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Supervenience of the Self

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Preface

It seems to me that what we perceive is well-formed with the boxes we have made. We communicate with others by passing the boxes called words and consider what we are doing in our minds and brains as playing with building blocks. Because of the virtual common world consisting of illusion and compromise, we can think that we all live within the same temporal frame like clock signals in a computer and within the same space that can be dismantled into the pieces embodied by natural language and whose dynamics can be described in the natural language also. Perhaps, owing to the theoretical tools based on this epistemological structure, we have been able to explore and discover facts of reality. The supposition that we all exist on the same tempo and all perceive in the same way might make it efficient to be unified in order to exercise a form of collective intelligence, science. Moreover, owing to the ease of implementation of the set of attitudes for individuals, this type of collective intelligence has been the biggest scale in human beings' history. The set of the facts captured by the system of science that is the peculiarity reduced perspective of the collectives of the clock and language users is treated as the common factual reality, though I do not doubt that this reality must be a part of the reality out there.

Then, suppose that the collective perspective show validity for extrospection, how about for introspection? In other words, is it possible for the perspective, whose constituents' peculiarity is eliminated, to capture or re-salvage the whole shape of cognition of its constituent? I personally consider this question as one of the biggest problems in cognitive science. it seems to me that the precondition or the supposition implicitly shared among the scientific methodology is questionable, especially when it comes to cognitive science, because the constituents of the collective are "cognition" or "cognitive" somethings. Thus, since the subjects of cognition as constituents of scientific perspective have a distinctive perspective towards reality owing to its unique properties from other organisms—of course, the other organisms have their own perspectives corresponding to their own properties—, and also, each individual is biased due to the properties that the subject had obtained through their experience up to the current moment; the form of the reality should be different in each individual. Probably, the common clock and languages might reduce the peculiarity in attitudes towards the reality of individuals. After all, that collective intelligence is able to capture objects only in the way that it can; the objects would be captured in well-ordered forms, even though our ontological natures are not explainable only by what we have used for scientific activities. For these reasons, scientists often consider cognitive systems as linguistic and/or computational processors, even though these characteristics are only some aspects of the cognitive systems.

Based on the analysis of the relationship between science and language above, from here, I would like to express an excuse for my thesis' abstrusity. The reason for my thesis' complication—besides my lack of language skills—is the subject matter's incompatibility with natural language. Perhaps, formal and natural languages are quite strong tools to express the facts that have happened. If the phenomena to describe are fixed, even in the case that the phenomena have stridden from one temporal point to another, they can be described straightforwardly. However, what I want to try to explain here is movements of a general object to non-existing spatiotemporal space.

An instance of an incompatible aspect with natural language in my thesis might be the influence of Asian philosophy and thoughts. Through my study here, I have strongly realized that I come from East Asia, where has the tradition to focus on "nothingness," "interval," and "relationship," rather than "being" and "identity" because I could even see the influence from these concepts that the tradition of my origin passes throughout the history, in my thesis. These themes are quite obvious in the texts of Japanese philosophy, including the texts referred to in this current study, or even in Asian philosophy, including Rigveda. Asian thoughts show a higher affinity with local religions than western thoughts do with their religions. This might be because it is harder to convey through either formal or informal language. Therefore, the comprehension of the thoughts relies on the interpretation of the words or other expressions of the people already enlightened. This may cause the doctrines to become a set of objects of worship. In fact, I was afraid several times that my study had slipped into mythical talk owing to the vagueness owing to the distance from the clear conventional method to study and report and the difficulty to describe my idea in English due to the nature of cognition, which is the transition of a state.

Of course, my excuse might be unacceptable since many predecessors have described and explained the complex and kinetic phenomena in written texts. Their clear descriptions have helped me to weave my idea and thoughts here as well as given me some support for my theory. However, I would like you to understand that the study and suggestions here are not about objects that have happened and are fixed in the past showing higher affinity with languages, but rather about movements of an object, which we might not be able to perceive. Therefore, I want you to know that my intention here is to contribute to cognitive science, not to confuse the readers.

Acknowledgments

Before any person, I have to express my gratitude to my supervisors, Prof. Jordi Vallverdú Segura and Prof. Anna Estanys Profitós for their guidance in my study and also, in terms of Jordi, for allowing me to join his private time with his family. Jordi has especially listened to and let us discuss my scattered ideas always and helped me to develop them.

To interweave my idea presented here, I have gotten support from many people, especially, Prof. Yukio Gunji from Waseda University, Prof. Anthony Chemero from the University of Cincinnati, and Mr. Takashi Uzuka, Mr. Shigeru Arima, and Mr. Souichiro Yokokawa from a studio of Miyadaiku, *Shokodo* (匠弘堂). Prof. Gunji has invited me to his laboratory to give a presentation and let me discuss it with the members. Prof. Chemero guided me to the philosophy of cognitive science in my last year in college. I could see him and hear his presentation at a conference in this Ph.D. again. The people from Shokodo welcomed me and generously told me their knowledge of the tradition of styles, skills, and thoughts in Japanese architecture. I have been influenced by many different thoughts and experiences, but the people named above directly gave me inspiration and ideas for the current study.

Besides academic purposes, my motivation for studying is to share my thoughts with my friends. I appreciate my friends who could be amused by me based on my experiences and thoughts including ones obtained through my philosophical works. The moment that I could laugh with my friends is when I could feel to be glad that I kept studying.

Also, I am thankful to my “Oshi (推し)” for entertainment, encouragement, and even inspiration for my study. I spent part of my Ph.D. during the COVID-19 pandemic. During this period, what encouraged me to keep going was entertainment. Without it, I might not finish this study. Through music concerts and talk shows streamed online, I could get the motivation to keep studying as well as the energy to live in a restricted and stressful situation. Also, their attitudes towards their creations made me honest about what I am doing, including the study.

My study for Ph.D. is completely self-funded, so without the support from my parents, I could not even start to study. I must thank my parents for giving me the option to come to Spain.

Love to my family—Marc, Meló, and Yuuri. Daily life with them is the basis of my everything.

Finally, thank you for your reading (or even your attempt to read).

Abstract

This thesis includes two different but related statements about the subject of cognitive phenomenon and cognition itself. The former statement is that a state of a cognitive system, which I call "the self," is the subject of a cognitive phenomenon. Also, along with the subject of cognitive phenomena, I suggest that cognition is a transition from one state to another of a system. The latter statement is that the transition or cognition is physical and driven by the maldistribution of energy and entities in physical reality.

1. Introduction

In the first chapter, I introduce the background of the current study, which is a rough presentation of the limitation of analytical perspective to observe cognition and study cognitive systems. Since the analytical perspective shows a high affinity to the way of perceiving the world, it is quite difficult to eliminate it from our attitude to explore and comprehend the world. However, because the field where the subject of study occurs is kinetic, cognitive science needs to implement a way possible to capture the movement.

2. The Self

In this chapter, I suggest that the subject of a cognitive phenomenon is a state of a cognitive system and that cognition is the transition of the self to another state. Moreover, as the relationship between the self and the present, in which the self is spatiotemporally located, I suggest supervenience. The structure of the self is based on an ontological view, "absolutely contradictory self-identity," of a Japanese philosopher, Kitarō Nishida. Also, supervenience supports the higher structure, objective temporal time scale, which is the emergence as the result of the selves located at the present and interacting with each other chaotically.

3. Transitions and Systems

In this chapter, I attempt to clarify what I mean by "transition" and "system." If readers have knowledge of computer science, the combination of these words would remind computation. Here, I would like to make a comparison between the two types of systems,

which I call here “computational system” and “physical system” to make it clear that these systems are ontologically different—at least, for now—due to the realities that they exist and the difference of the transitions that they exercise.

4. (Possible) Principle of Cognition

This is the main chapter for the latter statement. In this chapter, I would like to show the continuity from physical reality’s complexity to cognition, by defining to be physical. To answer those fundamental questions to consider cognition, first place in this section, I would like to present brief but still relevant ideas within non-equilibrium thermodynamics and complexity theory. I will also provide my view to define cognition based on the ideas and theories that I presented here. Also, I would like to analyze the process of transition. The subject matter of those ideas, especially non-equilibrium thermodynamics, is mainly a micro-scale phenomenon; however, although a certain type of complexity is escalated for organisms’ cognition, the basic principles should be applied to any level of scale.

5. Architecture of Thinking

In this chapter, I would like to present my study about the architecture, showing the fact that our existence as complex cognitive systems plays the role of agents for complex systems on a larger scale. This study is to suggest that architectures, especially sacred ones, also play a similar role with natural languages, as the robust facility of a system. Also, I would like to state that human societies or tribes are complex systems that develop robust facilities within their own bodies. The fact indicates that cognitive phenomena are not unique for “organisms” in common sense and that the collective system of human beings is similar to its agents’ cognitive functionalities. In this sense, complex cognitive systems are scalable and function under the same principles, as I discuss in the previous chapter.

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1. Introduction

In this current study, the first purpose was to shape a subject of cognitive phenomena. Then, I could have defined the subject as “the self.” The reason for this attempt is, to be honest, that I believed that shaping the cognitive subject is equal to capturing what cognition is. The self, in the literal sense, is the starting point of intentional actions towards or upon the other and the subject of experience of the quality of interior phenomenon. Even though employing 4E (Embodied Embedded Enactive Extended) cognition, which is the attempt to make the subjects or phenomena themselves extended or vague in terms of their boundary with others, the concept of individuality cannot be ignored. However, the concept of individuality as a subject cognitive phenomenon was getting far away from the self that is commonly referred to by the subject of natural language such as “I,” as keeping studying cognition. It is difficult to comprehend the cognitive phenomena while considering what we can refer to with “I” as the spatiotemporally single definitive object.

The self, the subject of cognitive phenomenon, is the state of a system. The system is the sequence of the states that alter from each moment to another. In other words, taking human beings individuals like us as the example of cognitive systems, we could be defined as the sequence of the selves transiting to another continuously. However, the theoretical model of the cognitive subject would not “function” by itself. The self is ready to transit to another state; however, by considering the self by itself, there is no definitive drive to make the subject to another state.

For this reason, the purposes of the second half of this study are to suggest that cognition is a transition of the self to another state and to find out a possible force pressuring a cognitive system to keep transiting to develop itself as a sequence. Non-equilibrium thermodynamics, especially far from equilibrium, is the possible precondition of cognitive systems, and complexity theory contributes to the hypothesis of the structures and vehicles of cognitive systems and phenomena.

I believe that there are several significances in this study; however, what I want to emphasize here are these two points: the point where the subject of cognitive phenomena, the self, may cover a wide range of types of systems and another where cognition becomes physical issues by considering the physical principles as the origin and drive of the phenomenon. I have theorized the self while referring to one of the most representative Japanese philosophers, Kitarō Nishida, and considering human beings as an example of cognitive systems; however, it allows a variety of types of systems to be subjects of cognition.

In terms of second significance, supposing far from equilibrium as the precondition of cognitive phenomena, cognition as the transition of one state of a system to another has become the issue of physics. Of course, it does not mean that the subjects of studies relating to our subjective experience become completely rooted in or able to consider from physics. Though I will mention later gain, the representative eliminated issues in the current study are mind and consciousness. However, by separating the background of actions and the quality of our subjectivities as the topics as subject of study, I could bridge between physical reality and cognition.

The biggest shortcoming of this study might be that it may lead to the conclusion that we cannot wholly comprehend a cognitive phenomenon. Because of physical complex systems' scalability, the measurement of the strength of influential relationships among phenomena, especially ones in different scales, is quite difficult. The micro-scale phenomena must influence the way of emergence in the macro scale; however, as the distance between the scales is further, the relational effect gets smaller. It will be small as ignorable; however, though it can be epistemologically ignorable, the phenomena on the micro-scale and the macro-scale cannot be non-relational ontologically. Therefore, when focusing on a phenomenon on a specific scale, our rational perspective must reduce smaller-scale phenomena relating to the target phenomenon into mechanistic phenomena.

Another shortcoming would be, as I mentioned briefly above, that this study cannot contribute to some of the most significant issues around cognition: mind and consciousness. From our experience of ourselves living this reality, what we are sure of at most is that we are experiencing the contents of our mind owing to consciousness. Mind and consciousness are definitively the most significant issues for not only the disciplines tending to be anthropogenic, such as psychology and philosophy of mind, but also for cognitive science that covers a wider range of existence as the subjects of phenomena. However, I could not find any room to go into issues of mind and consciousness from the current study's argument. The only exceptions are a certain type of "pain" and a brief idea about the emergence of consciousness based on a broad interpretation of physical principles.

In the last, for the second half of the current study, the limitation might relate to and is caused by my lack of skill in language command, since this study and the object of study are scalable, the focal point and perspective frame of this study keep jumping to a scale from another. From this unstable perspective, it might be hard to get what I try to explain. Perhaps, the final goal of cognitive science is to understand the case of cognitive phenomena in human beings. However, historically, the analytical perspective that focuses on and frames to study human beings has failed to capture cognition because of our arrogance in considering human beings as special existence. Still, this perspective's advantage is to have a fixed subject and framework of study so that it should be clear whether sub-issues relating to the subject of study are inside or outside of the epistemological framework.

On the other hand, one of the aims of the current study is to theorize and capture the movement of cognitive phenomena. For the sake of achievement of this purpose, I have to extricate myself from the analytical method of taking a snapshot of phenomena as the subject of study because the structures of systems and phenomena under complexity principles are openly and fractally scalable and temporally continuous. Moreover, to generalize this phenomenon to a certain degree, it demands to include the generalized phenomenon itself or even partially into the target phenomenon. This nesting structure causes difficulty to explain with a fixed perspective and framework. For these reasons, the description of the current study was challenging, at least for me. To complete my lack of skill, instead, I have added figures. I hope that they could help my readers understand what I am trying to say.

1.1. Background

1.1.1 Cognitive science

Some people might take objection to for the reason of methodological issues such as one that we could see the objection towards anthropogenic tendency in the discipline of cognitive science by Lyon (2006), but still, I believe that the ultimate goal of the discipline has not changed from its origin, which is to understand human beings. Also, I consider that this introspective motivation should not be changed, even though cognition itself is the functionality common in other systems.

The origin of cognitive science and the other disciplines relating to the human mind is the interest in ourselves. This interest, perhaps, has come from our introspective perspective. Our personal world is developed and extends from "ourselves," the origin of our subjective perspective. The representative theoretical formalization of the subject of experience has appeared as empiricism and rationalism. I would say that the rough summary of these attitudes could be whether what we have obtained as knowledge fundamentally origins from the state of the world or from our innate functionality of ourselves. The point that I would like to emphasize is that those attitudes are developed from the motivation to comprehend the current state of ourselves. Then, having an interest in ourselves as the origin and extending the awareness towards the exterior, modern science has evoked. In short, the origin of even the activity of human beings seeming to be with the intentional direction towards the exterior is the introspective interest.

The problem throughout the history of introspective investigation is to regard the state in the same light as the continuum including the state. The collision between empiricism and rationalism also comes from this equation. As long as we seek the nature of our states, we cannot say whether empiricists or rationalists are correct because the state must be the result of the phenomena suggested by both of them. Moreover, targeting only human beings with the aim to comprehend it holds the same problem because to comprehend human beings is equal to comprehending it as a state of the larger scale system. Considering this point, I agree with the proposal for the implementation of the biogenic perspective. By taking the consideration of functionalities of primitive systems for investigation, the approach may provide an explanation of the basic common mechanisms for cognitive functions among individual human beings as the result of "improvement" through evolution.

