Creativity Consists in the Mental Ability to Sense and Respond to the World around Us

Possibilities Opened up by Putting "Natural-born Intelligence" to Work

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Climate change and other difficult challenges facing global society are prompting a search for new ways of approaching social innovation. At a time when increasingly complex circumstances are rendering accepted wisdom and existing systems of knowledge less relevant, the concept of "natural-born intelligence" put forward by the theoretical biologist Professor Yukio-Pegio Gunji represents a potential key to overcoming a growing rigidity in societal systems and technology. How can this natural-born intelligence be put to work in a society that is in thrall to artificial intelligence? A proponent of the idea that the natural-born intelligence of human beings is the wellspring of innovation, Professor Gunji here discusses this proposition with his former student, Youichi Horry, who has been involved in a wide variety of work at Hitachi, Ltd.

Finding Ways to Compare Social and Environmental Value

——I understand you have known one another for a long time?

Horry: Since 1987, it has been 36 years now. Professor Gunji came from the graduate school to teach at the Department of Earth and Planetary Sciences in the Faculty of Science where I was studying at Kobe University. While I may not be his greatest acolyte as such, I was his first. I learned all manner of things from him, whether it be how to look at things, fundamental ways of thinking, or what stance to take as a researcher.

Gunji: He still often drops in at the laboratory and offers his advice to the students. I expect it is encouraging for them to see a former student who is playing an active role in society and I am always pleased to see him. However, I have not heard much about what he has been up to recently (laughing).

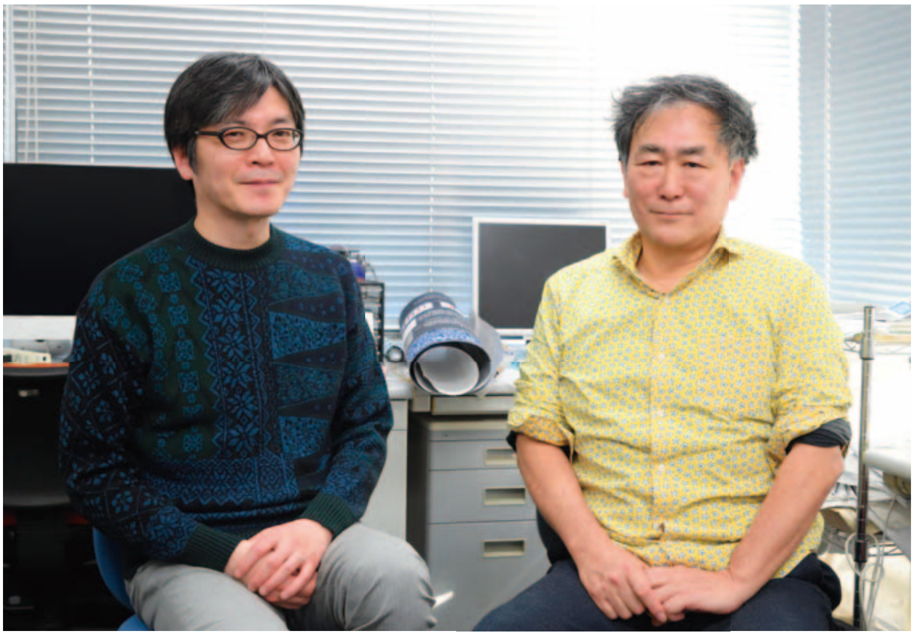
——In that case, Horry-san, could you start by telling us about your recent activities?

Horry: I am currently working on the development of platform technologies to support the transition to a sustainable society. One of the main things I am involved with is the social and environmental return on invested capital (hereinafter environmental ROIC) approach to quantifying total value of economic activity. Along with decarbonization, which can be thought of as a challenge for the entire world, there has been strong demand recently, especially in Europe, for making the shift to a sustainable society in ways that also take account of the circular economy, biodiversity, and human rights issues. Such measures are closely interlinked with societal systems and corporate management strategy, with people looking at making it obligatory for companies to disclose non-financial information. This has included work that went into establishing the Task Force on Climate-related Financial Disclosures (TCFD) and Taskforce on Nature-related Financial Disclosures (TNFD) as well as the Task Force on Social-related Financial Disclosures (TSFD) that also focuses on respect for human rights.

