Intrinsic Motivation Is the Driving Force in Developing a New Methodology

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Abstract

In 2021, the Japanese national team won the gold medal in the women's softball competition at a major international sporting event held in Tokyo. Behind this triumph was a new attempt to clarify the brain mechanisms that enable top athletes to execute their superior techniques and improve such techniques through training using the latest information technology. We interviewed NTT Fellow Makio Kashino, who is exploring the mechanisms of the mind and body by focusing on the implicit brain function, and asked him about his research activities and his approach as a researcher.

Keywords: implicit brain function, cognitive neuroscience, inverse translational science

Uncover and develop the brain function of which you are unaware

—Can you tell us about the research you are currently working on?

What I am consistently interested in is the *implicit brain function*, that is, the brain function that we humans are not aware of. The various activities of daily life, such as understanding situations, making decisions, performing appropriate actions, communicating with others, and feeling various types of emotions, are all the result of an enormous amount of information processing in the brain, and we are unaware of most of those processes. In fact, our mind is supported by our implicit brain function.

The implicit brain function is also deeply connected to our body. For example, athletes achieve superhuman feats by skillfully moving their bodies instantaneously without having to think about it. When we are moved by music, we also have physical reactions such as trembling and shedding tears. Physical discomfort leads to mental discomfort. The research goal of our project is to explore the mechanism of the implicit brain function, namely, the interface between mind and body, and establish a methodology that leads to a more desirable state of mind and body.

This process inevitably involves the issue of diversity. Since each person's brain, body, and accumulated experiences are different, there is no single correct interpretation of the *desirable state*. Therefore, how can we enable people to make the best use

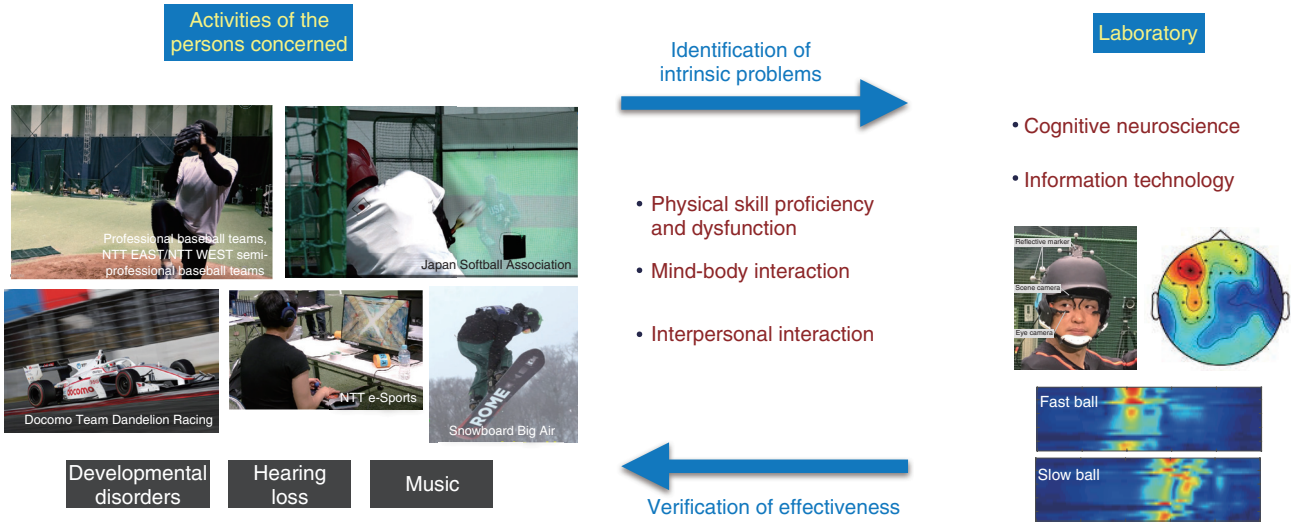

Fig. 1. Exploring the implicit brain function with the approach called inverse translational science.

of their individual characteristics, maximize their abilities, and achieve a sense of well-being? We hope to provide the scientific and technical foundation for answering this question.

—What is your specific approach to research activities?

Over the past few years, I have been emphasizing the approach called *inverse translational science*. Instead of researching in a direction *from basic research to real problems*, research should be conducted in the direction *from real problems to basic research*. This mindset does not simply mean that applied research with a defined purpose and short-range goal is preferable. As Alan Watts said, "If you want to study a river, you don't take out a bucketful of water and stare at it on the shore." I have come to realize that the research on cognitive neuroscience that we, researchers, have been doing is a bit like examining water in a bucket. That is, if we conduct experiments with established methodologies in the research field, the problem setting itself may be unrealistic and off the mark in terms of actual human activities.