However, it is important not to forget the original interest in the nature of ourselves. Especially, in terms of this current study, my interpretation of cognition and cognitive subjects based on their theorization covers a wider range, most likely more than the biogenic approach to interpret cognition as the functionality of organisms in general. Moreover, the scalability of complexity that is one of the principles of cognition makes us lost in thinking of the fractal structure. To avoid wanderlust in a complex reality, I consider our original interest in ourselves and keeping it in our mind that the interest is the motivation of discipline as a crucial matter for this discipline.

1.1.2 The title: "supervenience of the self"

At the beginning, the purpose of this study was to understand the nature of cognitive subject. Supposing that the options for actions are explainable by "affordance" (Chemero, 2009; Gibson, 2014), the aim of the study was to contribute to how the subject would take an action while picking up an option from the other. Until when I have realized that the subject of cognitive phenomena by itself cannot bring about cognitive phenomena, I had believed that the activeness of cognitive existence could drive themselves to take an action. Hence, at the beginning of this study, I considered "the self " as the subject of choice of affordance to take an action and the origin of activeness.

Owing to my misunderstanding or wrong wording, "supervenience" was not taken as serious matter; I had considered just as synonym with "basis." For this reason, as the "bases," I focused on the options available owing to affordance and the sense of self-agency and self-ownership as the origin of the activeness and subjectivities. However, later I have realized that, if I am not wrong, supervenience suits on this study to describe the relationship between a whole complex system and its constituent systems to allow the whole system to have emergent property upon the interactions among the constituents.

1.1.3 Analytical perspectives

To be analytical is one of the most common attitudes to study, and (philosophy of) cognitive science is not exceptional. When non-analytical philosophers studying cognitive science criticize the analytical attitude to study cognition, as far as I understand, the non-analytical philosophers consider the analytical methodologies as the attitude ignoring the importance of the subjectiveness or being distant towards the object of study even if the object should be the researchers themselves. I agree with their criticisms; however, the stance, especially 4E cognition, where non-analytical philosophers often take is, in fact, also the attitude possibly considered analytical. For instance, one of the representative analytical perspectives highly related to 4E cognition is biosemiotics.

Biosemiotics is the perspective to comprehend the biological realm with the semiotics, “the sign process—the fundamental process that carries meaning and in which meaning is created” (Emmeche & Kull, 2011). Also, Magus and Kull (Magnus & Kull, 2009) pointed out the significance of understanding Umwelt, the concept suggested by Jacob von Uexküll. According to de Jesus, the significant contribution of Umwelt is that it demonstrated:

> (i) that it provided a phenomenology grounded in the organism because (ii) organisms are embodied agents that live in meaningful environments and therefore (iii) not static units cut-off from the world but deeply embedded in it to the extent that it collapses the subject/object dichotomy and that (iv) in order to fully appreciate points (i) to (iii) biologists need to reject anthropocentrism and avoid anthropomorphism. (De Jesus, 2016)

Umwelt succeeded to draw the argument of cognitive science to the same level as biology. Biosemiotics is the discipline of trying to understand cognitive phenomena as the result of a semiotic relationship between the environment and the subject. Semiotics is independent of our languages neither formal nor natural because the interpreters of the meanings are not existences interpreting it from objective perspectives. In short, considering any kind of organisms developing Umwelt in order to take an action, we may understand them including human beings as the vehicles of cognition.

This idea is compatible with what I suggest as the self in some aspects. From the perspective of biosemiotics, the self can be understood as the Umwelt of the subject at a moment. For instance, the structure of the relationship between the system's abilities and the environmental features, which is affordance (Chemero, 2009; Gibson, 2014), as the significant constituent of the self can be analyzed as the semiotic relationship.

As a supporter of the 4E methodology to investigate the nature of cognition or cognitive system, I did not consider myself taking methodology of analytical perspective because what I had taken as the object of study exists or occurs in the relatively wider spatiotemporal range. Although there are some aspects necessary to be reviewed, we still have to admit that the analytical methodology is a powerful and useful perspective. In fact, I could theorize the subject of cognitive phenomena through this methodology, though I had not realized the fact.

Here, I would like to present my view of what an analytical perspective is. In a nutshell, the analytical perspective is to observe and dismantle a fixed object with a perspective based on logic and language. In the first place, the object of study for this methodology is a concrete fact that we can conceptually capture with our rationality. A fact that we can conceptually capture with our rationality or a fixed object indicates, in other words, things that occurred in the past. By taking phenomena that occurred already as the object of study, the analytical perspective dismantles the relations within the phenomena for their own languages and reconstructs them with logical reasoning.

Even though the object includes themselves when it comes to the disciplines targeting human beings as phenomena such as psychology and cognitive science, the investigators' being distant towards the object of study comes from that both the object and tools are separated from the cognitive phenomena in analytical studies. When conceptualized by the researchers and captured by languages, the object of study is ontologically separated from the object itself because the object of study becomes a phenomenon in the past since the moment of linguistic fixation. The linguistics phenomena would be independent of the utterers since when the phenomena occurred, meaning that the utterers verbalize them. Moreover, what the utterers may utter are things occurred already, including the phenomena inside of our imaginations. If the object of study is independent of the analytic investigators, it might not be a crucial problem. Capturing target phenomena, which had occurred before the current studying moment, by language and establishing relationships logically among sub-phenomena, indeed, have been contributing to comprehension of the structure of nature. However, this alienation among the actual objects of study, the original object of study, and the investigators would become an issue for cognitive science and related disciplines because the object of study is ontologically independent of what the disciplines try to comprehend originally, yet intrinsically those must be the same object. The original object of study should be the cognitive system that must be a continuous existence so that, once cut off from the continuum, the object of study becomes a fundamentally different object. Moreover, there is a contradiction because the investigators of research strongly assume that the object of study includes the investigators themselves, though what they do is to separate the object from themselves as much as they can to maintain an objective perspective. As long as the discipline holds this contradiction, there would be a distortion between the ontological nature of the target object and what we perceive and recognize through the filter of science.

1.1.4 "Conventional" science

Compared with the perspectives to observe cognitive phenomena as the result of complex non-linear dynamics of this physical reality, I would call the scientific perspective with an analytical attitude as conventional science. For cognitive science, the representative attitude of the perspective is to assume a cognitive system as a system with a component dominant structure (Reed & Vallacher, 2020). Component dominant structure is, briefly, the structure where the connections among the components or subsystems are linear, as most digital devices with the current technology.

As another representative attitude, the conventional science for cognitive science is often based on dualism. This is because we have been thinking that our mental phenomenon must be distinctive from the other physical phenomena, for the sake of identifying human beings as special existence, consequently identifying each individual, as a subject of the mental phenomena, as the special one. In other words, why human beings are different from physical phenomena is that each of us has a special capacity named as mind, and we may communicate about its contents with others owing to the special aspect. From the conventional scientific point of view, it has been regarded as basic common sense that other existences, even other animals, do not have this unique facility.

Most probably, the first success of this form of enterprise in (cognitive) science is behaviorism originated by Watson and represented by Skinner owing to his radical methodology (Jones & Skinner, 1939; Watson, 1913). The most significant aspect of behaviorism is to focus on the analysis of the conditioning state of the object of the experiment and its results (Stimulus-Response relation). They are against the introspective methodology or 'self-observation' 'suggested by Wundt (Wundt, 1905) and consider our psyche as a set of behaviors. In other words, as studying the mind scientifically, behaviorists must postulate on what is publicly observable. From what is generally sharable, we could obtain the same knowledge because the system of science provides the same valid way reasoning of the cause and effect between the observed phenomena. The set of what is described by this methodology is the nature of our mind, for behaviorism.

Behaviorism’s methodology provides the cause-and-effect relationship between two or more points of the subject of the action. In this sense, the methodology is conventional. Therefore, the methodology focuses on the facts that had happened and reasoned for the relationship between the facts. The cognitive subject, for them, is the set of the potential to take actions according to outside stimuli, and a series of conditionings would develop ourselves as the set.

In fact, this methodology to consider a cognitive subject as a set of conditioned potentials for behaviors must have contributed to cognitive science. The study based on this methodology is comprehensible and in accordance with the manners of science. However, of course, cognitive systems’ nature cannot be explained as a set of conditioned behaviors. Rather, actions and behaviors with definitive causes or being conditioned previously must be rare, though explanations of even rare cases should have been great scientific contributions.

I would say that cognitivism is also nearly based on analytical and conventional perspectives. Cognitivists seem to consider the processing by the central processor as cognition. Also, they consider an individual cognitive system as the central processor and the cognitive gadgets with the component dominant structure. For this reason, their methodology is to analytically dismantle an individual cognitive system into modules and central processors.

Cognitivism has emerged as a counterargument to behaviorism. Cognitivism considers behavior as the result of informational processing mainly through the brains as our central processors, whereas behaviorists do not take it into account for the explanation. The inside of the “black box” is not observable, so, at least for behaviorists, the study of the inside of brains cannot be scientific. The most sophisticated methodologies of cognitivism are the computational theory of mind (CTM) and the representational theory of mind (RTM).

The transition from behaviorism to cognitivism is not definitive. For instance, Hull's Drive-reduction theory (Hull, 1943) seems to seek the formula happening the inside the subject of the response, and Tolman's introduction of the variables into the relation between Stimulus and Response (Tolman, 1938) can be considered as the appearance of interest in the inside of the subject. However, during the middle of the 20th century, influential ideas and methodologies that can affect scientists' attitudes toward the mind issues have been developed in parallel with this gradual shift from behaviorism to cognitivism. These influential ideas might have decided the direction of the new ideology to study our minds.

The ideas have encouraged the establishment of a set of methodology that externalizes what we cannot observe and check if the imitation of cognition shows what the scientists consider as mental phenomena. Falsifiability (Popper, 1935) in scientific theories from the philosophy of science and functionalism (Putnam, 1975) from the philosophy of mind have influenced the discipline. Functionalism suggests that the nature of our mental state depends on the corresponding function of a device. Therefore, according to functionalism, it is possible to reproduce a specified mental state in an artificial device made with non-organic materials if the device can process the corresponding function. It implies that it is possible to externalize our states from our subjectivity due to a device that could have the same state as us. Also, with the device, it is possible to study our minds scientifically. Moreover, the development and progress of the study of artificial intelligence to simulate part of human cognitive facilities and generative linguistics, which considers that we have naturally capable to acquire languages holding systematicity (Chomsky, 1957), contributed to the tendency of discipline that human beings' cognition processes computationally. In addition to these interests focusing on the central processor, neuroscience has been radically gaining precision for observation and study. Taking these interdisciplinary influences, 'cognitive science' has been developed while being derived from psychology. Owing to the study within this discipline, various types of processors have been suggested.

The representatives could be the computational theory of mind (CTM) and representational theory of mind (RTM). The former theory takes our cognition as a certain type of computing system. RTM has the symbols as what the central processor manipulates (Fodor, 1983; 1990; 1975). Also, based on the contribution of neuroscience, connectionism has come to the fore because it shows both potentialities of comparison with a biological neural system and the practicality for radical improvement of artificial intelligence.

Cognitivism is also a dualistic view as well as behaviorism. It treats the cognitive subject, mainly human beings, as the informational processor. The body of a subject is a subordinated facility controlled by the central system. However, there are problems such as the symbol grounding problem (Harnad, 1990) because this dualistic view separates the informational realm (the central and neural system) and the physical realm (the sensory motors) but still, it considers them as continuous circuits.

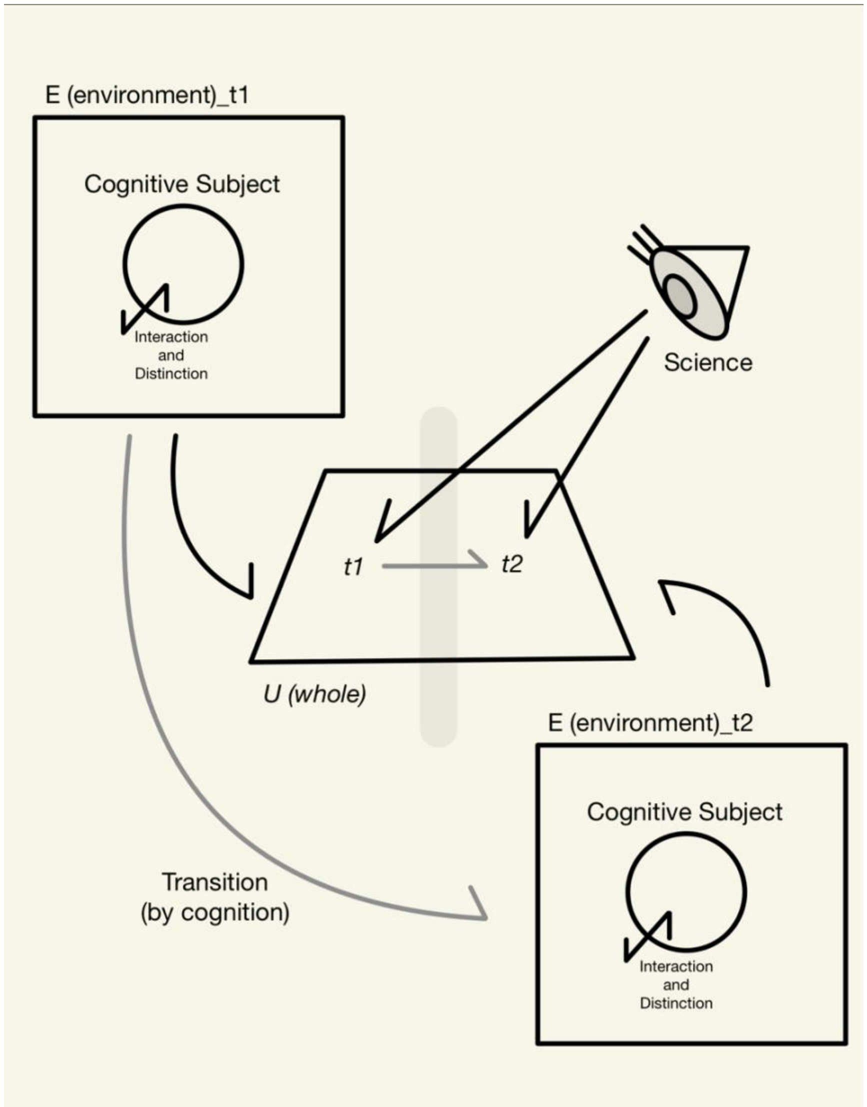


Figure 1.1. This figure represents the relationship between an analytical perspective and the object of study which is a continuum. The object of the study for cognitive science, a cognitive subject, transits from temporal moment *t1* to another temporal moment at *t2* along with the environment. “Science” observes phenomena at temporal points differently and relates them with logical or linear relationships. The cause-and-effect relationship between two phenomena can hold validity if science properly works. However, how to cut the continuum into phenomena at different temporal points is an epistemological issue. Thus, science as an epistemological system or operators’ bias would intervene in the comprehension of the object of study. In physical reality, the situations and phenomena at *t1* and *t2* are contiguous. The cognitive subject at *t1* experiences a transition upon the environment to the state at *t2*. To understand the cognitive phenomenon between *t1* and *t2*, the perspective at *t1* towards *t2* must be implemented in the perspective for the investigation. This is one of the significant issues in (philosophy of) cognitive science.

1.1.5 The capturing the self

Even though the analytical and conventional perspective may hold contradictions or critical problems within the methodology itself, it is still useful, or even only valid, scientific perspective, especially for what we could perceive or conceptualize as a fact that occurred in the past. As you may see in ‘the title,’ the first aim of the current study was to define the subject of cognition. This first aim comes from where, before I found out that cognitive phenomena would not happen only by the existence of the subject of cognitive phenomena, I thought that the subjectivity of the action was identical to cognition itself. Referring to 4E cognition and Japanese philosophy, which puts emphasis on phenomenological perspective when it comes to the subjects relating to human beings’ interior phenomena; I had not realized that I was theorizing the subject of cognition through the analytical methodology.

