtaining good experimental data but also for ensuring the high quality of the feedback video for athletes. To make the SBL more viable, we are continuously modifying it by taking into account the opinions from various professionals and the demands of researchers and athletes.

4. Smart sensing with "hitoe"

Another important objective of our project other than the basic research of sports brain science is to establish smart sensing skills using "hitoe" in sports scenes. The functional material "hitoe" is a conductive fabric that enables us to measure electrocardiograms and electromyograms by using it as a sensor electrode on human skin. Consequently, electrical signals are generally sharper and more stable compared to pulse signals. In addition, one of the major advantages of "hitoe" is that its hydrophilic property enables low-noise measurements even when subjects are sweating during hard practice.

A remaining important issue, however, is determining how to configure the transmitter and loggers on the body. It is necessary to configure them so that they do not disturb the athlete's activity. For example, in the case of C3fit IN-pulse*, a transmitter set at the chest sends data to smartphones via Bluetooth Low Energy (BLE). We have so far performed heart rate measurements at a baseball game in an attempt to visualize the mental tension of the pitcher using "hitoe" [2]. For these measurements, the pitcher wore a small smartphone as well as the transmitter because it was difficult to send the small BLE signal outside of the playing field. This solution was only applicable to practice matches. Furthermore, the operation of the smartphone would disturb players, even if the rules of the game allowed them to wear a smartphone.

To solve this problem, we are developing a system that automatically measures the athletes' biological signals when they are inside the SBL. This is done by having them wear "hitoe" smart wear. This system is based on the same wireless technology used in the rehabilitation institution introduced in this journal [3]. In the future, we will develop and implement the same kind of system in a real baseball stadium.

* C3fit IN-pulse: Brand name of a sportswear-type device using "hitoe" supplied by GOLDWIN since 2014. One's heart rate and electrocardiographic waveform can be measured by wearing it.

5. Future development

Although measurement tools are now smaller and smarter than ever, the measurements themselves still impose a psychological load on some athletes. A coach of junior high school aged athletes told us that getting used to such measurements at a young age is important because athletes would then be able to undergo them without any undue psychological stress when they had reached the top level in their sport. We were impressed with his long-term training vision and expectations regarding our scientific approach. Our goal is to train athletes' brains for winning, but this cannot be achieved only by researchers. Collaboration with athletes as well as with coaches and staff is necessary for our project's success. By creating the appropriate environments and having a research vision that makes athletes want to participate, we are putting forward projects to gain novel insights into human science and to assist athletes in attaining victory.

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Trademark notes

Masumi Yamaguchi
Senior Research Scientist, Molecular and Bio Science Research Group, NTT Basic Research Laboratories, and Sports Brain Science Project, NTT Communication Science Laboratories.

He received a B.S. in physics from Kanazawa University in 1998 and an M.S. and Ph.D. in physics from Kyoto University in 2000 and 2003. He joined NTT Basic Research Laboratories in 2003. He has been part of the Sports Brain Science project since 2016. He is a member of the Physical Society of Japan, the Japan Society of Applied Physics, and the Institute of Electronics, Information and Communication Engineers.