Think from Multiple Perspectives so that You Can Enjoy Your Work

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Overview

Human body movements, including highly skilled movements by athletes as well as people's everyday movements, are strongly supported by unconscious sensory-motor processes, embedded in the central nervous system. NTT Communication Science Laboratories revealed, for the first time, that body-state information based on vison is involved in the adjustment of one of those processes, namely, stretch reflex. We asked Hiroaki Gomi, a senior distinguished researcher at NTT Communication Science Laboratories, about his research results and his attitude as a researcher.

Keywords: stretch reflex, vision, body-state representation

We discovered that body-state information based on vision is involved in the adjustment of the stretch reflex

—Tell us about the research you are currently conducting.

We are pursuing research to clarify the mechanism of information processing concerning human body movements that are unconsciously performed using sensory information (such as vision and somatosensory) by combining kinematics, psychophysics, electrophysiology, and computational modeling, etc., and deepen our basic knowledge about information processing in the brain.

Roughly speaking, there are two types of human body movements: voluntary, which are activated consciously, and involuntary, which are activated unconsciously. A well-known involuntary movement is the phenomenon called the *knee reflex*, by which the foot rises involuntarily when the area just below the kneecap is tapped suddenly, e.g., during a medical examination. Although this action is executed unconsciously, the body is being moved by stretch reflexes. An involuntary movement is involved in motor control, namely, the ability to coordinate various body mechanisms required for movement, and it is thought to enable a quick reaction that corresponds to, for example, the movement of an opponent in sports. Not limited to sports, everyday movements such as walking, standing up, and reaching for objects involve involuntary components that are processed unconsciously through peripheral and central nerve reflexes (**Fig. 1**).

By elucidating these mechanisms, we want to advance research on the entire information processing of the brain.

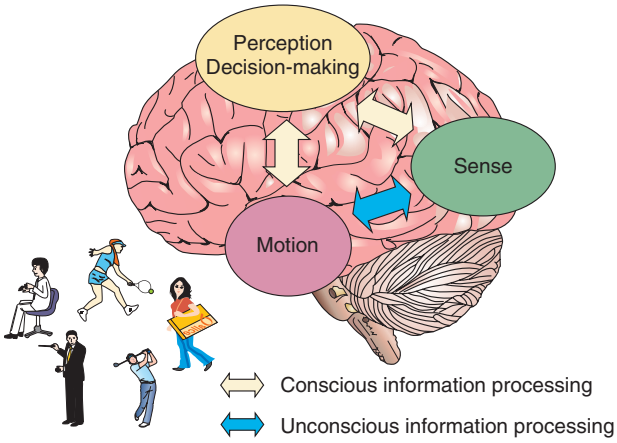

Fig. 1. Conscious and unconscious information processing of the brain that generates movement from input sensory information.

—When we hear about elucidation of our everyday movements, your research sounds very familiar to us. Please tell us more about the research you are focusing on.

We are investigating information processing concerning the stretch reflex, a nervous reflex caused by proprioceptive information sent from receptors (sensors) such as skin, muscles, tendons, and joints. The stretch reflex is caused by the passive expansion and contraction of muscles, and it is thought to play an important role in stabilizing posture (**Fig. 2**). Studies have shown that the stretch reflex response is not constantly generated; instead, it is adjusted in accordance with the ever-changing states of the body during movements. It is, however, not well understood what kind of information processing is performed in the brain for calculating the appropriate adjustment. For example, it is unclear whether the adjustment of the stretch reflex depends on proprioceptive information only or a body-state representation (i.e., the imagined body in the brain) obtained by integrating multiple sensory information, including vision.

We have shown for the first time that this stretch reflex is regulated in accordance with visual information representing the ambiguity of the body state [1]. Our experiments confirmed that the stretch reflex during the movement of the wrist to reach a visual target is smaller than normal under two conditions: (i) mismatch between the visual feedback of hand motion and the actual hand motion and (ii) elimination of the visual feedback of actual hand motion. On the basis of the knowledge we have thus far obtained, we aim to further elucidate the information processing performed in the brain for regulating the reflex system. In the future, I'd like to gain a deeper understanding of controlling mechanisms of human-body movements.

Our hypothesis that "the adjustment of stretch reflexes is regulated not only by proprioceptive information but also body-state representations obtained by integrating multiple sensory information, including vision" is currently being debated worldwide. We are going to present additional evidence that supports this hypothesis, which will help expand our understanding of brain processing for smooth and dexterous movement control when interacting with various environments.