The current study concludes the subject of cognition as a state of a cognitive system. The significant difference or benefit from this notion is that it succeeds to separate who we are as analytical researchers and the object of study, as well as revealing the nature of the subject of a cognitive phenomenon. As I mentioned, one of the problems of the analytical and conventional scientific attitude for cognitive science is that it holds a contradiction in itself between the principle to be objective and the fact that the object of the study is the researchers themselves. This is due to the equation between the subject of cognitive phenomena and the continuum of the subject. The continuum is, fundamentally, unrecognizable from an analytical perspective. Intrinsically, the researcher and the continuum of the subject of cognitive phenomena are supposed to be identical in their conceptualization of cognition. By detaching the subject as a state, which is a point of ontological locus of the cognitive system, it would be possible to theorize it in an analytical manner without contradiction.

The basis of the theoretical model of the self is “Absolute contradictory of self-identity,” the ontological concept intertwined by a Japanese philosopher, Kitarō Nishida. The significance of his view is to allow us to take a phenomenon as an object of theorization with a spatiotemporal range. Therefore, the self based on his view includes different spatiotemporal sections as single ontological existence. The idea of absolute contradictory of self-identity could be considered as a non-analytical view owing to the idea's inclusiveness. However, even though the range gets wider, still the model of the self theorizes the subject of a cognitive phenomenon as a state. Moreover, the properties of the system that provide potentials for transitions are analytically explainable since they come from the former than the current moment of the state or the past in the objective time scale.

The state is the interval of before and after the occurrence of a phenomenon that the subject would subjectively experience. In this sense, the state is in a contradictory situation. However, still, the analytical perspective is a proper sight to theorize the state because the state holds its properties that are there owing to the facts that phenomena had happened and because its potentials are owing to the properties.

1.1.6 The transition of the self

The issue that the analytical perspective might have a hard time capturing is something temporally moving or something with the movement itself as its nature. Cognition is relevant to this issue. In this current study, I define cognition as transition, so at least for investigating cognition as my current study, it is difficult or even impossible for the analytical perspective to capture the transition. As the alternative for methodology and perspective, I suggest non-equilibrium thermodynamics and complexity theory because I think that these perspectives seek the principles and mechanisms to bridge between phenomena rather than to analyze the condition of the states and relate to each other by logic. In short, there is a fundamental difference in the analytical perspective and the perspectives including the potential to capture cognition: the focal point of the analytical perspective is "point," whereas the one for the other perspective is "linear."

1.2 Structure

In the current study, first place, I would like to present the self and the relationship between the self of an individual system and the "present." I would like to discuss this in the chapter on *the self*. After defining the self as the subject of cognitive phenomena, I would like to present the difference between types of transition and between types of systems in the chapter on *Transitions and Systems*. As I define cognition as transition, it is necessary to indicate what kind of transition and the background of the transition I assume, especially to emphasize that transition as a cognitive phenomenon has to be a physical phenomenon rather than a computational transition in virtual reality. In the largest chapter, *(Possible) Principles of Cognition,* I would like to present the significance to consider through the perspective of non-equilibrium thermodynamics and complexity theory and would like to draw a rough sketch of cognition with these perspectives making cognition ubiquitous physical phenomena rather than an anthropogenic way to consider cognition as peculiar properties of human beings. Instead of a conclusion, I would like to present the study that cooperated with my director Prof. Jordi Vallverdú, *Architecture of Thinking*. Up to this chapter, I have discussed general matters of cognition; however, by setting sacred architectures as the subjects of the study and discussing them as robust properties of the society or tribes, we could demonstrate that they are also complex cognitive systems functioning under the same principles as other (more primitive) systems. Like this study case, the cognitive phenomena suggested by this thesis might be more general phenomena so that the attitude to comprehend subject matters could help us to explore and discover new aspects of nature.

2. The Self

In this section, I would like to suggest what the 'self' is, as a subject of a cognitive phenomenon. The self, here I mean, is a state of a cognitive system at each moment. The issue of the self has a quite long history to investigate, especially in philosophy. The meaning of this terminology differs in each context. In my study here, however, it is easy and simple to define: what accomplishes the transition, defined as cognition, upon a state.

Cognition is a transitive phenomenon from a certain state of a system toward another, from a state at a moment to another state at the next moment. Thus, the system, as a continuous existence, consists of those states. The self or the state at a moment is a constraint of the range of possible states in the following moment. In this sense, it is crucial to consider the state as "the self" when it comes to a cognitive phenomenon. The self at each moment differs from the other because what composes the self in a spatiotemporal space is different, though the closer the temporal distance between the two is, the more they share common elements. This gradual change can be the bridge between the states, which could allow us to be aware of our existences as unique continuums.

The self supervenes upon the present. The present is a spatiotemporal space at a point on the objective time scale. The present consists of various matters, and one of the significant constituents is the states of cognitive subjects. The components of a cognitive subject's state at the present come from three different sections: the former of the current moment, the current moment, and the later than the current moment.

This view to the self of a cognitive system is based on the absolutely contradictory self-identity or unity of opposites by a Japanese philosopher, Kitarō Nishida (Kitarō Nishida, 1989). According to him, the reality of the present as the field of contradictories, the past contradicts with the future. The present as the contradiction between them establishes the flow of the time. His statement implies that the past and the future are flexible depending on the perspective to stand. Thus, a temporal moment is conceptually contradictory because it can be past or future. The temporal space that can cancel or hold this contradiction is the present. This present will be transit to another present while cutting some past and including some future. Nishida states that this alteration of the present is the flow of time.

2.1 Nshida's philosophy

At first, I would like to present the theoretical basis of the self. The current study theorizing the self as the state of a cognitive system is based on the absolutely contradictory self-identity or unity of opposites by a Japanese philosopher, Kitarō Nishida (Kitarō Nishida, 1989)[1]. According to him, the reality of the present as the field of contradictories, the past contradicts with the future. The present as the contradiction between them establishes the flow of the time. His statement implies that the past and the future are flexible depending on the perspective to stand. Thus, a temporal moment is conceptually contradictory because it can be past or future. The temporal space that can cancel or hold this contradiction is the present. This present will be transit to another present while cutting some past and including some future. Nishida states that this alteration of the present is the flow of time.

Nishida identifies *the Unity of Opposites* in his essay named as this term as follows:

> The world of reality is a world where things are acting on things […]. But this mutual acting on things means that things deny themselves, and the thing-character is lost. Things forming one world, by acting on each other, means that they are thought as parts of one world. […] But when things are thought as parts

- [1] The English version, *The Unity of Opposites*, has been published by East-West Center Press in 1958. The e-book of the original text is uploaded in Aozora Bunko (http://www.aozora.gr.jp) in 2001. The original text is the same title published by Iwanami Shoten in 1989 (ISBN-10:4003312465). I have read the e-book in Japanese but refer to the English version for quotations.

> of one whole, it means that reality is lost. The world of reality is essentially the one as well as the many; it is essentially a world of the mutual determination of single beings. (Kitarō Nishida, 1958)

The world is the field of interaction among individual things, which are also the constituents of the world. However, if individual things have been considered as only the parts of the whole, the world would be just deterministic and fall into a paradox. At the same time, the ontological existence of beings would be vague when the world is considered as the field of interaction. Interaction among individual things demands its subjects to alter their state so that the thing before interaction and after interaction essentially cannot be identified as the same existence. These opposites are both the principles of this world, even though they contradict each other. The present is where this contradiction is unified. In this sense, the world of reality is the field of unity of opposites that 'absolutely' contradicts each other, according to him.

The question here would be how we should conceptualize the contradiction. Nishida states that this contradictory field spatiotemporally transits its states from the present to another present. Nishida states:

> The fact that in the present the past has passed and not yet passed, and the future has not yet come and yet shows itself, means not only, as it is thought in abstract logic, that the past is connected with the future, or becomes one with it; it also means that they become one, by negating each other, and the point, where future and past, negating each other, are one, is the present. Past and future are confronting each other, as the dialectical unity of the present. […] In so far as the present is the unity of the one and the many, as well as of the many and the one, and in so far as the present is a space of time, a "form" is necessarily decided, and time is destroyed. […] But this present, as unity of opposites, is decided as something which is to be negated, and time moves on, from one present to another present. (Kitarō Nishida, 1958)

In the present as the field of contradictories, here, there are two pairs of contradictions: one and many, and past and future. Owing to time's flowing as present to present, the contradictories are unified, and this unity is manifested as a phenomenon in this physical world. Or, due to the unity, a phenomenon happens as a supervening property of this physical world upon the time flow. Whether time could exist or not without phenomena happening would be a critical argument; however, here I would focus on only the unity of

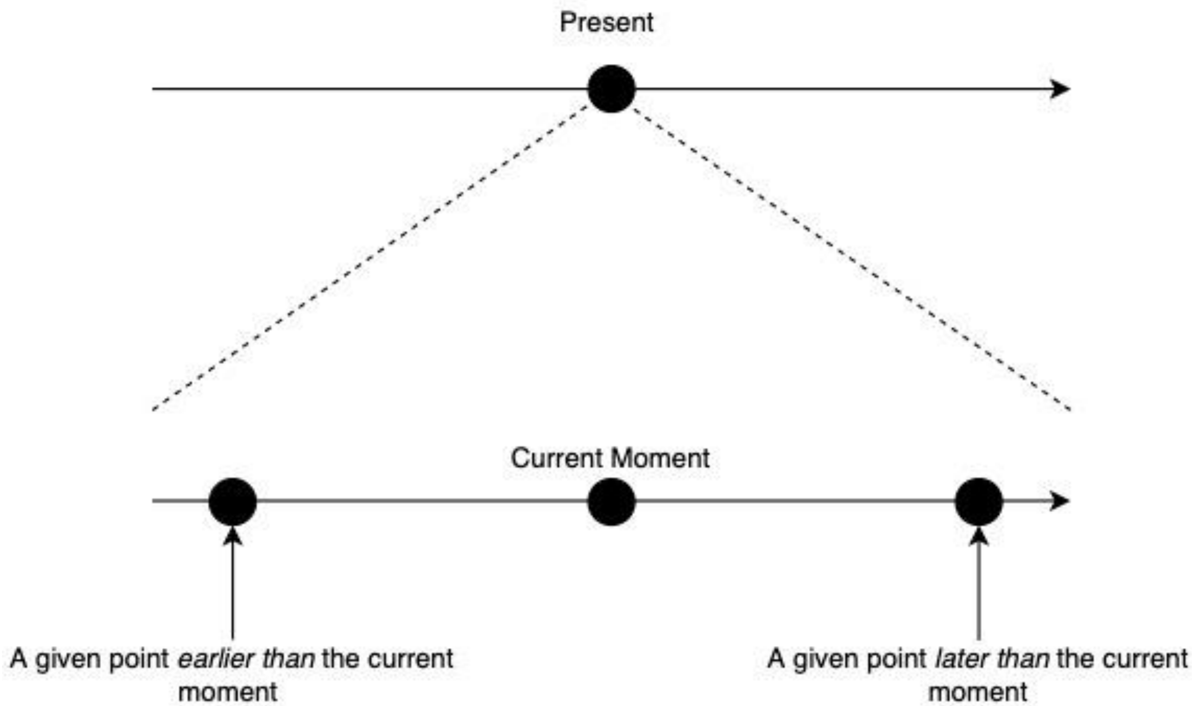


Figure 2. *The scale of the time flow*

The present has the range for the subject of the transitional phenomena. The subject of the phenomena exists within the range between the former than the current moment and the latter than the current moment. The transition would occur owing to this contradictory situation for the subject and the objective present. When the phenomena pass through the present, they will a fact and become part of the objective past.

contradictories and flow of the time.

In the beginning, the present to the past and future is expanded into the scale including the three points: *current moment*, where a subject of a phenomenon is located, a point *former than* the current moment, and a point *later than* the current moment (see figure 2). Past and future within the present become the relative concepts in this sense. For instance, taking the point of view at the point former than the current moment, we may consider not only a point later than the current moment but also the current moment, where a subject of a phenomenon is located, as the future. Similarly, taking a point later than the current moment, we may consider the current moment as the past.

Another notable notion in Nishida's contradictory is singularity and plurality. Going back to the first quotation above; when considering this world as the absolute single existence, Nishida indicates that the things composing the world are interacting with each other. However, the plurality due to the existence of components must be negated because the interaction among the things means that the things alter their states or conditions by effects from each other. Thus, any kind of property of a thing at a moment cannot be rigid to refer to it from this view to define the world as the absolute singularity. In contrast, Nishida also states that a thing has to be part of the whole. In this perspective, the thing must be with concrete existence. If this is the case, there must not be interaction among things, and the world is just a sum of its components.

In the former case, there can only be a flow of time as the sequence of change, whereas there can be only space in the latter case as the field occupied by fixed existence. To follow Nishida's ontology of the physical world, these two opposites have to be compresence of the world. In other words, it has to allow the subjects of interaction to exist definitively as they are the existence of things as the subjects of interaction. Moreover, it has to be the result of interactions that negates the subjects' definitive existence. In this regard, Nishida suggests as follows:

> That the one is the one of the many, indicates space character; the mechanism has the form: from the many towards the one; it means movement from the past into the future. On the contrary, the fact that the many are the many of the one means the dynamic time-character of the world; purpose and evolution have the form from the one towards the many; it means movement from the future into the past. The world as unity of opposites, from the formed towards the forming, is

essentially a world from present to present. (Kitarō Nishida, 1958)

Let me start with the latter half of this quotation, for the sake of ease of explanation. ‘From the one towards the many’ here refers to the part of the world as follows: from a given moment—where would be considered as the current moment—, the moment later than the given moment would be the future—these moments are within the present that I mentioned above. Also, there is a target condition at the moment later than the current moment as the ideal goal for transition(s) from the current moment, though this target condition does not ‘exist’ at the moment later than the current moment nor is not guaranteed to be going to exist. This target condition provides the reason to actualize one among numerous options in the current moment as a phenomenon. The phenomenon happening in the current moment is, in this sense, purposive or teleological from the point of view from the target condition. Thus, ‘From the one towards the many’ can be said in different words as such: from the target condition towards the current moment holding multiple potentials. The future provides the drive of altering. However, if the world only has this aspect, there are no options to be actualized as a phenomenon. Therefore, as Nishida says in the first quotation here, there is no thing’s character. A property of a thing is what allows the thing to appeal to its surroundings for the sake of establishing relationships or interaction as the thing itself with others. In the world only with ‘from the one towards the many,’ however, there is no what interact; there is only direction and drive of transition to happen.

‘From the many towards the one’ complements the part of the world above as follows: from a given moment, a moment former than the moment would be in the past. These moments are within the frame of the present as same the relationship between the given moment and its future. The state of the current moment is the result of the sequence of moments former than the current moment. The phenomena that had happened in the sequence, from the standpoint of the current moment, have become facts, which do not have any other potential, differently than the current moment. Therefore, the state of the current moment is the result of those facts having occurred as phenomena, so the relationship between the state and those facts must not contradict a mechanical explanation. This is to say that ‘From the many towards the one’ is synonymous with ‘the moments that have already been facts towards the state of the current moment as their result.' This half of the world is where a moment is alienated from an occurrence of a phenomenon. Thus, there are the 'things-characters' in the state of the moment. As existences forming the state, they are concrete because they are the results of what has already happened. Those concrete existences are the subjects of the interaction and provide the options to be actualized as a phenomenon.