While this is to some extent a rule-making competition, creating a genuinely sustainable society will require that these issues be addressed in a comprehensive manner, instead of addressing each issue individually. We developed environmental ROIC as a decision-making support tool that will facilitate comprehensive and realistic action, one that works by quantifying the social and environmental value produced by corporate projects and other economic activity, thereby providing an insight into the benefits and outcomes of this work that takes account of society and the environment (see figure on next page).

Environmental ROIC looks at how various elements interrelate, considering the different products, technologies, and other individual components of economic activity and determining which globally recognized indicators they contribute to, such as the Sustainable Development Goals (SDGs). The total social and environmental value (V) of the economic activity is then calculated using the formula shown in the figure.

In an example application of the technique to the electrical facilities at a water treatment plant, we used carbon dioxide (CO_2) emissions reduction as a yardstick for technology for reducing the power required to operate the plant. This involved calculating a contribution factor (Y_k) by multiplying



annual power consumption by the CO_2 emission coefficient for the location, where annual power consumption (kWh) is the product of multiplying the power required to operate the plant (kW) by the annual operating hours (h). The social and environmental value V is given by summing the Y_k values, weighted by the C_k coefficients, after first converting them to financial values. The environmental ROIC is then obtained by adding this calculated value of V to the financial return on the project and dividing by the amount of capital invested.

Need for Standardization of Coefficients to Enable Value Comparison

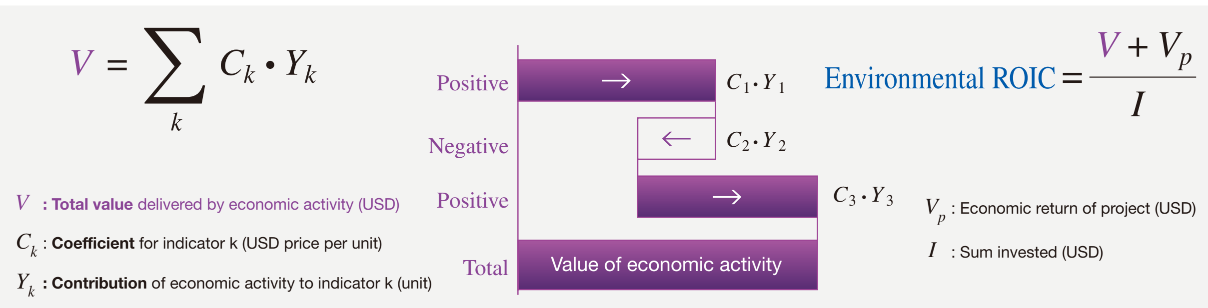
——How do you go about determining the coefficients?

Horry: What matters most is to standardize how the C_k coefficients are determined. To explain the role that coefficients play, consider how Hitachi has operated an internal carbon pricing system since 2019. This system attaches a price of 14,000 yen/ton to reductions in CO_2 emissions by newly installed equipment, the intention being to highlight the extent to which such capital investments reduce emissions. In this example, this price serves as a coefficient. That is, it is a numerical expression of what Hitachi values.

As for how coefficients are determined, one way is for the person making the decision to set the value by themselves. Alternative objective approaches are to determine a market price based on market principles or to use cost-benefit (B/C) analysis, or to calculate a value using data and an algorithm.

However, whichever method you choose, the decision will reflect your values and thinking. Moreover, economic activity will have participants on many different levels, such as companies or workplaces and local or national government, with each of these organizations having different values. That is, different organizations place weight on different elements and this will cause a lot of variability in the coefficient lists.

If meaningful comparisons are to be made between quantified values, it is essential to standardize the list of coefficients. To achieve this, we started by publishing the lists so that the participants could see what others had chosen. We hoped that this would encourage convergence as people were prompted to look at what others had come up with and make changes where their own coefficients were out of step.



Figure—Environmental ROIC Technique for Quantifying Social and Environment Value of an Economic Activity

Collating coefficients as lists is necessary for them to be incorporated into programs automatically and also to enable appropriate adjustments to be made to the decision-making by artificial intelligence. Having anticipated this, we are currently making environmental ROIC calculations for customers in a wide range of different industries.

Revising the Formulation of "Problem" and "Solution"

Gunji: I see. That is very interesting. Speaking in fundamental terms, the typical way we think about issues, whether they relate to the environment or something else, is in terms of there being a "problem" and a "solution." However, doubt arises as to whether the problem really is a problem. A problem is something that only becomes clear when we frame it in some way. While we don't necessarily need to look beyond this framing to bring together the relevant factors, it is also possible, conversely, for us to choose a framework that suits our own purposes, pushing aside those aspects we prefer to ignore. This means that our ability to resolve a problem depends in many cases on whether we can choose a framework that is convenient to ourselves. As it is easy to get stuck on this way of looking at things, it may be that we also need to consider stepping away from our chosen framing.