An example of an actual application of somatosensation is a small device we developed called "Buru-Navi," which gives the user holding the device the feeling of being pulled by stimulating tactile sensation (**Fig. 3**). By considering the characteristics of the skin's tactile system, we succeeded in downsizing, increasing the number of degrees of freedom, and improving the efficiency of the previous version of Buri Navi developed by our former colleagues. It is now possible to create the sensation of being pulled in various directions, even though nothing is physically connected to it from the outside.

In addition to being able to guide the visually impaired, this technology can also be used to enhance the feeling of being immersed in a video of first-person-view motion, such as riding a motocross bike on a rough road, by stimulating synchronized haptic sensations. We hope our research can help in developing

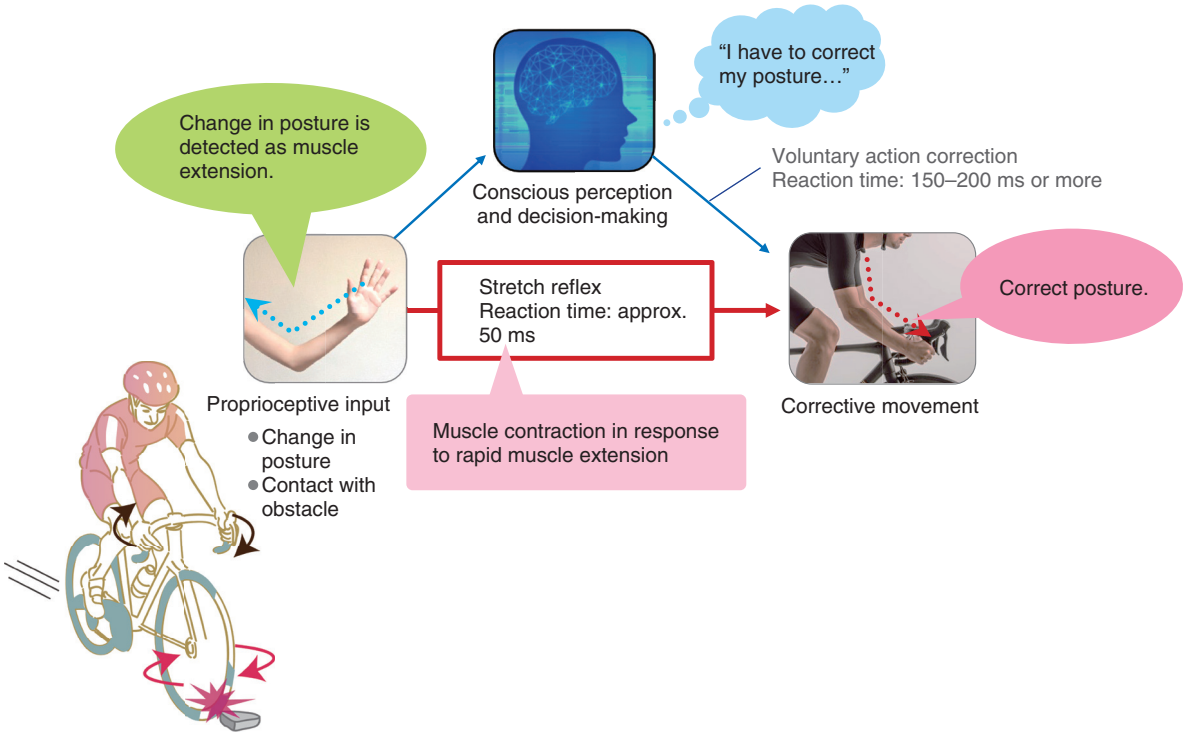

Fig. 2. The process of conscious and unconscious reactions in contact with an obstacle.

devices that exploit the ability of human information processing.

Determine what is important and make anything interesting and useful

—You said that your findings are causing worldwide debate, but do you have any idea about how to announce your research results?

I think there are various perspectives on how to evaluate research. Regarding papers, this involves publishing results that are unknown to the world and getting those results recognized and published after peer review. In this process, the degree of importance of the results will be questioned, and if they are deemed very important, they can be accepted by influential journals. Our ongoing research on the brain covers various fields, such as physiology and psychology. The current trend is not to pursue research from one perspective in a specialized field but to pursue research from a complex perspective that combines knowledge from various fields. By combining motor and sensory aspects, psychological viewpoints, and neuroscientific evidence, we will continue to obtain convincing and impactful results in understanding brain computation.

Fig. 3. Buru-Navi4.

One of my daily goals is to engage in research by taking these trends into account, explain in papers how our results are important, by introducing new perspective. Results on proprioceptive reflexes have received worldwide attention due to being announced

in the press release of a journal.