The present including the current moment as the core and the other two is where these two absolute opposites are overlapping. In one aspect of the present, things do not exist because they interact with each other to lose their ontological identities and to make a phenomenon occur. On the other hand, things do exist as the results of what has been happened and true already, to form the world at the current moment. In physics, there is a quite clear thought experiment devised by Schrödinger, known as Schrödinger's cat (Schrödinger, 1935). The cat inside of the steel chamber is, indeed, the state under the absolute contradictory between the two opposites; the cat and the other components consisting of the setting of the thought experiment have held the concrete existence until the moment that the chamber is shut to be separated from the outside. From the moment, the two different states, dead or alive of the cat, are overlapping during the period, where the cat is in the chamber. Then, when it is opened, the result of the interaction is to be recognized as the fact having happened as a phenomenon. The current moment that I have mentioned above, in the case of the thought experiment, is the state of the inside of the chamber. Concrete existences consist of the world inside of the chamber, and there are the target states, where the state inside of the chamber is supposed to transit, although the target states are on the bifurcation of if atomic decay would occur or not. When the world inside of the chamber is observed, the phenomenon that occurred at the current moment is determined as a fact, and the current moment becomes a part of the past. The current moment shifts to the next moment accordingly to the occurrence of the phenomenon. While the current moment becomes a past moment, the truth value is given to the target state at the moment later than the current moment.

The significance of Nishida's ontological view is that it can be taken as an epistemological discussion and does not fall into the dichotomy between West and East, namely the microscopic view and macroscopic view. We have been observing the world and the phenomenon with the perspective of 'from many towards the one,' following Nishida's idea. This is to say that we have only considered the facts that have been concrete as the results of the past. Western ideology and scientific or analytical view developed from the ideology captures the facts composing the world owing to their concreteness. Then, to reveal the nature of those facts, we investigate the relationship between the condition of the target in the past and the target at the moment that it is observed. In other words, we have been considering the relationship between two different points in the past as science. On the other hand, Asian thoughts, especially Buddhism and the thoughts developed from it, states that there is no concrete existence since all kinds of existence and phenomena keep transiting into a different state. This perspective does not allow the things to be there; it completely alienates its ontology from the past, which provides the concreteness to the things. Considering Nishida's text, he established a bridge between West and East in the ideological realm by theorizing ontology. In this sense that Nishida's unity of opposites does not negate any kind of epistemological views, it is truly holistic.

It is reasonable to consider Nishida's unity of opposites in the context of cognitive science in the following points. At first, Nishida's unity of opposites is an ontological statement that seems to be able to apply to any kind of phenomenon. It is obvious to see from the first line of the essay, 'The world of reality is a world where things are acting on things.'(Kitarō Nishida, 1958) Second, the idea is an Asian holistic attitude to observe the ontological nature of this reality; yet, does not negate the contribution and view attributed to Western ideology. If we accept that the world is functioning as such, it is non-negligible to include, as our knowledge about the world, the contributions of conventional science telling us about the nature of a target object at a moment in the past and the relationship between them at different moments in past.

The attempt to theorize the subject of cognitive phenomena is, in fact, analytical in a sense because theorization is to dismantle a cognitive system as a continuum and to analyze the structure and the constituents. However, the significance of Nishida's idea and its utilization for the investigation of cognition is that, even though the self is separated from the system, fundamentally, the self has tabs to bridge to both the past and the future because of the inclusion of the unity of the contradictories. Owing to this feature of the basis of the theoretical model of a cognitive subject, it would be smooth to discuss issues of the continuum from the state.

Especially, the biggest issue or difficulty of the current subject of study is capturing the transition. For the analytical perspective of conventional science, it is difficult to deal with an object that keeps moving because the perspective does not hold temporality. However, owing to the feature of the theoretical basis based on Nishida's idea, the nature of the subject of cognitive phenomena can be analyzed; at the same time, this basis allows how the subject could establish a temporal relationship with other subjects from the same system to be considered.

2.2 The nature of the subject of cognitive phenomenon

Based on Nishida's idea, the nature of the self that is the subject of a cognitive phenomenon is the state located in between the two contradictory states. This state is, in other words, where to be ready to shift towards the next state because the state holds the potential to be various states in the following moment owing to the locus that the system had experienced before. Therefore, readiness is established within the present for the subject system. Note that the self is only ready to alter its state rather than is ready to be a certain state. The potential states included by the self are not committed as the self's following states even though it takes an action with the intention to be a certain state within the potentials because the transition cannot be executed with consideration of intervention for the transition by the other systems' transitions in the field.

The present is embedded on a certain temporal time scale that we could perceive through the change of states of surroundings. The analog clock is a good example of this temporal time scale. Suppose that you realized that the minute hand had moved from 1 to 2. By this difference, you 'perceive' passing 5 minutes; however, it does not mean that you perceive the temporal sequence itself rather you perceive objectively the change of state of the clock symbolizing 5 minutes passing. I would call this temporal sequence that we may perceive objectively the "objective temporal sequence." The present consists of the elements coming from three different temporal sections: the former than the current moment, the current moment, and the latter than the current moment. Here, I would call the sequence going through those three sections the “subjective time sequence.”

The self in each moment is ontologically different, even though the system of the selves is identical. The state is based on the range of the present that the subject may relate to. Thus, the selves of a system in each moment cannot be identical because the basis of the self, including its location and its condition, can never be the same. Then, the question would be why we could identify ourselves in the previous moment as ones at the current moment. The possible answer to this question may be found when focusing on intersections between the states at the former than the current moment and ones at the latter than the current moment.

Precisely, the contradiction between the former and the latter than the current moment plays the role of a bridge. Within the states before and after a cognitive phenomenon, there are still mutual features. Thus, the states of course have the same past because, as a continuum, they are identical in existence. Also, for the future, the current state anticipates the future state after taking an action or transition. Moreover, when it comes to developed cognitive systems, they have the facility to check if the state after the transition or the transition itself is match with what the system anticipated—called efferent copy (Jeannerod, 2003). At least, our bodily structure would not change radically in short term, so the efferent copy would function to control the body while providing the sensation of subjectivity for bodily movement.

The self is the result of the locus of the system; at the same time, it is the aggregation of subjective potentials to direct to the following moment. The contradictory state, where is one fact as the result of the locus that the system has experienced and, simultaneously, where is the set of the possible states that do not exist yet, is the nature of the subject of the cognitive phenomenon. Owing to this contradictory condition within the subjective time scale, the system may have “created” the fact for the past of the objective time scale. Also, by being a contradictory existence, it can be the constituent of the present and an influential existence for the future that has existed yet.

2.3 Supervenience of the self

The objective time scale for subjective existence is the sequence of points. The points are created by the subjective existences while transiting their own states to different states. The transitions of the constituents of the field of the objective time scale make the present different from the points in the past. The difference created by transitional phenomena is objectively observable for the constituents, and they could recognize the time sequence by perceiving the difference. On the other hand, the subjective time sequence is, for the subject of the sequence, unperceivable because it is the field merging the former, the current, and the latter owing to the contradictory state of the subject.

Although the objective time scale is the sequence of points for subjective existence, the present is also the point that is located between the facts and potentials due to the contradiction of the constituents. Actually, the objective time scale is just a relative notion; supposing that there could exist a subjective existence of the objective time scale, for the subject, the sequence of points would become seamless among the past, the present, and the future. Therefore, the difference between the subjective time scale and the objective time scale is just the difference in the point of view.

The significant issue is the relationship between the self as the current state of a (cognitive) system and the present as the moment in the temporal sequence or the objective time scale and as the field of interaction among its constituents. In other words, it is the relationship between the subject(s) of transitional phenomena on a smaller scale and the subject on a bigger scale. This structural relationship is important because it can be applied to the scalability of complex systems developing the stratum structure of physical reality.

To get straight to the point, I would suggest that the relationship between the subjects is supervenience. The significant issue is the relationship between the self and the present. The self is the state of one of the creators of the objective sequence, and the present is “the self” of the objective time scale as the system. This structural relationship is important because it can be applied to the scalability of the complex system to develop the stratum structure of this physical reality. The supervenience relationship between the self and the present could be considered as follows (Leuenberger, 2008; McLaughlin & Bennett, n.d.):

> Supervenience is the idea of "There cannot be A-different without B-difference" when "a set of property A supervenes upon a set of property B."
> This can be expressed formally as follows: $(A \neq A') \rightarrow (B \neq B')$
> Hence;
> 1. $(A \neq A')$ and $(B \neq B')$ true
> 2. $(A \neq A')$ and $(B = B')$ false
> 3. $(A = A')$ and $(B \neq B')$ true
> 4. $(A = A')$ and $(B = B')$ true

Now, let me consider the specific case of the relationship between the self and the present. To think of this case, it is necessary to implement the possible worlds. *W* in the following argument indicates the possible world where the self and the present are located.

> The sentence, "the self supervenes upon the present," can be expressed in a formal language as follows: $(self_{W1} \neq self_{W2}) \rightarrow (present_{W1} \neq present_{W2})$
> Hence;
> 1. $(self_{W1} \neq self_{W2})$ and $(present_{W1} \neq present_{W2})$ true
> 2. $(self_{W1} \neq self_{W2})$ and $(present_{W1} = present_{W2})$ false
> 3. $(self_{W1} = self_{W2})$ and $(present_{W1} \neq present_{W2})$ true
> 4. $(self_{W1} = self_{W2})$ and $(present_{W1} = present_{W2})$ true

Where I would like to point out is the difference between sentences 2 and 3. For 2, it says that it cannot be the case, where the presents in the worlds *W1* and *W2* are identical though the self or selves of the constituents are different from the other. For 3, it says that, even in the case where the self or selves of the constituents of the present are identical in both worlds *W1* and *W2*, the present in the worlds could differ from the other.

It could be hard to imagine the case where sentences 2 and 3 are consistent simultaneously; however, this relationship, supervenience, is reasonable when it comes to the relationship between a complex system and its constituents, which are also complex systems. Even though the constituents' states are the same in *W1* and *W2*, the state of the presents in the world can be different in each world since the state of the present is based on not only the states of the constituents but also the emergent properties developed by the interaction among the constituents. The detail will be discussed later; the self's following state does not exist at the moment before the transition. What exits is the state of the subject. Hence, the result of interaction does not exist either yet because the interaction happens because of the transitions of the subjects in the field. In short, although the state of a higher scale might be expected by states of agents in lower scales, it is impossible to talk about the state of the present while only considering the selves of its constituents.

In contrast, it is clear that, if the self or selves of the constituents are different in *W1* and *W2*, the presents in the worlds must be different from each other because it means that the sets of potentials of the present or the locus of the temporal sequence is different in each world. In fact, the situations where the sets of potentials are different and where the locus of the temporal sequence is different might indicate the same. The self is the result of the locus of the transition of the continuum and the set of potentials that are the result of the relationship between what the subject has gained through the transition and the condition of the surrounding at the current moment. If this is different in the worlds means that the scale of the difference is the objective temporal time scale, and the difference had occurred before. Even focusing on a constituent and supposing that its locus is identical in the worlds; if the set of potentials is different, it means not only that the present is different due to its potentials also different but also that the surrounding, which is the part of the present, is different. Moreover, to reach the results as the different surroundings for a constituent, the locus of the objective time scale has to be different in the two worlds.

Most probably, most of the phenomena in physical reality, or at least cognitive phenomena, can suit this ontological structure. In other words, the subject of the smaller system composing a larger scale system supervenes upon the subject of the larger scale system. Also, the fact is that cognition goes through the time sequence. The present is the state of the objective time sequence. In other words, the present is the self of the time sequence as a system. To exist on the time scale means that a cognitive system contributes to the development of the objective time sequence as one of the constituents of the larger scale system. Then, the issue could be how the cognitive system exists on the objective time scale or a part of its state. Next, let me discuss the structure of the selves of cognitive systems as the constituents of the present.

2.3.1 The former than the current space

This section of the self, the former of the current moment, corresponds to 'knowledge' relating to the situation, where the subject is located. Knowledge, at least what I bring up as the subject matter here, can be classified into roughly two types: ability and semantic memory. Those features are the ones extracted from the experiences as a subjective system. The terminology 'knowledge' might mislead to that matters of this kind have to be contentful in the sense of the argument for intentionality. However, here, knowledge refers to both contentful and contentless matters. Semantic memory must be contentful because it can be the target of intentionality, whereas the ability does not have to be because this type of knowledge partially depends on the exterior features.

Ability is to know how to exercise the subject's properties contributed from the past of the objective time scales, or to know how to utilize tools as the extensions of the physical bodies. This type of knowledge cannot be there by itself. To be in the cognitive field (the current moment) demands the corresponding property (what the cognitive subject may extend towards) and the environmental feature that can be related to the ability.

To take an action for cognitive transition, the features of the cognitive subject have to be related to the environmental feature (Chemero, 2009). To relate the cognitive subject itself to the corresponding environmental feature, the subject needs to have the bodily morphology and 'knowledge' to exercise the morphology upon the environment. Some morphological aspects come from the individual objective time scale and others come from a higher scale objective time scale. For example, the morphologies acquired in ontogenetic development should be considered as the properties coming from the past in the individual objective time scale, whereas the ones acquired through phylogenetic development are considered as the properties coming from the past in the higher objective scale.

I consider that the distinction between properties and abilities strongly connects to learning. Let me define a body a little differently from its common concept. Most probably, from the common perspective, the body refers to our individual and physical body covered by skin to partition off from the exterior. However, as the subject's body is the interface of the self to get related to the environment, I would define it as a set of abilities. The physical body of the subject may include the properties contributed by the development. The subject's body has to include these properties for the sake of the establishment of a relationship with the corresponding environmental features. However, it does not mean that, if the physical body has properties such as morphological features, the subject may relate to the corresponding environmental features automatically.

The process of acquiring abilities to establish the corresponding environmental features is the process of learning. The subject expands the realization of ownership through the development. In addition to that, the subject could obtain abilities to exercise the properties through experiencing or action with them (see figure 3). The first exercise of the property should be intentional. It should be the actual action for the transition. After the process gets done, the ability allows the subject to get related to the corresponding environmental features automatically. Thus, when there is a corresponding feature out there, the relationship between the ability and feature, which is called affordance (Chemero, 2009), cannot be unrelated to the cognition of the subject located at the present because it involves the field of relevant affordances (Bruineberg & Rietveld, 2014; Rietveld, 2012). The personal field composed of affordances makes one or more affordances stand out from the other. Therefore, just considering this aspect of the relationship between the constituents of the former than the current moment and the environmental features, the self is unique because the options for the affordance to take an action depends on what is available at the moment both from the subject's side and the environment side.

In this sense, abilities are acquired through the subjective temporal scale, which is the locus of transition. This locus plays a significant role for the self because it provides the set of options upon the location of the self.