Horry: That is right. Environmental ROIC itself is not intended as a way of defining problems. Rather, we anticipated that problems might arise from the variability of coefficient lists.

Gunji: Whether it be environmental problems or anything else, the way it often works is that someone has something they want to accomplish and science is used to achieve it. While people often talk about the importance of objectivity in science, the issue is whether objectivity and the like are present to begin with. This is because a strict insistence on objectivity risks excluding the human perspective to the extent that humans could be allowed to become extinct. In that regard, having a variety of different coefficient lists represents a form of dynamism in the sense of a jumble of different subjective perspectives. By taking advantage of this, it may be possible to deliver a more successful outcome than could be achieved by something that has been carefully designed from scratch.

Horry: Environmental ROIC works by combining elements of various different types. As the number of such elements was not stipulated from the outset, they can be added indefinitely. While this has the potential to become somewhat arbitrary, I believe it also aligns in some respects with Gunji-sensei's own thinking.

Seeking Optimal Outcomes that Allow for External Factors

Gunji: The concept of self-organized criticality was proposed and modeled by Per Bak, a Danish theoretical physicist. The idea is that, when the behavior of certain phenomena or materials is modeled mathematically without stipulating a framing or problem in advance, they achieve a dynamic stability on their own that is in effect a close approximation to the optimal, even in a disordered open system that is exposed to external factors. This is in complete opposition to the conventional approach to design that seeks to obtain optimal solutions under ordered conditions.

One example of self-organized criticality is the sand pile model. When grains of sand are progressively dropped from above onto a flat surface, a pile tends to accumulate up to the point where a section of the pile collapses, a process that repeats over and over again as more sand is dropped. While it is the slope of the pile that determines when such collapses

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After graduating with a degree in earth sciences from the Graduate School of Science at Kobe University, he joined Hitachi, Ltd. in 1990 at the Central Research Laboratory where he worked on research into computer music and graphics. In 1997, he took up a position as a Visiting Researcher at the Institut National Recherche en Informatique et en Automatique (INRIA) in France, began his research into human interaction in 2000, and established the Hitachi Human Interaction Laboratory (HHIL) in 2003. Since 2010, he has been working on management science for social infrastructure at a number of institutions, including Hitachi's Advanced Research Laboratory, Central Research Laboratory, and the Matsudo Research Laboratory of Hitachi Plant Technologies, Ltd. He was appointed to his current position in 2022.

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will happen, this in turn depends on the physical properties of the sand (size and friction). When this sand pile model experiment is run, the collapses happen on a range of different scales such that the frequency with which a collapse of any given size occurs decreases as collapse size increases. That is, the relationship between collapse size and frequency follows a power law[*1].

When phenomena follow a power law, it is impossible to predict the scale of future events based on the mean size of past events. That is, a very small change in conditions can result in a phase transition. This is why they are called critical phenomena and they occur frequently in nature, earthquakes being one example.

While Per Bak passed away in 2002, ideas of this nature are once again attracting a lot of attention. In the case of animal gait, for example, a probability distribution for step length that follows a power law is called a "Lévy walk." Animals are known to use this to search for food efficiently. Formulated as a mathematical model, this could be used to improve efficiency when searching for something under unknown conditions. While a variety of models, our own included, have been proposed to show the mechanisms that are incorporated into the way animals walk so that they exhibit criticality, my own view is that it represents a form of natural-born intelligence.

While I will talk more about natural-born intelligence later on, in simple terms I describe it as intelligence that arises from sensing and responding to external factors. My goal is to develop a theory of this natural-born intelligence and incorporate it into an intelligence model that provides ways of responding not only to predetermined conditions, but also to unanticipated external factors.

In the case of your own environmental ROIC, you do not impose a predetermined framework on the indicators and coefficient lists. By avoiding this, it may be that environmental ROIC will evolve dynamically by incorporating not only those factors that can be anticipated in advance, but also mechanisms for dealing with the unexpected or factors that conflict with one another.