I also think it is important for researchers to communicate. NTT values dissemination of research information by researchers, and every year, NTT Communication Science Laboratories organizes an open house to present research results to the general public. Needless to say, ease of understanding is important when communicating with the public. Applying trial and error when explaining results to the general public at the open house is useful for giving lectures at universities. Therefore, explaining a research project to others improves one's communication skills. Since many departments exist within NTT, we have many opportunities to explain our research projects to researchers outside the field and non-researchers. Even for a particular research result or plan, the perspectives, background, understanding, etc. differ according to department or specialty, so it is important to explain in a manner that matches the audience. Explaining the necessity and importance of a research project, especially to managers outside the field, may be thought of as a time-consuming and non-essential job that is not directly related to research. However, this process, which is sometimes accompanied by severe criticism, has a positive aspect to extend the viewpoints that may be difficult to imagine ourselves.

—Just changing the viewpoint definitely contributes to maintaining a positive attitude.

I think it is very important to make anything interesting and useful by changing the way you look at things. Research activities require steady effort but often fail, and success stories are rare. Each activity is a repetition of revealing something unknown, failing, recovering, and doubling one's efforts. If you find this process uninteresting, you probably won't be able to move forward. However, even if you keep that positive way of thinking in mind, it may not actually be interesting. I'm conducting research while simultaneously determining what's important and what's not. No matter how much you change your perspective, if you don't think your research is important, it won't be interesting. While repeating the process I mentioned above, it is really interesting to find the essence or kernel of each research topic, and I believe it is important to strive for this.

In contrast to what I said above, some things may not be interesting but are important; therefore, I think it is necessary to make every effort to make them interesting. For example, when I was in junior high school, I wasn't very good at English and didn't like studying it until I was a high-school student, so I was mostly focused on studying science and mathematics. However, when I suddenly thought, "If I can speak English, I'll be able to communicate with various people, so I'll acquire the means to do so," my attitude toward studying English, which I was not good at, changed. If your method of studying is not interesting, I think you should make it interesting. I feel that if we are not so good at communicating in English, we should make such effort through trial and error.

Recently, the international conference of a new academic project initiated by the Ministry of Education, Culture, Sports, Science and Technology and organized by Professor Kenji Doya of OIST (Okinawa Institute of Science and Technology) was held online. It was planned to have world-class researchers related to artificial intelligence come to Japan to attend the conference. Unfortunately, due to the coronavirus pandemic, the conference was held virtually. Although I was assigned to be a session chair at that conference, I didn't expect it to be held online. I thought it would be a little difficult to hold an online meeting even in Japanese, let alone in English. It was a bit of a burden to put together an online discussion among researchers—including researchers of computational theory of cognition and behavior, the current hot-topic of deep learning, and physiology—who would give video presentations on a variety of topics. To be the chair, it was necessary to understand the details of the topics given by all speakers. Since I wanted to perform my duties as chair properly, I frantically watched presentation videos in advance. I watched 26 videos (each 30–40 minutes long and including presentations on topics other than those of the discussion I chaired) and repeatedly reviewed what I didn't understand; it was like studying for exams. I was desperate to make the discussion interesting.

I value the sense of excitement and wonder when conducting research

—We get the sense of your accomplishment from you studying hard. How do you maintain your enthusiasm?

Experimenting is sometimes really boring because of many repetitions of trials. I have talked about how people use surrounding visual information to move the hand. In that experiment, we sometimes needed to

continue an experiment on that movement (i.e., checking hand and eye movements of all subjects) all day long. Even if this task itself was not interesting at all, I was excited to imagine where the findings of the experiment will lead and what we can understand about the computational mechanism from them. Only seeing the difficult things in front of you will only discourage you; it ought to be fun to think about the results beyond those difficulties.

If a researcher thinks he or she is an authority in their field, I believe that he or she will stop being a researcher at that moment. There are many unsolved problems in each field, so focusing on one of those unknowns is what makes research interesting. For that reason, it is necessary to sincerely deal with what you do not understand. I think we can do our best as long as we have the enthusiasm to understand what we are interested in.

To maintain this enthusiasm, I value intrinsic motivation and interest. I also have frequent discussions with researchers in close but different fields. Every time I talk about sensations, behaviors, research trends and the like that I think are interesting, I realize the importance of communicating. I also value the feeling of "That's strange." When studying information processing in the brain, I sometimes find it interesting at unexpected moments in daily life. The experiment on stopped escalators that I described in my previous interview [2] is a good example. We feel an odd sensation when we get on a stationary escalator, and I started developing thoughts about what kind of information processing in the brain is involved in creating this sensation. Exploring ideas in this manner is vital to understand the human sensorimotor mechanisms.