Semantic memory in the sense of the idea of Endel Tulving (Tulving, 1986) is also significant for the self in the same sense as the abilities, although this type of knowledge might be special for advanced organisms. This type of memory plays a role in symbolic manipulation. According to Tulving, "semantic memory involves general, abstract, timeless knowledge that a person shares with others (Tulving 1986)." As well as abilities, the subject may obtain semantic memory through experiencing the surroundings. The

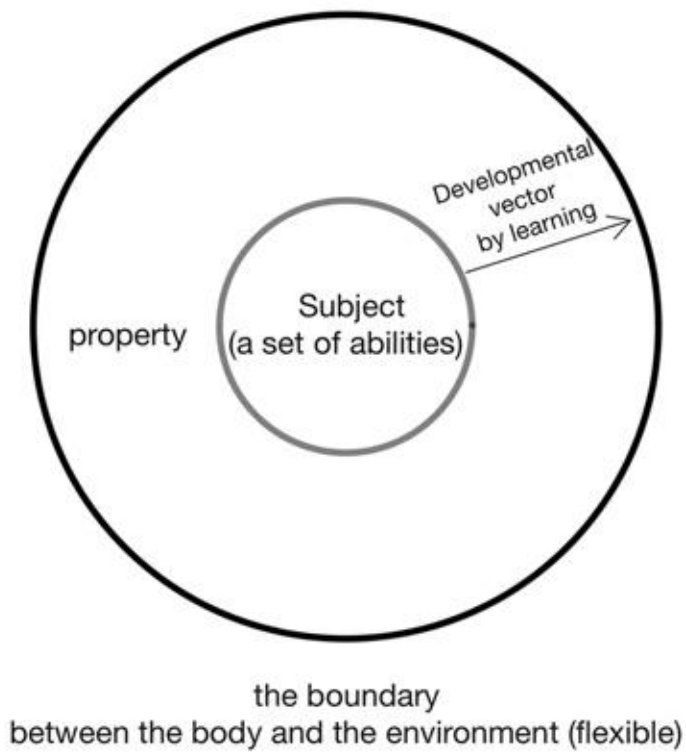


Figure 3 *The extension of the subject through the former than the current moment*

The subject of cognition develops or learn the abilities that are how to utilize its properties. The set of abilities may relate to the environment as a whole to make options to pick up the best way of transition. The boundary is flexible because the subject may include the tools as the parts of body (Extended body).

difference between these two is whether they hold contents or not. In other words, semantic memory is independent, whereas abilities' existences in the current moment interdepend with the environmental features.

Although the episodic memory is categorized as a declarative memory that is the same category as the semantic memory, the characteristic is distinctive from the semantic memory. In short, retrieving through episodic memory is not to recall independent information, but rather to locate the subject itself in a virtual situation similar to what has happened to the subject. Therefore, it is a cognitive action rather than bringing knowledge to the present for the sake of the establishment of the field of cognition. The autonoetic consciousness, which is the basis of the episodic memory, places the agency on the imaginal environment. To recollect an event in the situation in the past is, thus, to reconstruct the environment and to place the subject's agency on the environment. Same as the situation currently going, though virtually, the subject may take an action, similarly to the moment that the subject tries to remember. This simulation of the moment in the past is the process of memory recollection as episodic memory.

The former than the current moment consists of these types of knowledge, and there must be more than what I have briefly mentioned here to consider. Cognitive subjects bring abstracted matters through the locus of experiences into the current moment. In the case of human beings' cognition, we have the facility of memory to store symbolic information, so that our selves may include this section relatively bigger. However, any kind of cognitive entity cannot be alienated from its history of existence. For the single-cell organism, it is impossible to store the symbolic information inside of its body; however, the morphology, which has been developed throughout the (objective for the individual organism) history of the species or throughout the individual (subjective) history of experiences, may allow the organism to act easily upon a certain environmental feature.

2.3.2 The latter than the current moment

This section represents a set of possible states that the subject anticipates. Each possible state is a destination of transition with an action for the subject. Owing to this set of anticipation, the potential to be of the subject in the coming up moment is reduced to the smaller infinite number of the possible states from the infinite logical possibility.

Each possible state is embedded in the whole. The gravity to pull towards an option emerges in the whole of the latter than the current moment. Therefore, In the case that there is a stimulus above a threshold, the state where the subject would attempt to actualize by action would be decisive; however, in most cases, the relationship among the states must be complex. Due to this complexity, when the possible states composing the whole of the latter than the current moment and the possible states do not stand out from the other, the subject would take an action that is the result of the emergence due to the complexity of the section of the self.

This complexity is similar to the field of relevant affordances that I have mentioned in the previous section (Bruineberg & Rietveld, 2014; Rietveld, 2012). Each possible state is embedded in the whole to affect the self to transit. Therefore, even if the elements of the set are similar to another, the influence on the transition from the set as a whole completely differs from the other. Moreover, since there are other factors affecting the development of the section of the subjective temporal scale, the effect from this section is impossible to comprehend objectively.

Another significant aspect of this section to mention is that none of the possible states can be actualized exactly as it is. A possible state in the set is anticipated from the subjective perspective, meaning that the set is all about the states of the subject. The state coming up to the next moment is the result of all the complex phenomena of coexisting systems. Therefore, although it might be possible to obtain the situation where the self is located as objective data, it is impossible to forecast the future state for both the subject itself and the objective perspective. In this sense, I would say cognition is a “creative” phenomenon because a situation that does not exist in any sense at any moment, even in the situation including imagination and anticipation, of the current moment, before emerges owing to cognition.

This section might be also misunderstood as an action allowed by autonoetic consciousness. The mental time travel to the future is to simulate the possible future for the sake of making a plan for the path of a series of actions (Schacter & Addis, 2007; Schacter, Addis, & Buckner, 2008; Schacter & Madore, 2016). This simulation should be considered as an action, so this section as the set of possible states is fundamentally different from this action. In other words, the latter than the current moment for the subject should include the possible state as the result of the mental time travel that is similar to the actual state coming after the action. Owing to the state after mental time travel to the future, the tendency or the direction of the transition might be constrained in a teleological way. On the other hand, the latter section is thoroughly the set of possible states in the next moment. This action-based influence from the possible future perspective and the set of possible states are different in how influence the current moment and also what kind of facilities it requires to do.

2.3.3 The current moment

The current moment is the intersection of existences relating to the cognitive subject for its cognitive phenomenon. In the spatiotemporal space, various things co-exist. The co-existences with the subject establish the environment for the subject, as well as the subject would be a constituent of the environment for others. The abilities of the subject coming from the former section would be paired with the environmental features for affordance. The pairs develop the set of the possible states as the results of actions upon the available affordances.

Simplifying the relationship between the former and the latter than the current moment, the figures, from Prigogine and Stenger's work (Prigogine & Stengers, 1984), represent how these sections affect each other in the field of the resent within the subject as the intersectional spatiotemporal space. See figure 4. In this figure, the solid lines represent the 'stable' condition of a system. However, the system would take the path of A-B-C, instead, A-B-D owing to the 'sensitive dependence on initial condition' of this complex system's demeanor. Therefore, as the system, it has the potential to take D in the latter than point B; however, the previous condition of the system plays the role of threshold to make itself transit to C.

On the other hand, figure 5 from the same work by Prigogine and Stenger represents the condition where the previous condition cannot say anything for a system's future path. In this symmetrical bifurcation, both paths as the system's condition after the

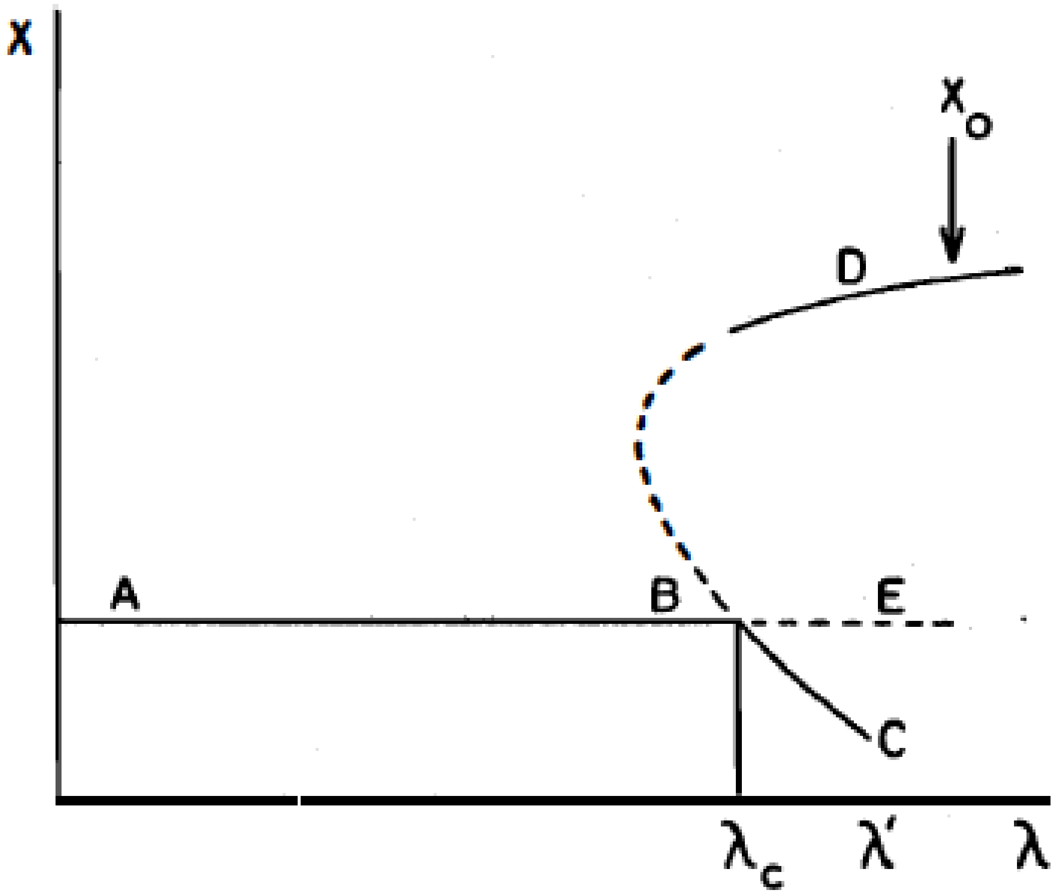


Figure 4. *Asymmetrical Bifurcation* (Prigogine & Stengers, 1984)

The potential locus of *f (λ)* from λ_c can be D or C; however, owing to the previous condition A, *f (λ)* takes C (sensitive dependence of initial condition).

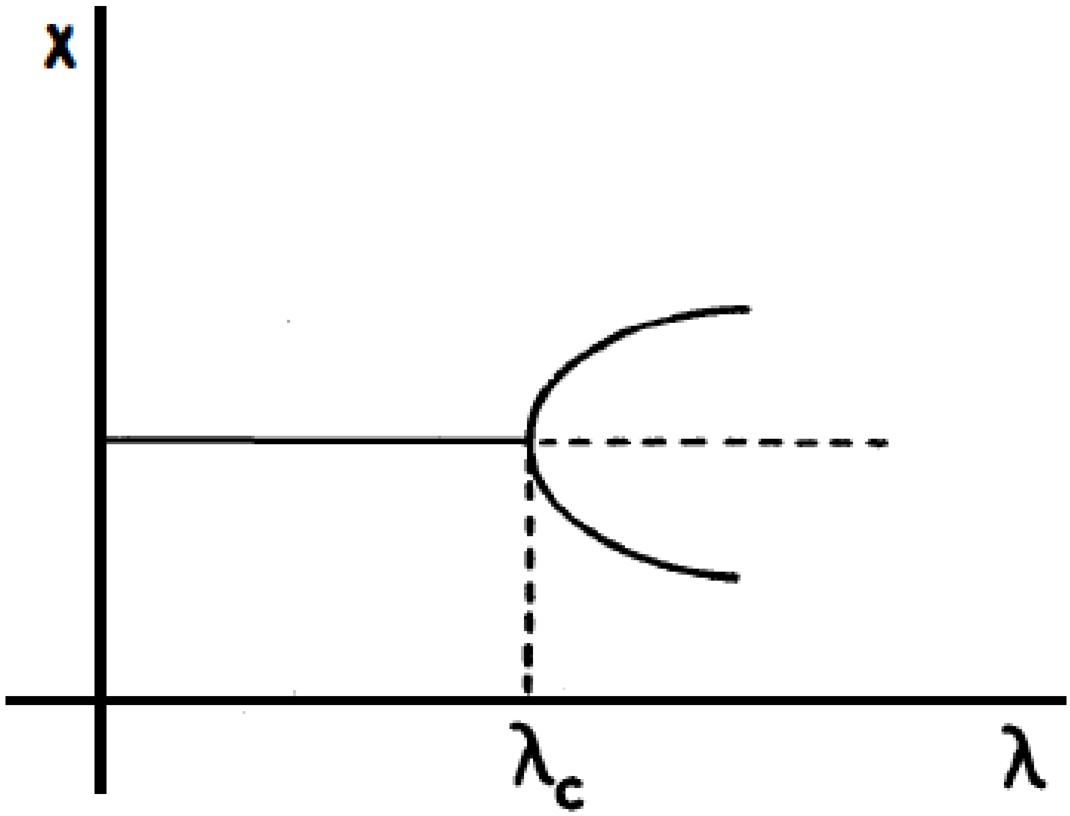


Figure 5. *Symmetrical Bifu*rcation (Prigogine & Stengers, 1984)

Here, I would borrow the words for the description of this figure from Prigogine and Stengers, "How will the system choose between left and right? There is an irreducible random element; the macroscopic equation cannot predict the path the system will take. Turning to a microscopic description will not help. There is also no distinction between left and right. We are faced with chance events very similar to the fall of dice."

$\lambda = \lambda_c$ would be stable. Nothing from an objective perspective can tell which way the system would take.

The self of a system could be considered as the collective of relationships between the former and the latter of the current moment represented above. Therefore, the condition represented in the figure could be considered as the relationship among the spatiotemporal location of the system, an ability, and a potential locus to be stable according to the location and the ability. Moreover, the functions upon similar relationships in the figures would influence each other for what the stable condition of the system. The current moment would be the field of mutual influence among the functionalities. In addition to this chaotic situation within the self, the system is located in a space, where other systems exist and execute transition upon their own states.Owing to this chaotic condition of the current moment, it will never be possible to forecast the future condition of a system. The system's subjective perspective may anticipate those possible states; however, none including the system itself can tell which state it is transiting to. Even if the system transits towards a certain state from the set of possible states, due to the present that numerous numbers of other systems co-exist, the system can never be at the exact state that it transits to, although the real state should not be out from the frame that allows the system to exist. Thus, the future in the objective time scale from the perspective of the present does not exist, yet.

2.4 t = the present to the future

Up to here, I discussed that cognitive phenomena are transitional phenomena by the subject. I have suggested a relationship between the objective time scale and the subjective time scale. Additionally, I have discussed the nature of the self, which is the subject of cognitive phenomena and the state of a cognitive system. Also, the self consists of three subjective temporal sections, namely the current moment, the former than the current moment, and the latter of the current moment.

The present of objective time scale consists of the selves of complex systems at the current moment. Each self transits to another state for the sake of the adaptation to the disturbance at the current moment; however, the result of the transition would not be precisely the same as the one of the potentials at the latter than the current moment. The present is a chaotic field where systems interact among themselves. Therefore, as long as the systems are located in the present, they cannot decide their own state as the fact in the future on the objective scale because the state where the self aims is intervened by transitions of the other systems' selves. In other words, the state in the future does not exist at the current moment.

At the same time, each self's transition is essential for the flow of the time in the objective time scale because the objective time scale up to the present is the sequence of the facts and because the fact is the result of the interaction among the constituents of the present (see figure 6). Without alterations of the states of the constituents, the objective time scale regarding the subjective time scale of the constituents would not exist as a continuum. On the other hand, this time scale is the phenomenon beyond the individual constituents of the present because, in the scale, the constituents are not each subject of transitions, rather they are the "many" constituents of the "one" state. In other words, the individuality of each constituent does not matter on the objective scale, although it does not mean that the states of the individuals do not relate to the present and the future because their relationship is supervenience. Thus, the subject of the (cognitive) transition of this scale is the present, which might be called the "objective self."

The influence of the objective time scale on the demeanors of the individual constituents is, however, considerable. For instance, when it comes to organisms, the representative contribution from the objective past is the genetic information that has been polished throughout the history of the species. Thus, the bodily morphologies as the expressions of genes are the forms of experiences by the species. Then, the system would experience its situation with its morphologies, at first with intention. The experiences with intention would become the abilities to relate to the environmental features. In other words, when a system has bodily morphologies as humans, the morphologies constrain how the system relates to its surroundings. This means that the objective time scale's past directly affects the shapes of constituents' selves.