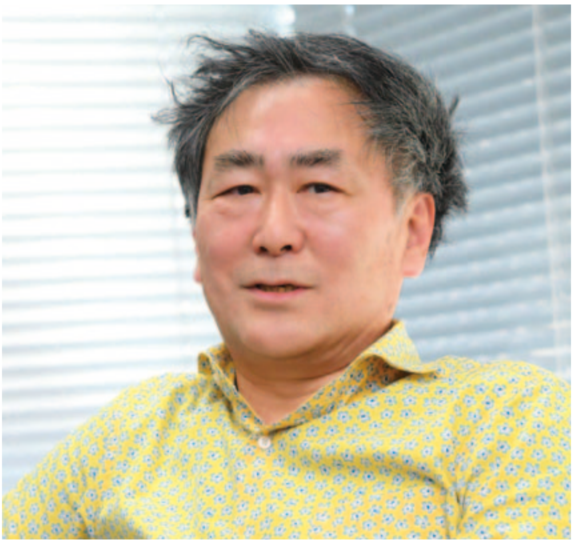
Horry: That's right. A list that allows for the comparison of coefficient values does not yet exist. Once it does, it would become possible, for example, to make explicit numeric comparisons of the different weightings that emerging nations and developed nations place on human rights, something that currently has only an implicit expression in policies. In a certain respect, this is a case of contradictory factors coming into conflict with one another and can be expected to drive convergence.

*1 Power law
A type of statistical model in which the values for a small subset of the population are much larger than the rest. The mean has no meaning for data that follows a power law.

While people tend to think of coefficients as being objective, I talked earlier about how the choice of whether to determine them objectively is in fact a subjective one, meaning that they embody people's values and opinions. On the other hand, decision-making calls for objective theory and data. Which is to say that the realm of coefficients is one where the objective and subjective are nested within one another, making it difficult in some regards to predict whether our lists will ever successfully converge.

Models that Combine Individual Intentionality with Group Order

Gunji: Is it possible to combine the freedom of individuals, such as their subjectivity and intentionality, with orderliness in the group they collectively comprise? This is an interesting problem, one for which modelling the movements of groups of animals can provide some useful insights.



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He obtained a Ph.D. in science from the Graduate School of Science at Tohoku University in 1987. He was appointed a Professor in the Department of Earth and Planetary Science, Faculty of Science at Kobe University in 1999 and a Professor in the Faculty of Science and Engineering, School of Fundamental Science and Engineering at Waseda University and a Professor Emeritus, Faculty of Science at Kobe University in 2014.
He has published numerous works, including "Groups are Consciousness" (PHP Institute, 2013), "Life, Indomitable" (Seidosha, 2018), "Natural-born Intelligence" (Kodansha, 2019), and "*Yattekuru*" (Igaku-Shoin, 2020). His most recent publication is "From Whence Comes the Memory of Having Once Lived in that Game World?" (Seidosha, 2022).

Flocks of starlings or schooling sardines move in a collective fashion despite apparent randomness. While modeling such movements is surprisingly difficult, in a model I devised myself that equips the individuals that make up the group with both reactive and autonomous movements, I found it was simple to replicate group behaviors such as how their movements sync up in a linear fashion under some conditions whereas in others they just circle about or suddenly scatter in all directions.

In terms of the mechanism involved, you can think of it as an expansion or contraction in the causes that drive the decisions of individuals. While people might think that achieving orderliness requires objective decisions based on an unchanging set of causes, it turns out that groups can exhibit synchronized and harmonious movement on the basis of varying factors whereby individuals make repeated autonomous decisions while also responding to external causes. This is a state of affairs in which orderliness and the breakdown of orderliness are controlled internally. It may be that we can build such systems and still be able to control them effectively.

Horry: This is the model you wrote about in your book "Groups are Consciousness."

In the case of environmental ROIC, having the coefficients set in stone would equate to an unchanging set of factors. In practice, however, we have provided dynamism by allowing them to be increased or decreased. As mentioned earlier, equipping environmental ROIC with the scalability to be used by organizations of different sizes is another feature.

Gunji: Mixing things that differ in scale may well prove interesting. The model I have been telling you about that allows for variable factors was developed out of the book "Groups are Consciousness."

Humans Have an Innate "Natural-born Intelligence"

——You spoke about how sensing and responding to external factors equates to natural-born intelligence. Could you please go into this in a little more detail?