With the above-described considerations in mind, first, I decided to go back to looking at the actual *river*. One of the fields characterized by themes such as implicit brain function and diversity was, in my case, sports. We are attempting to do basic research on cognitive neuroscience while keeping in mind the direction of solving real problems faced by the people involved (**Fig. 1**). We will not only publish the results that we obtain as a paper but also feed them back to the field to validate them and their effectiveness. Considering the results, we repeat the feedback loop so that we can delve deeper into the next problem. It has been about five years since we implemented this approach, and, fortunately, with the cooperation of top athletes and various others in the field, we are beginning to produce concrete results.

We are focusing on three main research themes. The first theme is the state of being proficient in certain skills and conversely, the state of being in a slump. The second theme is the mechanism of mind-body interaction, so-called *mentality*. In other words, we want to reveal the mechanism by which an athlete fails when they become nervous or succeed when they are in the zone. The third theme is interpersonal interaction, namely, the mechanism by which the presence of others, teammates, opponents, or spectators, influences an athlete's performance. Since we want to elucidate the implicit brain function, or unconscious processes, involved in these themes, it is pointless to ask the person in question, and it is essential to have an objective method of measuring the function in as natural a situation as possible. Devising such a measurement method is part of the research.

Fig. 2. Initiatives with the Japan women's national softball team.

Contribution to winning a gold medal at the major international sporting event held in 2021

—Your practical work with the Japanese women's softball team, which won the gold medal at the major international sporting event held in Tokyo in 2021, was a great achievement.

That work has certainly become a symbolic example of our approach. Of course, the outcome of a game is partly a matter of luck, so they could have won the gold medal even if we had not been involved. It goes without saying that the team's staff and players are the ones who made the most of their time and effort. Thus, I hesitate to say that we contributed to winning the gold medal; however, it is true that we have had a close relationship with the Japan Softball Association since we launched the Sports Brain Science Project (currently, Kashino Diverse Brain Research Laboratory) in 2017. It was decided in August 2016 that softball would return to the official competitions of the international sporting event to be held in Tokyo. Immediately after that decision, Shinsuke Yabata, deputy training manager (now general training manager) of the Japan Softball Association, Reika Utsugi, head coach of the national softball team, and others showed interest in our research. Perhaps the desire to take on new challenges resonated on both sides. In October 2017, we signed an agreement to conduct a joint experiment and have been working with the national softball team on various initiatives to put into practice the motto "train your brain and win the competition" (**Fig. 2**).

One example of our joint efforts is a pitching machine, which was featured as a "secret weapon" on television and in newspapers after the competition. At first glance, it does not look much different from a pitching machine with a video screen at a batting cage. However, this apparatus is a *pitcher simulator* that reproduces as precisely as possible the pitching form and quality of pitches thrown by pitchers who are expected to compete against each other. The pitching form and pitch quality are based on footage taken by members of our research team at international matches. Provided with that footage, we used a proprietary algorithm to analyze the pitch-rotation information and reproduce it in a programmable pitching machine. This machine can be considered a solution, from the perspective of cognitive neuroscience, to the problem that Mr. Yabata has been talking about since the beginning, namely, "The biggest challenge to winning the gold medal is to counter moving fastballs thrown by US pitchers." Our experiments demonstrated that good batters use information about the pitching form and the trajectory of the ball immediately after it is released by the pitcher to predict the

ball's arrival point without being aware of doing so. Even if the batter knows that pitcher A's riseball changes by a certain number of centimeters at a ball speed of over 100 km/h, the batter will not be able to hit the ball. To refine the predictive model in the batter's brain, the batter must repeatedly watch the video of the pitch, "experience" the trajectory of the ball, attempt to hit the ball, then learn the correspondence between these factors. Our pitching machine enabled batters to carry out this task in the absence of actual competition due to the COVID-19 pandemic. Although it is difficult to quantitatively evaluate the effectiveness of this machine, the fact that the players were actively using it at such a crucial time—just before the competition—seemed to us to be the most-positive evaluation of all.

—It is great that you have gained the trust of top athletes. Can you tell us again about the academic and social significance of this initiative?

I think the primary significance lies in the fact that we have practiced the approach of conducting research *from real problems to basic research*. This approach is easy to say but hard to apply properly. There is a reason that until now there has been little interaction between basic research on cognitive neuroscience and an actual practice like sports. Basic researchers simplify a problem, break it down into its elements, and attempt to uncover the mechanism behind the phenomenon causing the problem through rigorously controlled experiments. From this viewpoint, actual sports is too complicated to handle. The complexity of the challenge in the laboratory and in an actual sporting environment vastly differs. Take softball as an example. Pushing a button of an experimental apparatus in response to a simple visual stimulus is completely different from using one's entire body to hit an American pitcher's moving fastballs. Even if we examine the effects of psychological stress, the ethically acceptable level of stress that can be exerted in a laboratory is incomparable with that faced by a batter in a gold-medal game. From the perspective of basic researchers, it is impossible to write a proper paper on a real problem, and from the perspective of sports, scientific findings are impractical.