Figure 6 describes the structure of the self and relationship with objective time scale. The self transits its own state to another that is one of the potentials. Though the transition would not be the exact same as what the self has anticipated, it promotes the interaction among other selves transiting to another state. The result of the chaotic interaction is the state where the objective self transits.

2.5 Problem

So far, I have suggested the subject of the cognitive phenomenon and the nature of the cognitive phenomenon. However, although the self is ready for the transition, it does not have to exercise readiness or transit to another state. As I define above, cognition is a dynamic phenomenon, but just being ready to transit is not enough to be active. A system needs the drive to be dynamic. Explicitly, even though my statements here that cognition is a transition of a complex adaptive system and that the subject of the phenomenon is a state of the system at the present are valid, there is no necessity for the system to transit its state to another. The purpose of the transition is, actually, the adaptation to the following situation. To comprehend cognition, I consider what sense the systems adapt to the new situation as one of the most significant matters.

I consider that the drive for cognitive phenomena is the maldistribution of matter and energy, which I will discuss in the fourth chapter. On the other hand, we know that there is a virtual or digital system that can be expressed theoretically: automata. This virtual or informational system can idle at a state when there is no input, whereas physical cognitive systems keep their states. In the next section, I would present the differences between systems in physical reality and ones in virtual reality and between the types of transitions by the systems within each reality.

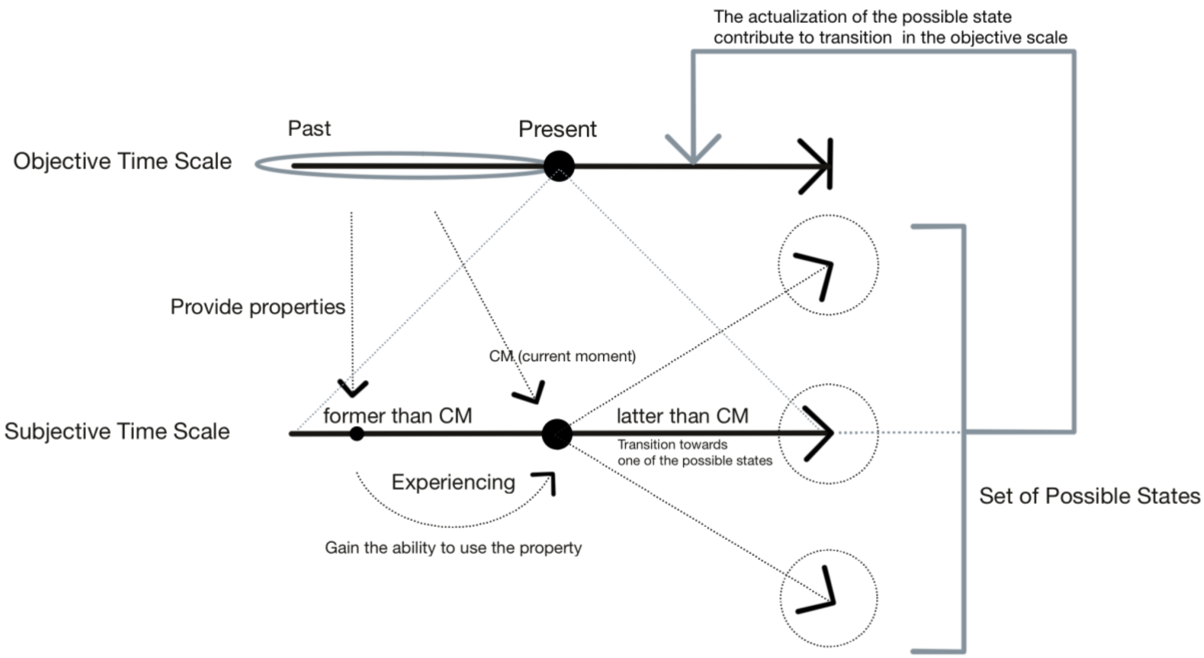


Figure 6. *The detail of the relationships among the three sections of the present and between the objective time scale and the subjective temporal scale of the subject system*

1. The past in the objective time scale (or higher scale) provides properties to the subject system.
2. The subject system has exercised the properties in the section of the former than the current moment and brings them to the current moment as the abilities.
3. The subject system establishes relationships with the spatiotemporal location of the current moment. Based on the availabilities of the actions, the system anticipates a set of possible states.
4. The system takes an action toward a possible state. The actual result will be the ‘future’ in the objective time scale.

3. Transitions and Systems

In the previous section, I discussed the possible nature of the subject of cognition. The subject, which I have defined as the state of a system at the present, alters its state to another in accordance with the total situation where the system is located at the moment. I have defined the transition upon the situation as cognitive phenomenon experienced by the self as the state of the subjective system at a moment. Therefore, I believe that systems that include the state holding spatiotemporal range at each of its subjective moment and is sequential owing to the chain of the states transiting for the sake of the adaptation to the following situation can be called cognitive entities or cognitive systems.

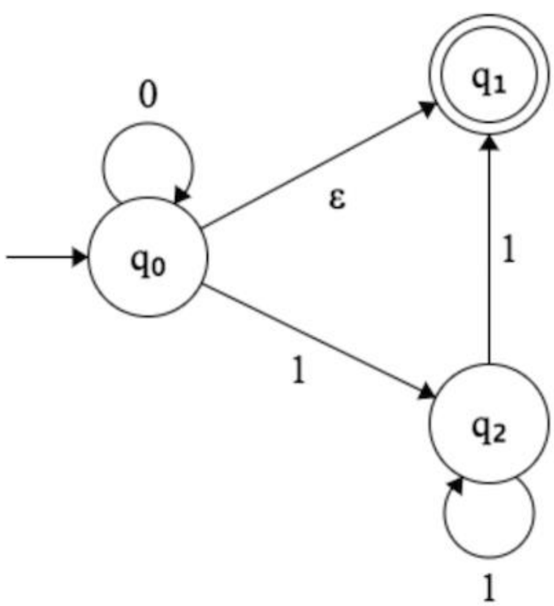
However, generally, the combination of the terms "system" and "transition" could make people think of theoretical computers, such as automata[2]. Here, in this chapter, I

[2] To compare computational system with creative system here, I have thought of automaton as the basis of the structure of systems. Automaton is a theoretical model of computation that consists of 5-tuple: states, inputs, transition functions, accepted states. The computational system indicates exactly automaton, which everything has been set already, and the system's function is just to follow the rules and to transit to the states that exists beforehand. On the other hand, the creative system holds the function to modify its own constituents (the element of the tuple).
If cognitive system may model with the former type, cognitive phenomenon would be deterministic (although the actualization would be intervened by probability) phenomenon, entailing that the whole natural phenomenon might be deterministic since the inputs from the outside of the system would be already set as the element of the system.

would like to make a comparison between the two types of systems, which I call here "computational system" and "physical system" to make it clear that these systems are ontologically different—at least, for now—due to the realities that they exist and the difference of the transitions that they exercise.

In the nutshell, cognitive systems must be physical systems because the systems have to be spatiotemporally open for interaction with other existences being in the same spatiotemporal location. Moreover, the transition that the physical systems exercise is "creative" in the sense that the transition would let spatiotemporal location—the present if it is on the objective time scale—emerge. The following state's inexistence-ness is due to the complexity of the field of physical reality.

On the other hand, the computational system's transition is only the "spotlight" for the states that have existed since when the system was developed. Theoretically, the digital reality that this kind of system exists is defined by computability. Thus, all the states where the system can be located exist, and the transition would be computational based on the process of the previous states and/or the inputs. Therefore, the transition by this system cannot be cognition because it does not alter anything.



Example of a non-deterministic automaton
http://mca.ignougroup.com/2017/01/how-does-nfa-use-epsilon-transitions.html

3.1 To be digital and to be physical

First, I would like to provide an explanation of "being digital" and "being physical." The most crucial point is where being digital is closed and being physical is open. In other words, a digital system is independent of other existences owing to its nature. This independence makes the system demand inputs from the outside of the reality that the system exists. On the other hand, a physical system is embedded in the physical reality, which has the width spatiotemporally. Because of being embedded, the system is ostensibly active for the transition, whereas a digital system has to be ordered by the outside to actualize the transition of its state.

This difference is significant when we consider the nature of systems. Digital systems can exist without the transition and the other existence, whereas physical systems must transit their states upon the situation where the other constituents of the field exist in order to keep the systems' existence. This is because of the nature of the realities in that each type of system exists. The digital reality does not have a time axis because the system or the reality will never change its states or, in other words, its potentials, whereas the physical systems could not exist in the physical reality without alteration of their states—or even the reality cannot exist without the constituents' alteration because the temporal movement possibly emerges owing to the constituents' transitions.

3.1.1 To be digital

A digital system, because of its virtuality, does not have to or even cannot alter its state and function its functionality if there are no external inputs. Where the external inputs come from and where the system exists are distinctive; the system would just function upon the inputs, but the result of the function would not affect anything as it is in the physical reality. Thus, digital phenomena do not have any means unless there are an intentional input and an interpreter who finds meaning from the phenomena and converts them into physical meanings that are the constituents of the current moment.

The representative system of this type is computers. It does not have to change its state if there are no exterior inputs because the system is closed and completed. Completeness here means that the set of potentials of a system is already determined. Moreover, in most cases, the inputs are with intention of the users of the system. The transition of the system's state would be meaningful to the users according to their intentions rather than for the system itself. In other words, the processes of the systems of this type are well designed to fit with the interpreters' demands.

For the sake of interaction with the exterior, the system owns the interface. The crucial difference between physical systems' bodily morphology and this interface is that the interface does not affect the process of the system whereas the bodily morphologies and modalities to relate with the exterior environment influence how the system would react to what it got through them. Specifically, to write in a text editing application, it does not matter for the application if I type a keyboard or use sound inputs in the case where the content itself does not change between the type and the sound. However, even though the matter of the stimulus itself is identical, the difference in the sensory modality for the perception would generate a difference in how the system relates to the target stimulus.

The ontological size of the digital reality could be compared with a state of the temporal sequence. In other words, digital reality is comparable with the state of physical reality that time stopped. Supposing that the space of this physical reality is spatially infinite, the set of infinite facts has been set and existed at the moment emerging the state of the reality. Then, since time is stopped at the moment, the set of facts is also fixed and never alter. The potentials of the theoretical computer are also probably infinite; however, the infinite number of states has been set since when the computer has invented or since the moment the Turing machine had invented. Therefore, what digital systems or computers can do is to direct a spotlight on the states that already existed, and more importantly, the set of the states does not change.

3.1.2 To be physical

Physical systems are the systems functioning upon the physical reality. Due to its physical embodiment, a system must keep function and execute transition upon the relationship with other physical systems (and existences). In other words, the system keeps changing its state as long as it is a physical existence and as long as it exists as the same system. Also, the reality where the physical existences are located can exist as such owing to the physical systems altering their own states to another. The system is ostensibly autonomous, meaning that the system takes an action without intentional inputs from the outside from the range or the world that it exists in, whereas the digital system demands them for its functionality. Moreover, physical embodiment forces the system to be under the physical principle. The principle is about the micro-level interaction; however, the superstructure consisting of the micro matters is also under the principle. Therefore, how we could define a system or its constituent might be a matter of scale and level of complexity.

One might say that computers are embodied as physical existences. Then, she might say that the actualized digital existence should be discussed as a physical phenomenon. A good comparison would be the mental reality and the digital reality. At the glance, mental reality is comparable space with digital reality when considering our physical body as something similar to the device for the digital system. However, for the computer, the device itself is the physical existence, but what the device actualizes is isolated from this physical reality, whereas our mental reality is a part of this physical reality. The alienation between digital reality and physical reality would be clear when it comes to time. As I mentioned above, digital reality does not have a time axis, whereas physical reality has. This is because the present alters its state to another due to its constituents' transitions. The interrelation between mental phenomena and physical phenomenon ensures the embeddedness of our mental reality in the physical reality. Our mental reality cannot be separated from the selves that are embedded in and a part of the physical reality.

Also, another significant difference between a digital system and a physical system is whether there is a limitation for the actualization of existence. The detail of this limitation comes following part in this section; roughly speaking, the digital existence can hold huge states in concrete, whereas the physical system holds only selected states that would remain as part of the system. Thus, the selves of physical systems can include a limited amount or range of the former than the current moment, whereas the digital systems theoretically could include the whole locus of the process for the calculation. However, the physical system can create and develop its own state upon the physical reality that also creates and changes, whereas digital existence is fixed since when having emerged. This means that both types of systems are constrained by their locus to be at the current location; however, the digital system is within the limitation of the set—even with an infinite number of the state—, whereas the physical system is free from the limitation because there is no option to be actualized due to the system's openness to interaction with other existences in the physical reality.

3.2 Transition

In this part, I would suggest that there are roughly two different types of transitions: computational and creative. Computational transition is to transit upon the state and inputs, and it is executed under the probability when the state is branching off into two or more states. This type of transition might hold two subcategories: one occurring in digital reality and one occurring in physical reality. The creative transition is to transit the system's own state to the state that does not exist by the moment of transition. The creativity of the transition also holds two subcategories: one to develop the larger scale's state and one to modify the system's own state. The following state on a larger scale and the state, which the system's self transits its state to, do not exist at the present. In the sense that the transitions let the non-existed state come to exist, these two types of subcategories are creative. computational transition and system cannot simulate the intelligence manifested by the creative system; however, the creative system cannot be creative without the computational aspect. After explaining each transition and system, I would present the arguments that can be developed once thinking of these distinctions.

3.2.1 Computational transition

When a transition is computational, the state before the transition holds the disposition to be the state after the transition. Thus, when a system confronts a certain condition—the representative case is inputs—, a system transits its state to a certain state while showing corresponding demeanors. When a computational transition is defined as such, the simplest example would be the computation of theoretical computers with deterministic and non-deterministic transitions. Deterministic transition refers to the case that, when the system is in a state and receives an input, the following state is already decided. On the other hand, a non-deterministic transition is when a state has more than two directions for the same input. Thus, the following state where the system would be is not determined at the current state; however, the possible following states are set, which means that it has to be distinguished from the creative transition.

Physical systems also implement computational transitions. However, in this case, the computationality of the transition is an epistemological matter. Thus, depending on the point or the scale of the observation, the transition could be computational or not. For instance, human individuals are physical and creative systems when observed from the same scale as these systems. However, from point of view of the larger scale reducing human individuals as agents or constituents of a system, their demeanors are computational. For the individuals and the larger systems sufficiently near in scale, each action should influence the transition of the other systems and the systems that the individuals belong to. However, from the epistemological view from a sufficiently large scale, human individuals would be, for instance, reduced to computational existences with the disposition to cease its existence after a certain period of time.

3.2.2 Creative transition

Creativity, here, refers to the capacity to make a state, which has not existed before, come to emerge. As I mentioned above, the creative transition includes two different types: one to develop the larger scale's state and one to modify the system's own state. For the former one, being physical or existing in the physical reality makes the systems such. The present in this reality is the field of the chaotic interaction among the systems existing there. The result of the transition would not be always the same as the one from the anticipated states, which the self has aimed for, because of the intervention from other selves' transitions. In this sense, the transitions of the selves in the present create the following present. The following present does not exist at the moment before the transitions, at all.