Regarding the feeling of being pulled by BuruNavi, deeply exploring what kind of information processing in the brain generates this sensation and what kind of stimulus should be given to start will lead to an appropriate problem setting, which will develop into research results. Since the subject of our research is close to everyday life, it may be easy to find a research topic by exploring everyday phenomena.

—Please say a few words for the next generation.

The goal or sub-goal in research should be created and motivated by ourselves. I think that if you feel you are being made to work, nothing will go well. If you feel that way, I want you to make every effort to change your mindset so that you will be enthusiastic about your work. I hope that through thinking positively, the research you are conducting will be something that makes you think, for example, "I forgot to sleep and eat because I got absorbed in my work." The "making the topic interesting" that I mentioned earlier will lead to becoming engrossed in your research topic.

Of course, if you overdo it, your health will suffer, and if you try too hard, you will often become stressed, so it is better to be mindful of those risks. However, I think it's okay to have a period of frantic work, especially when you are young. All the same, if you are "on" all the time, you might be crushed, so I want you to properly switch "off." What I find difficult in my research life is separating my personal curiosity and work. I'm sure some people can separate them, but I'm one of those who is not so good at it. As researchers, we must constantly learn new things. It would be sometimes difficult to separate efforts to acquire knowledge or skill for personal intellectual curiosity from those for work if all efforts are related to the research topic. If this distinction cannot be made on an objective scale alone, I think that you need to set a boundary with your own subjective scale. This boundary setting might be quite essential in your research life, which is not common for every researcher, rather it is greatly dependent on your personality, ability, and capacity, etc. I hope that we can keep this diversity (or freedom) in our research environments.

I'd also like to touch on the changes in the environment surrounding researchers. I feel that the speed of research is increasing due to the increase in useful tools such as the Internet. Papers that had to be searched for in the library or ordered after several weeks in the past can now be read instantly via the Internet. However, I want research to proceed while thinking about the essential issues rather than searching speed. I sometimes see researchers trying to solve a problem in a superficial manner without addressing the essential issue. I'm always trying to take the time to figure out the essence of the problem. NTT Communication Science Laboratories has an environment where you can spend time on interesting and original research. I feel very fortunate to be able to research in such an environment and have excellent colleagues. I want to pursue new scientific ideas and technologies that will be interesting to my colleagues, worldwide collaborators, and society.

I really like the saying "Sokutenkyoshi (Live naturally)," which was used by the Japanese novelist Soseki Natsume. It means that you can live by

abandoning your narrow view of looking at things and living according to the principles of nature. People, including myself, are weak, and we're obsessed with our own perspectives. By thinking from many perspectives, the perspective of others, the perspective of society, and even the perspective of the universe, I think that you will be able to find enjoyment while doing so. Research is often unsuccessful and frustrating; however, I hope you will enjoy it and try not to feel too much pressure.

References

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■ **Interviewee profile**
Hiroaki Gomi

Senior Distinguished Researcher, Leader of Sensory and Motor Research Group, NTT Communication Science Laboratories.

He received a B.E., M.E., and Ph.D. in mechanical engineering from Waseda University, Tokyo, in 1986, 1988, and 1994. He was involved in biological motor control research at ATR (Advanced Telecommunication Research Labs., Kyoto) from 1989 to 1994, where he developed computational models of human motor control, robot learning mechanisms (demonstration learning), and a manipulandum system for investigating human arm movement. He was an adjunct lecturer at Waseda Univ. (1995–2001) and adjunct associate professor (2000–2003) and adjunct professor (2003–2004) at Tokyo Institute of Technology. He was also involved in the CREST (1996–2003, 2010–2015) and ERATO (2005–2010) projects of Japan Science and Technology Agency. He served as a committee member of the neuro-computing technical group of the Institute of Electronics, Information and Communication Engineers (IEICE) (1997–2000), its vice chair (2006), and chair (2007), committee member of the Japanese Neural Network Society (JNNS) (2012–2018, 2020), and chair of the 'Brain and Mind Mechanism workshop' (2015–2020). His current research interests include the computational and neural mechanisms of implicit human sensorimotor control and interaction among sensory, motor, and perception, and the development of tactile interfaces. He is now involved in the 'Correspondence and Fusion of Artificial Intelligence and Brain Science' Project (2016–2020). He is an IEICE fellow and member of the Society for Neuroscience, the Society for the Neural Control of Movement, the Japan Neuroscience Society, Japanese Neural Network Society, and the Society of Instrument and Control Engineers.