Gunji: While people often talk about systems being "open," I believe that this is in fact a very difficult concept. We are frequently aware that the scope of our own knowledge is circumscribed and that more exists outside. This raises the question of how we link together those things that are inside and outside this scope to make a system open. The problem is that there are also "unknown unknowns" that are even farther outside of our scope of knowledge, what I distinguish as "external factors," factors that we have never even thought to consider. What is important is how we handle these.

In terms of this division into what is inside and outside of our scope of knowledge together with unknown unknowns, what we call artificial intelligence works by applying its inference capabilities to its known world. As highlighted by the frame problem*2, because addressing what is outside our scope of knowledge will get us nowhere, we bring those factors we are able to consider into the scope of what we do know and provide a solution to the problem within this context. This is first-person intelligence whereby we make logical and rational decisions about things after having first established our own scope of knowledge. This goes beyond the realm of computers as we humans also frequently deal with things in the same manner as artificial intelligence.

"Natural intelligence" is the term I use for the transformation of this first-person perspective into a third-person one, meaning a way of thinking that comes from natural science. While it might make more sense in the context of natural history, we utilize the knowledge of the outside world that we have acquired over time as we set about finding out more about our world. This is intelligence that seeks to build an objective third-person scope of knowledge.

In contrast, natural-born intelligence does not seek to build a scope of knowledge. You could call it a "one-point-fifth-person" intelligence, one that simply responds to those external factors that are so far outside our scope of knowledge that we cannot even know they exist. While putting it this way might have you thinking it is some special intellectual capability, in fact natural-born intelligence is something that humans and other animals are equipped with innately. Unfortunately, many modern-day humans tend to think like artificial intelligences and in a convoluted sort of way there is a need to get back to natural-born intelligence.

Of course, the reason I choose to study natural-born intelligence is not because I want to discredit mechanistic artificial intelligence and put my faith in the sort of intelligence that is innate in animals. Rather, it is because I am fascinated by the question of how we can incorporate the natural-born intelligence approach into mathematical models and whether we can get it to work.

How Natural-born Intelligence Routinely Creates New Things

Horry: Given that, when you talk about what is inside and outside our scope of knowledge, you are only using this to

*2 Frame problem
An important problem in artificial intelligence. Defined by cognitive scientist Patrick J. Hayes and John McCarthy, a computer scientist who was one of the founders of AI and gave the discipline its name, the problem states that: "A robot with finite information processing capacity cannot deal with all of the problems that could potentially arise in the real world."

demarcate the world that is already known, one way to sum up what you have been saying is that it is the world in which problems are able to be defined and in which there is a clear link between problem and solution. However, everyday life in the real world is not normally that clearly defined. Your mood might change unexpectedly and have you doing things you would not have anticipated doing, or you might suddenly forget things you knew or make a mistake in a simple calculation. That is what life is like for ordinary people. While people use the terms "logos" (logic) and "physis" (nature), the reason why these things happen is because the world is not made up of logic alone. There is no way to explain it other than to assume the influence of external factors of which we are unaware.

Gunji: What I talk about as "external" may be difficult to grasp, and when you think about what sort of things it might refer to, images immediately come to mind where you can draw arrows showing systematically how they relate to ourselves. However, we can only draw these arrows for things we know that we don't know, not for external unknowns. When I talk about natural-born intelligence, what I mean rather is those situations where our unconscious or subconscious self reacts to something that happens due to external factors we are unaware of.

An example in the form of a problem and solution is how, when we intuitively imagine solutions to the problem we are considering, we instead come up with something completely unrelated. The intelligence that gives rise to such things is natural-born intelligence. You can also describe it as our capacity for routinely creating new things.

The question, then, is how best to model this type of intelligence? What I have been thinking about is how we should go about handling external factors in a systematic manner.

Affirming Both, Denying Both

——The book "Intelligence Simulation Using Cellular Automata—Implementing Natural-born Intelligence" that you co-authored came out in 2021. Have models based on natural-born intelligence already been developed?

Gunji: Yes. An indirect way of describing what sort of models these are would be to say, for example, that they involve two elements: a problem and a solution. When a problem is seen as a problem it has no solution. When a solution is found, it isn't a problem any more. Which is to say, you do not normally have both at the same time. When you create a situation in which these incompatible things are simultaneously affirmed and denied, it is like a gap opens up between them and something comes in from outside to fill it.

You may think that both affirming and denying two things that cannot coexist is not logically tenable. In the real world, however, tiny changes in boundary conditions or a shift in context can cause a problem to not be a problem any more. Moreover, such boundary conditions or contexts that are exposed to external factors cannot be controlled or tinkered with. As we make our decisions in just such a world, one that is beyond our control, it is possible for such situations to arise.