Another type of creative transition allows the system to modify its ontological nature. The system's nature is the sequence of the states that have altered their previous state to the following state. In each transition, the system has created its new state. Anticipation for the potentials in the present is the possible states as the results of the transition in ideal conditions for the transition, whereas the state that the system is in the following moment is the result of the whole present and also of the loss of the part of the system. For this creativity, computationality of systems is a precondition because the constituents from the systems' locus through the former than the current moment is held at the current moment as possibilities to show dispositions. The abilities coming from the former than the current moment correspond with the environmental features to develop the relationships to manifest the potentials to take action (Chemero, 2009). Owing to the readiness for the environmental features there, the self can be intentional towards what the system has to adapt and can take an action in order to the adaptation. As a result of the action, the self transits itself to the state including the fact that the system experienced the disturbance and without the abilities lost owing to the "decomposition" of the system. Therefore, the things gained through these transitions are the computational aspects of the system; at the same time, the decomposed parts of the system due to the transition are also the computational aspects of the system.

Moreover, this type of transition that creates the state of the system is available owing to computationality that the system holds. As I discussed in the previous chapter, the latter than the current moment is the set of potential states. Each potential state is dispositional as the state after the transition by a certain action—at least, phenomenologically for the subject—when excised from the self as the whole. When a number of these simple dispositional relationships get together, the set develops a chaotic field of potentials, which interfere with each other to change the dispositional relationships. Due to this field of interference, the transition would not be accomplished as what the self has anticipated. The creation of the new state—at least, new for phenomenological

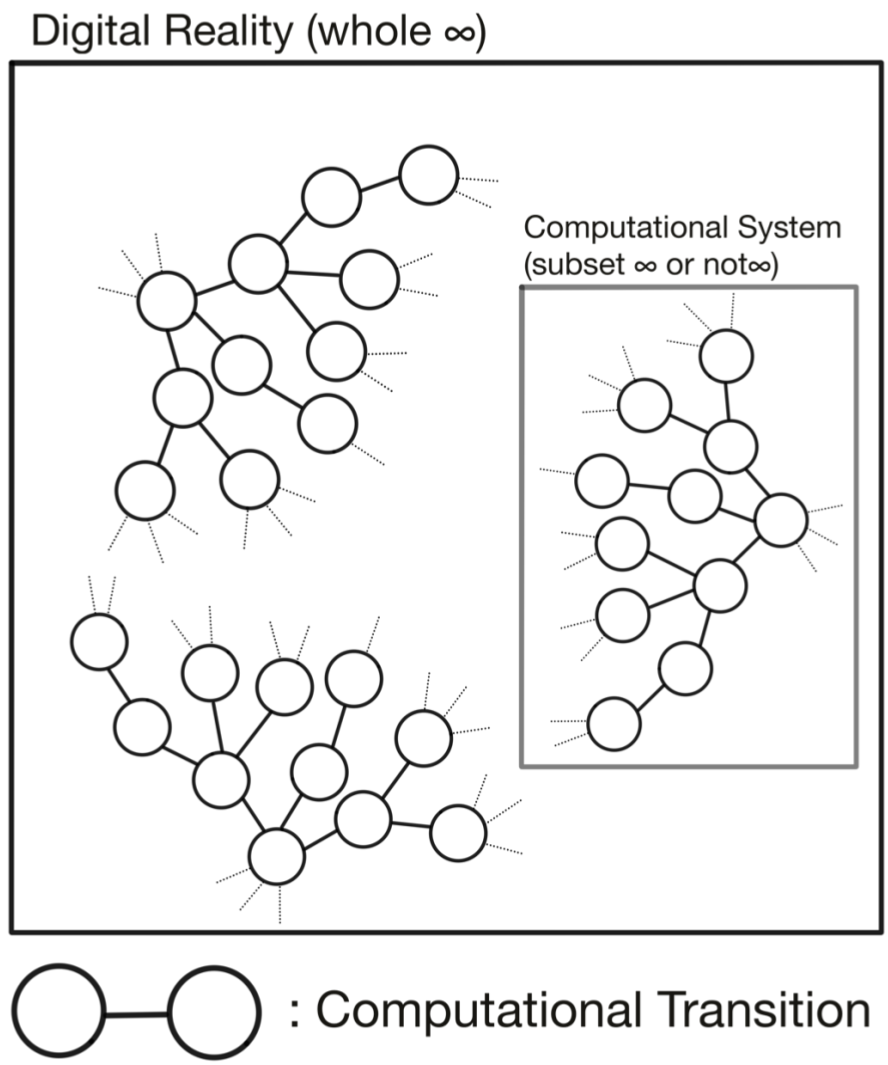


Figure 7. *Computational system in digital reality*

Computational systems in digital reality are sets of states and computational transitions. The sets, then, are the subsets of digital reality described as the square in this figure. Computational systems' transition is to transit within the states described as the circles. Digital reality may include an infinite number of states and transitions so the variety of forms of systems in this reality is also infinite. However, the reality and systems there are fixed. For this reason, it cannot be "creative."

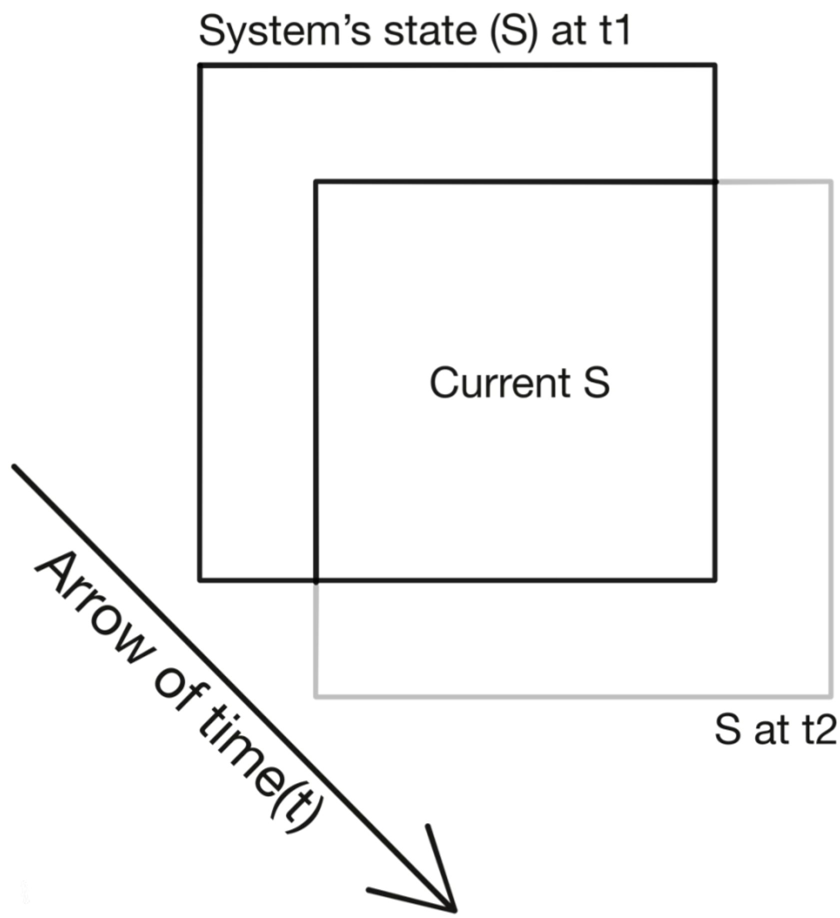


Figure 8. *Creative system and its transition*

The squares in this figure represent a creative system's states or the selves before the transition and after the transition—the square can be interpreted as physical reality, also. The significant point of this figure is the outside of the current state of the system (*Current S*). When transiting to *t2*, the system loses the outside of the current S of S at *t1* and obtains the outside at *t2*. The whole system at *t2* does not exist at *t1*; how the state would be cannot be known before the actualization of the state. In this sense, the system is creative, and also, the reality including one or more creative systems may develop itself as a sequential continuum.

perspective, maybe not for the perspective from the larger scale—by the self holding the field is the exercise of the creativity.

3.3 Systems

Based on the attributions and the functionalities that I have discussed above, I would like to discuss systems' types. Computational systems are, literally, systems functioning only computationally. This type of system consists of 5-tuples. The 5-tuples are fundamentally the nature of the systems so that the computational systems cannot alter their states to another state in the same meaning as creative systems. On the other hand, creative systems are the ones with the capacity to alter their ontological nature. In the case where the self is considered as the combination of the system side and the environment side, The system's side of the self largely depends on the former than the current moment. In other words, —though it is impossible for the creative systems to exist in the following supposition—supposing that the environment did not exist for the system, the self would consist of what the former than the current moment contributes. The self of the system in this case could be quite similar to the computational system in digital reality regarding being deterministic or relying on probability; however, the creative system would still be able to alter or develop the set of states for the self, whereas the computational system could not. This is the significant difference between these two types of systems.

3.3.1 Computational System

Computational systems that I call here are ones that systems as a whole consist of computational transitions (see figure 7). This means that the entire states have existed since the moment of the emergence of the system. In the case where the systems exist in the digital reality, compared to the nature of the digital reality, computational systems can be considered as subsets of reality. More precisely, the digital reality could be defined by the computability of the Universal Turing machine. Computational systems in digital reality, then, should be possible to be simulated by the theoretical computer, so that computational systems are the subsets of digital reality. Therefore, the computational systems in digital reality cannot be creative or exercise transitions likewise the creative systems, fundamentally.

Suppose systems that are the subsets of digital reality can modify their nature. The nature of this system is 5-tuples to function within the structure of the automata. Thus, the modification of nature would mean altering its functionality. This would be possible to do; however, it is going to be only deformation, extension, or shrinking within the reality, which has the definitive and fixed ontological nature defined by things that already existed as possibilities. Therefore, it is out of the definition of creativity from what I have set.

For this explanation, what I mean by referring to creativity might become clearer. If the systems in the digital reality want to be creative, they have to gain the parts that have not existed in the digital reality. Therefore, the reality capable to transit its state like the objective time scale is a necessary condition for systems to be creative. In this sense, as I mentioned above, the present of the objective time scale is ontologically comparable with digital reality.

Computational systems in digital reality can be categorized into deterministic and non-deterministic.

Determinism considers the reality that we exist as a deterministic system or the deterministic digital reality. Since the occurrence of a phenomenon wholly depends on its previous state, the state existed at the state of causation. By induction, this cause-and-effect relationship between the states before and after leads that every phenomenon in the past, now, and future in this world has been decided when this universe originated.

Non-deterministic is the state after the transition will be decided by probability. The probability would be processed when there is the possibility to be a state. Therefore, in this case, only when the states blanching off from a state have existed, there is a probability. Thus, even when the system's transitional path has not yet been decided, every state, as the whole of a system, must preexist. Therefore, the transition of a computational system is "spotlighting" one of the preexisting states.

Supposing a cognitive system is this type, the spatiotemporal location of the subject system has already existed since the moment of the origin of the system of the physical reality. The reality that the subject system 'cognizes' is a part of one of the numerous or infinite numbers of nodes on the way to reach the result of the system of the physical reality.

3.3.2 Creative System

I believe that this system's type includes cognitive systems such as organisms. The distinctive characteristic of creative systems from computational ones is that the system transits to states that have not existed yet at the current moment (figure 8). In this sense, as I mentioned above, I would like to define "creativity" that the capacity to create something that does not exist in the current moment of creation. The system as a whole keeps changing its ontological nature at each moment. The computational system is ontologically the same even when it executes transition because the set of states has already existed, and what would change due to the transition is the part of a preexisted whole where the current state of the system is located. On the other hand, any state of a creative subjective system had not existed at the moment of its birth. Then, by transition, the system develops its own ontological nature, while actualizing the state.

As I mentioned when discussing creative transition, the creativity of a system would be manifested in two ways when the system actualizes the transitions creatively. One way is that transition promotes the interaction among the other systems or existences. Due to the chaotic interaction, the present as the field of interaction becomes a complex creative system, which is capable to "create" its following state from non-existing conditions. The other way is the phenomenon having similarity in scaling with the manifestation of the creativity that I have shown here. It is to say that the self of a creative system would be the field of interaction that creates the system's following state. The agents in this scale that interact with others chaotically would be the computational aspects of the system.

The precondition to be creative is, then, to have the computational aspect in the system. However, this creative system's computationality is the epistemological computationlaity, which is different from the characteristic of the systems existing in digital reality. Therefore, the agents themselves might hold complexity, but it would seem to be computational from the scale of the system as a whole (figure 9). For this point, I would

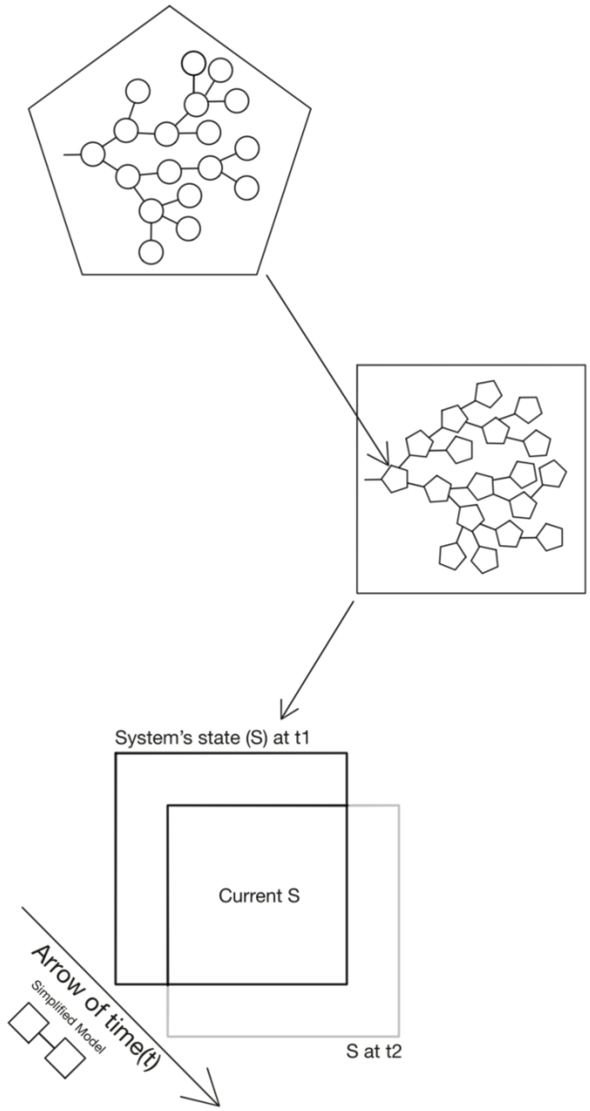


Figure 9. *Relation between computational aspects and creative aspects in a creative system*

Computationality in a creative system is epistemological because the system holds scales in its structure. The transitions in each scale in physical reality are creative in the sense that the transitions actualize phenomena that have not existed up to the moment of the actualization; however, on a macro scale, the transitions on a micro scale approximate to be computational. At the same time, the creative transition on the macro scale develops the computational aspects on the micro scale.

like to go further into the details; the systems with creativity in physical reality are embedded in the scalability of reality that will be discussed in the following chapter.

Not only the computational system allows a system to be creative, but also creativity allows the system's computational functions extended. By learning the pattern to act upon the situation, the system can develop a more complex field of anticipation, or it can be intentional toward a different aspect of the situation. I take affordance as an example. In a broad sense, a cognitive system can establish a relationship of affordance owing to learning. The system cannot relate to an environmental feature at the first moment of confronting the feature. As I mentioned in the previous section, it is the case that the system only has "properties," not abilities corresponding to features in the environment. However, if the system can establish the relationships with the other features smoothly, it can be intentional to the environmental feature where it relates to the first time. This is because the automated process to establish the relationship would open up the space for the process of the new situation of something equivalent to working memory. Then, when being constant, the relationship would be a constituent of the subject's field of relevant affordance, which would make the system find another environmental aspect. Therefore, computation allows the system to be intentional toward a new thing, and the creative system may gain new computational functions through being intentional and learning.