Therefore, our aim was to bring up real problems for discussion in the realm of basic research without sacrificing reality. This would have been difficult ten years ago. In the late 2010s, wearable-sensor and computer-vision technologies advanced dramatically; thus, it became possible to measure the movements and biological responses of athletes in action in a relatively natural way. We are also actively adopting these technologies as well as developing new ones. For example, when we analyzed the relationship between the state of the autonomic nervous system and performance by measuring the heart rate and body movements of athletes during actual competition, we found phenomena that could not be observed in a conventional laboratory setting.

Advanced information technology can also be used to modulate implicit brain functions and improve unconscious movement. The aforementioned pitcher simulator is one example of such technology, and we are also developing various training systems using technologies such as virtual reality, motion visualization, and motion sonification. These systems are used by top athletes in the field, and we are improving them while listening to the opinions of these athletes.

Naturally, such initiatives will contribute to not only improving performance of athletes but also changing the world of sports. Sports is said to involve a combination of three fundamentals: *mind*, *skill*, and *body*. However, although scientific training for *body* has become widespread, those for *mind* and *skill* has yet to become widespread. It is not uncommon for coaches to force their athletes to do things on the basis of their own successful experiences or to label athletes who do not do well as having no sense or weak mentality. As the implicit brain function that supports *mind* and *skill* becomes more fully understood, systematic and rational methodologies for developing abilities in accordance with the characteristics of each individual athlete should become mainstream.

We are not only focusing on the world of elite sports. We have targeted athletes because, in a sense, their implicit brain function appears in the purest form. We believe that the methodologies and accumulated knowledge developed in this field can be applied to various types of people such as the young, elderly, and those with disabilities with diverse characteristics and in different situations.

The starting point of research is pursuing what is interesting and irresistible

—What is your current attitude toward research activities?

I have become aware of the importance of going back to the basics. On reaching a certain level in your

career as a researcher, you'll stop getting so excited about your research or the research of others. You might feel, "OK, I get the picture…" However, when I think back on my childhood, I literally forgot to eat and sleep as I was absorbed in space, castles, music, electronics, and other topics. My passion had nothing to do with schoolwork, and I was acknowledged by no one. In fact, even if I was prohibited from doing something, I wouldn't be stopped. I was motivated purely by intrinsic feelings such as curiosity and fun. I suppose that I'm just inclined that way. As it turns out, that intrinsic feeling is my strongest source of energy. I don't think it's easy to reach a point of expressing one's originality through extrinsic motivation, such as being told to do certain research or choosing a certain research theme, because the topic is currently popular, might produce results, or will allow you to be acknowledged.

Quite often, Nobel-Prize-class research is the result of new entry of researchers into a field that differs from their original specialty. In some respects, since the new entrants do not know the conventional wisdom in that field, they are able to come up with ideas that overturn the conventional wisdom. If you are familiar with a certain field, you may implicitly set a problem that seems to be solvable by using an established methodology in that field. Essentially, you should first decide what you want to know then think of a methodology of acquiring that knowledge accordingly; however, the more you advance along your research-career path, the more you find that this process is somehow reversed. One of my motivations behind starting research in sports brain science was such reflection. It is not easy to come up with new methodology of doing things, but trying to do so is exciting.

However, simply doing what is interesting and what you like to do is hardly enough for research professionals. To secure research funding and recruit team members, you must be able to explain the value of your research effectively from a variety of perspectives. That sounds like opportunism; however, it is also a good opportunity to think about the potential of your research from the perspective of others.

—How do you plan to proceed in the future?

I want to hit the jackpot! In academic terms, that means overturning established theories or proposing new concepts. In social terms, that means changing people's lives or shaking up their view of human nature. However, I haven't accomplished anything on that level yet. Regardless, I've been taking on a new challenge over the past five years, and I feel that this endeavor is expected to produce quite interesting results. We are now entering a phase of more serious exploration and development based on these challenges. Although my focus is on the academic side, I also want to pursue social and business impact at the same time.

This endeavor, of course, cannot be accomplished alone. It is essential to collaborate with researchers from various disciplines as well as athletes, team staff, business people, and others in various capacities. Fortunately, we have already established such a network and are gradually expanding it. I have found that like-minded people naturally come together for interesting projects, even if they have different positions and backgrounds. It is quite common for athletes to be almost exclusively researchers in terms of mentality.

The laboratory that I lead is unique in that many of its members are young and have moved from completely different fields. They voluntarily joined the lab moving from within and outside the company because they each like sports, music, and other things they couldn't get enough of. In that sense, their intrinsic motivation was sufficient, and the fact that they already had a background in another field was also advantageous. I'd like to provide an environment in which they can take on essential themes without fear of taking risks. If each one could create a new methodology for research on humankind, it would be a great asset to society.

■ **Interviewee profile**

Makio Kashino received a B.A., M.A., and Ph.D. in psychophysics from the University of Tokyo in 1987, 1989, and 2000 and joined NTT in 1989. He is currently a visiting professor at the Graduate School of Education, the University of Tokyo. He has been investigating functional and neural mechanisms of human cognition, especially auditory perception, cross-modal and sensorimotor interaction, and interpersonal communication.