Horry: Do you have a good example of where things are jointly affirmed and jointly denied?

Gunji: As I wrote about in my book "*Yattekuru*," there was a handicapped high school student who communicated with people by showing them photographs of things he liked. His mother made up a ring binder for him filled with laminated photographs of his teachers and objects such as police cars or trucks. He would go about showing these to people he met, asking "What is this?" Once the person told him what the photograph showed, he would go on to the next person. When he came up to me to show me his photographs, I started by playing the game properly, but after a couple of rounds he showed me a photograph of a police car and I answered on a whim that it was a rhinoceros beetle. He broke out in a great big smile and hugged me saying "Gunji-san!" Since then, we have been on very good terms.

What happened between us was that, as he was someone who found it difficult to speak to other people, showing photographs to get a reaction was, for him, a way of achieving the communication of which he was only barely capable. Put another way, the situation was framed as one in which the photograph represented the problem and naming the object shown was the solution.

Then I came along and told him a police car was a beetle. He showed me a photograph and I gave him an answer, so in some sense that constituted a solution. On the other hand, it was also a problem in that he must have been wondering what on earth I was talking about, meaning that "rhinoceros beetle" became both a solution and a problem at the same time. You could also take the view that what I said was no more than a nonsense reply and so it was neither a problem nor a solution.

Something being both a solution and a problem is like a Zen koan: all you can do is ponder it. Were it neither a solution nor a problem he could just ignore me for not playing the game properly. In fact, he momentarily entered a state in which the two were in a delicate balance and so was able to experience a new phase of communication. I think it was an experience he enjoyed.

Horry: In terms of the technology, I understand you are using distributed computational models in the form of cellular automata.

Gunji: Generally, simulation by a distributed computational model involves synchronized calculation. Biological processes, on the other hand, arise from large numbers of cells working in an uncoordinated way. For this reason, asynchronous calculation is occasionally used in models that simulate biology. While a variety of methods have been developed to achieve this, they mostly involve uncoordinated actions happening randomly.

However, the workings of living systems are not entirely random, with the cells able to organize among themselves in some way to achieve coordination amid all the asynchronicity. That is, coordinated and uncoordinated behavior is negated while at the same time being achieved. This was the concept that I modeled.

Daily Life is All Innovation

—While natural-born intelligence refers to the intelligence innate in living organisms, you also noted that many people have come to act like artificial intelligences. What kind of problems do you think this will cause in the future?

Gunji: If you continually repeat a cycle of framing problems like an artificial intelligence and solving them on these terms, you will eventually run up against technological limitations. In societal terms, if a certain group of people continually solves problems based on their own framing and problem definitions, the society will likely become dismissive of anything that lies outside their frame. If that happens, I will no doubt think that I am one of those being dismissed (laughs). I will likely take offence at being ignored.

We talk about how artificial intelligence can do these wonderful things, how it can work in ways that outstrip humans. How would you feel then if someone told you, "An artificial intelligence (AI) robot can appreciate food much better than you can so you don't need to eat any more"? I would think "You're kidding" and wonder how best to keep on saying so.

Horry: What Gunji-sensei is saying sounds difficult, but he is dealing with something that is very ordinary, namely the intelligence that humans possess innately. For example, it is not at all easy to get a robot to perform actions that come naturally to animals. You have to analyze the mechanisms at work and construct theories to replicate the same actions using different materials and apparatuses. He is doing much the same thing, only in his case what he is trying to replicate is intelligence. There is much that is yet to be explained about animal intelligence and the workings of nerve cells, and about the problems of awareness and perception. His theories and model of natural-born intelligence are seen as one such solution.

This means it is not about denying artificial intelligence, rather that the practical realization of natural-born intelligence could be of great significance in our society that, as a whole, has gone too far in adopting AI-like ways of thinking. It may well open up possibilities that nobody would have thought of.

—You have spoken of how natural-born intelligence routinely creates new things. Are you saying it equates to innovation?

Gunji: Yes, that's right. One way of looking at it is that, rather than the world continuing as normal most of the time and only occasionally being punctuated by innovation, daily life is in fact all innovation. Rather than being a big deal, innovation is like the experience everyone has had of finding a particular food to be unexpectedly good to eat even when they are eating the same thing as usual. If we were to take a step outside our usual problem-solution framework and look at the world, I expect we might see that innovations are simple to come up with.

What Does "Specially Trained Rhinoceros Beetle" Make You Feel?

—Given that scientists and engineers are continually seeking to create new things, what do you think such people need to do to become aware of their own natural-born intelligence?

Gunji: Hmm… My laboratory website has a post about the phrase "specially trained rhinoceros beetle." "Specially," "trained," and "rhinoceros beetle." Look at these words one at a time and it is their dictionary meanings that come to mind. When you put all three together, however, I expect you find it conjures up images that are perhaps sinister, dubious, or amusing, such as some secret organization working night and day to put beetles through a rigorous training regime.

And yet, none of these images appear in the phrase itself. If you ask why they come to mind, it is because putting words in the right order causes a deep gap to open up, into which flows things from outside that you might never have expected. This deep gap is invisible. So, how do we create these invisible gaps? I believe the sensibility it entails equates to literary flair.

This is what poets do. However, they do not expect every reader to respond to their poems in the same way. You only need to open up such a gap for it to draw forth surprising responses, though they will likely be different for different readers. People may well think that those who work in the sciences are the least likely to have this literary flair, this awareness of an invisible gap. However, given that this awareness is in essence the same thing as creativity, it is important to cultivate it.

Horry: The best expression of innovation in my opinion is the "*neuen Kombinationen*" (new combinations) of Joseph Schumpeter. As with the way you put your words together, innovation results from putting things together in new combinations. This is something else I have learned from you.

Gunji: The cognitive scientist, Margaret A. Boden, divided creativity into three different categories: unfamiliar combinations of familiar ideas, the exploration of new areas, and the transformation of conceptual spaces. While Schumpeter's "new combinations" correspond to the first of these, Boden made the point that there was more to this than just putting existing things alongside one another. Because different arrangements can have completely different meanings, the creativity lies in how you chose to put them together. As in common phrases like "read between the lines," creativity comes about from successfully bringing out or grasping the value that lies outside the words themselves.

Incorporating Ways of Responding to External Factors

—How can we cultivate this sensibility?

Gunji: What I find deeply interesting is that the students of mine who produce interesting papers or good research are those who read a lot of fiction. They are also very familiar with modern literature from outside Japan. As foreign books often expose Japanese readers to different values or experiences, it maybe that this has something to do with it.

Horry: Nevertheless, I expect there is more to it than just reading books. Rather, I imagine it is to do with people's different attitudes to reading. You spoke earlier about the attitude people have that all you need to do is identify and then solve the problems facing the company or wider society, and that this approach has reached its limits. What is needed to overcome this is the ability to identify combinations that have the power to drag external factors into play.

Gunji: That human beings are adopting AI-like thinking despite their innate natural-born intelligence is, I believe, because we continue to be taught that it is a more logical and superior form of intelligence. We are trained from a young

age to hone our abilities to distill things down to their essence, in the sense of taking difficult problems and asking how we can define them in such a way that they can be abstracted and simplified to obtain a solution. Releasing us from this spell will be no easy task.

While we often divide things into the humanities and sciences, in most cases, even the humanities adopt logical AI-like ways of thinking. In broad terms, artists are the only people thinking about how to get away from this. And even then, it is only some artists. As this amounts to only a very small number of people, it is no surprise how difficult it is to get the wider community to appreciate the need for natural-born intelligence and to convey to them the idea that the problems with today's technology lie in AI-like thinking.

That is why I have high hopes for you. The work you are doing provides a good practical example, and if you can make the case for the importance of external factors and natural-born intelligence from the front line of business where you are striving to achieve social innovation, it may be that things will change.

Horry: Something I particularly want to say is that the great inventions and discoveries associated with the rise of human beings, such as fire or writing or music, could only have come about as the result of natural-born intelligence. When writing, for example, was invented, it seems unlikely that the need for writing was even recognized as a problem.

While research and other forms of work always tend to be framed in terms of problems and solutions, daily life is full of situations where this approach does not apply. My favorite example of natural-born intelligence is, when thinking about the problem of what to have for dinner, instead of wondering whether to have udon noodle or soba, I choose instead to simply go home and go to sleep (laughs). I expect situations like this happen all the time. I believe we can foster innovation by taking this ordinary thinking along with ways of responding to external factors that are based on natural-born intelligence and incorporating them into all sorts of different areas.

—This has been a very interesting discussion. Thank you very much.