I would present a more concrete example. Suppose bodily movements are the lowest in the structure. We can walk on our feet without thinking (or even unconsciously in some cases). The reason that we can do so is that walking against gravity has become a computational process. Then, because walking is semi-automated, we can be conscious or, at least, consciously intentional toward the action taken while walking. Therefore, what we are conscious of is based on the (semi-)computational process. If this hypothesis is true, the contents of consciousness are about what we have not faced by the moment to be conscious. Plus, at a moment, for the system, walking should have been conscious level. Considering the case of infant of human beings, even when they had legs as their bodily properties, they cannot exercise them. Later, as they grow, they start to exercise the relationship between their bodily morphology and environmental feature. They may 'learn' to walk because the ground and gravity are constant environmental features, then walking becomes a less conscious action for them. When the exercise of the relationship between a bodily ability and an environmental feature becomes constant, it can be learned, meaning it can be computational to a certain degree.

In other words, it can be also said that creativity for an individual system is to gain new computational functions through creative functions (plus, it is to abandon the part that is not used any more—I would detail it in the next chapter). If we could define the system's ontological nature as the set of the states that the system has passed; developing the new computational functions, the system's nature becomes different from the previous one, whereas the complete computational systems' nature would not change for transition because the set of states that the system would pass has existed already.

3.4 Conclusion and observation for current AI

The question would be if a creative system can be expressed in or as a digital system. The hot topic these days (2022-2023) is if artificial intelligence (AI) can be equivalent to human intelligence or not. Services that we had not been able to think to be actualized have come up such as *ChatGPT* and *DALL•E 2* invented and distributed by the company, Open AI [3]. These services are based on machine learning with reinforcement learning from human feedback (Ouyang et al., 2022; Ramesh, Dhariwal, Nichol, Chu, & Chen, 2022). These AI-based software seem surprisingly to be creative—in the sense that may provide aesthetic experience—and communicative. However, if my ideas exhibited here hold validity, including the assumption that cognitive systems are creative systems, at least, the current technology cannot develop digitally an intelligence device the same as the intelligence of organisms. What we are calling AI can never be creative because its format is the computational system. Everything that can be processed with the computational device has "existed" already since the emergence of the computing device. What comes in sight as a phenomenon in this system is what is spotlighted as the current state of the subject system among the numerous possible

[3] These services are available from the website of Open AI: https://openai.com/

states. Owing to a closed range of possibilities, the system cannot create or get out toward a state within the range.

Why we are deceived that the result of computational processing is a phenomenon created by a system of the same kind as us, even though the system is artificially invented, is that the computational system's range of possibilities is infinite. This misunderstanding is owing to the misconception between "infinite" and "nothing." The range we can recognize is extremely limited compared to infinity. So, once we confront new expressions within the infinite possibility, we believe that the expression is the created phenomenon that has not existed before the moment.

Additionally, digital matters' being isolated is also a barrier to the development of creative systems. something creative cannot exist within the fixed whole or as a fixed existence. The creativity of a system is due to the capacity to transit to a state that does not exist up to the moment of the system's transition. For this creativity, any kind of existence in the physical reality is creative to a certain degree because the state of the reality as a whole at a moment does not exist before. The constituent of reality alters its nature, when the state of reality changes, as its constituent. Moreover, if the constituents' states are not decisive up to the moment, then the physical reality's state cannot be decisive because the reality is the field of interactions among its constituents. On the other hand, supposing that several digital systems exist within a digital environment. This environment would not alter its state to anything because, for the digital phenomenon expressed by the current technology, the Turing machine can express any digital phenomenon in the digital reality. This indicates that any phenomenon in the digital reality that we could deal with with the current technology has existed already, although the range of the reality is infinite. Therefore, the result of the systems' functions including the result of interactions among the systems had existed and was determined already.

It is reasonable to consider a cognitive system as a creative system because the beneficial aspect to believe in that way is that the system does not need so-called intelligent design. If the cognitive system consists of only computational transitions, an infinite number of the sets of tuples for transitional functions for an infinite number of situations has to pre-exist. Moreover, when the system interacts with another system, which is a quite common phenomenon in any situation, the system has to be previously ready for any kind of action of the other. This consideration concludes that each system must have the knowledge as the universe. It has to know about everything relating to the system at a moment, plus everything relating to everything relating to the system. If there is no fault in space, all the matter should be linked in this relational chain. Thus, the system has to exist based on the knowledge of everything.

A system capable of the creative transition does not need the existence of intelligent design. Also, it is natural to think that the cognitive system is creative when considering self-organization and other phenomena that will be explained in the following section.

4. (Possible) Principles of Cognition

In the previous section, I suggested a cognitive system is creative and exists in the physical reality while referring to the ideas derived from theoretical models of computers. A cognitive system must be creative for now as long as the universal Turing machine is the strongest computational model. If we could invent a computational model that may exist in an isolated world from physical reality and the system (or even the whole reality) keeps changing its ontological nature, it might be possible to invent an equivalent system with natural intelligence like ones of organisms. However, it seems that our current technology has not achieved to actualize it, yet.

The question would be, for now, how we could define “being physical.” What aspect of this reality different from the virtual one allows the creative system to emerge? What makes systems existing in the physical reality keep altering their state? To answer those fundamental questions to consider cognition, first place in this section, I would like to present brief but still relevant ideas within non-equilibrium thermodynamics and complexity theory. For non-equilibrium thermodynamics, I refer heavily to the ideas of far from equilibrium and dissipative structure from Ilya Prigogine and Isabelle Stengers. Owing to these principles, at least, I could hypothesize how a system emerges from “particles,” the simplest and most primitive existences. For the complexity theory that is also under the principle of non-equilibrium thermodynamics, I would like to list the relevant ideas to cognition mentioned by Ezequiel Di Paolo while putting the definition of complex systems by Melanie Michell as the basis. By running through the ideas, I could see how complexity plays the role of the basis of the creative system’s alteration of its own state.

Finally, I will provide my view to define cognition based on the ideas and theories that I presented here. Also, I would like to analyze the process of transition. The subject matter of those ideas, especially non-equilibrium thermodynamics, is mainly a micro-scale phenomenon; however, although a certain type of complexity is escalated for organisms' cognition, the basic principles should be applied to any level of scale.

The significant points appearing by considering cognition as a phenomenon occurring because of far from equilibrium conditions as the precondition of the phenomenon and as the demeanors of complex systems are as follows. At first, cognition becomes secular and physical. Even though each type (or species) of cognitive system is peculiar, they function under the same principles as physical complex systems. Second, the perspective may include the contributions from the analytical perspective to investigate cognition or the case of human beings' cognition. The mechanisms of specialized faculties or modules for cognitive functions can be revealed by the analytical perspective that has been the dominant ideology in cognitive science. However, the faculties are the robust properties of a cognitive system and the results of cognitive phenomena. Therefore, to understand the mechanism of a cognitive system, it is necessary to comprehend the way of emergence of the aspects that we could capture with analytical perspectives. Then, how they can contribute to the system's complex cognition would be the subject matter. Moreover, the complexity theory may provide a possible explanation of how those specialized faculties. Third, by considering cognition from this perspective supposing thermodynamics and complexity theory would be the fundamentals of cognitive science, a new question could come up. Of course, to answer a question, the supposition must be valid; however, this means that the perspective may provide new subject matters to science, which is a quite crucial point for a methodology.

4.1 Non-equilibrium thermodynamics

Non-equilibrium thermodynamics, especially far from equilibrium thermodynamics, is the basis of cognitive phenomena in physical reality. The theory holds potential not only as the basis of demeanors of physical cognitive systems but also feasibility to theorize how a system organizes itself from the whole.

As I mentioned in the previous section discussing the self, a system's state at one moment differs from one in another moment. The state is the result of a transition from the previous moment. Thus, the state must alter, at least, for two different senses. One is that the system is located in a spatiotemporally different location. Where the subject system is currently is the result of the interaction among the systems existing in the space. Another is that what the system may bring to the present is different from the other moment. Since the system had experienced a phenomenon upon the previous present, the system's body to relate to the environment is different from any other moment.

Thus, the cognitive system exists in the irreversible temporal sequence. Rather, if something transits irreversibly, then there should be the flow of time in the field in which it exists. However, what makes the system transitional to make the field flow temporally? Or does the field make the system transit? Considering digital reality, which does not have a temporal sequence, a system does not have to alter if there is no external input. On the other hand, we as cognitive systems must keep altering our states.

Digital reality is in the equilibrium condition, where everything is stable. Therefore, the reality and the systems there do not have to transit to another state because they have reached the ideal situation since the moment of their emergence. However, in physical reality, the non-equilibrium condition is "ubiquitous" (Jaeger & Liu, 2007), or rather, the whole reality might be non-equilibrium.

If a system is under the non-equilibrium condition, especially where it is sufficiently close to equilibrium; generally, the system goes forwards to be equilibrium. When reaching to equilibrium condition, the system would stop functioning ostensibly, although the constituents of the system continue to interact with each other. The systems close enough to the equilibrium condition would keep changing their state while directing towards equilibrium, but the important thing is that the systems' function is linear and replicable. It is computable. In this sense, in the situation where they exist, there is no flow of time because, same as the digital reality, as the whole situation, it would not change anything since every state there has existed since the system being near-from-equilibrium.

On the other hand, being far from equilibrium shows non-linear and chaotic demeanors. The significant point is that the demeanors in the far from equilibrium in which the system would be located are unpredictable, whereas the near-equilibrium situation would be all given once the initial condition is decided. Thus, to consider the creativity that I have defined previously, far from equilibrium thermodynamics is a better perspective to implement as the basis of the study of cognition than the other scientific view that only can deal with linear type occurrences.

Moreover, the demeanors of the system in far from equilibrium condition seems to hold a part behaving to be distinctive from a whole. A new system within a whole is developed while organizing itself to create a new whole. This may be the tentative answer for why a most basic cognitive system has occurred.

The discipline is quite complicated and covers a broad range that an amateur, like me, cannot understand wholly. So, here, I would like to pick up the small parts that I could deal with and that can relate to the discipline of cognitive science, directly.

4.1.1 Far from equilibrium

Literally, it refers to a condition far from equilibrium. A near-equilibrium system gets closer to the equilibrium state, whereas a system in far from equilibrium conditions would show peculiar demeanors, such as self-organization while taking a dissipative structure.

To understand this idea, it might be better to mention a state in equilibrium. In an isolated system, when entropy, the measurement of dissipation, is at maximum, it can be said that the system is in equilibrium. Basically, entropy only increases in the macroscopic view[4]; thus, a system in equilibrium is completed as a system.

Conversely, the far from equilibrium condition is developed when a high gradient of energy and entropy occurs in the field. The gradient is too 'far' from equilibrium, so the field shows specific behaviors. The representative phenomenon is the emergence of the dissipative structure. It seems to me that, for some reason, the field gives up reaching

[4] Schrödinger states that the organisms maintain entropy that they hold at a low rate while 'feed on negative entropy.' (Schrödinger, 1992) However, even though we, organisms, may maintain the entropy low; macroscopically, entropy is increasing while taking what we need to feed ourselves and living in our lives. In this sense, we are peculiar physical phenomena to be considered from a local perspective, but, as macroscopic physical phenomena, we are not exceptional for the natural tendency that entropy increases (Planck, 1903).

completion in the global field as a system. Then, the field establishes the structure for the sake of the establishment of its own equilibrium or steady state due to the qualitative distance from the global equilibrium. The point of shifting the attractor, where a system directs to be, from one to be the global equilibrium to the one to get separated from the field might be the division point of ‘near’ and ‘far’ from equilibrium.

Conventional science has been focusing on phenomena in the equilibrium or near equilibrium to study, so it seems to us that those phenomena are normal in this physical reality. However, as I mentioned, the systems under equilibrium or near equilibrium do not exist in the temporal sequence or do exist within a limited temporal sequence. The system in equilibrium or near equilibrium apparently stops, though the constituents keep changing their states. An “apparent stop” is the stop of the functionality of the system from the objective perspective. Thus, this system cannot contribute to the creation on a larger scale owing to its crystallization and closedness. On the contrary, the matters existing in this physical reality keep moving and altering their states. Those actions and alterations make where they are located change and make it temporal. For this reason, phenomena that are crystalized durably and permanently should occur quite rarely in the physical reality, which is on the temporal flow.

For the cognitive phenomenon, a subject system keeps transiting its state to state. Being far from equilibrium is the fundamental drive for systems to keep being the systems themselves alongside this physical reality that always has a gradient in space.

4.1.2 Dissipative structure

When there is a sufficient thermodynamic gradient in the field, a dissipative structure will appear. This organized structure makes itself an open system distinctive from the global field. Moreover, this structure allows the system itself to function constantly to organize itself—self-organization.

The formation of this structure from the global field provides ontological identity to the system. When the dissipative structure emerges, the structure generates outside and inside of the structure. This discrete system from the global field, which is the outside, would establish a relationship to organize the system itself with the outside.

More interestingly, the system's inside itself can become a global field. When the steady state of the relationship between the system and the surrounding is perturbated, fluctuation within the system would occur. Once the fluctuation is big enough to cause far from equilibrium, a discrete system would emerge within the system. Thus, the structure could develop the structural fractal pattern against the system including the structure. This is thought to be as one of the reasons that the complex system could develop scalability.

4.2 Complexity theory

One of the significances of complexity theory to discuss cognition is its scalability; far from equilibrium thermodynamics can be considered as a type of complexity theory, or the sight from a different point of view in scale, than organisms or other relatively macro scales. The crucial difference between them is that far from equilibrium thermodynamics ideals with the most basic matters such as energy and entropy as the direct reason for a system's demeanors, whereas complexity theory would talk about individual agent's functionality as the cause of emergent functionality of a system. Therefore, it can be said that, within the range of our recognition so far, thermodynamics can talk about the principles for the emergence of a system and that the complexity theory can be the basis to study the system emerging from the principles and systems scalable from the most basic one.

4.2.1 Definition of a complex system

According to Mitchell, there is no definitive science of complexity nor 'a single complexity theory' (Mitchell, 2009). Different fields of science have different stances to investigate their subjects of studies from complexity theory. However, the following properties of systems are the common features of complex systems. Thus, the representation of a phenomenon, such as dynamic, informational, computational, and evolutional phenomena would be different for each discipline; however, in all cases that can be observed as a complex non-linear phenomena, the system showing such demeanors should satisfy the following definition:

> "A system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution." (Mitchell, 2009)

Or according to Uri Wilensky in his lecture for an online course for agent-based modeling organized by Santa Fe Institute (Complexity Explorer, 2018):

i. Systems with a large number of interacting parts evolving over time.
ii. Decentralized decision vs Centralized control.
iii. Emergent global patterns from local interactions and decisions.
  —Emergent phenomena
  Structure (rules) at the micro-level leads to the pattern at the macro-level.
  Order without design.
  No leader or orchestrator of the pattern.
  Probabilistic centralized control (interaction of distributed 'agents')
    —Even if knowing the micro, we cannot predict the macro.
    —Even if knowing the macro, we cannot find the micro generating the macro.

Complex systems consist of numerous agents with relatively simple functions. A complex system is a collective system or higher-order system owing to its composition. For instance, a social phenomenon such as economics is a result of the demeanors of society as a complex system consisting of relatively simple agents, human beings. Theoretically speaking, those social outcomes are not due to a single controller nor due to a central system within the whole system. Rather, the outcomes of the system's demeanors are owing to the collective of its constituents. Moreover, most interestingly, the agents' behaviors for local interactions among the others develop emergent phenomena within the system as a whole.

Emergence within a complex system can only be described as the system's global pattern as the result of interaction among the agents, without any kind of designer. The cause of the pattern is spatiotemporally distributed among the agents. In other words, emergence would happen as the result of when constituents act upon the interactions among others. However, the result would be different, even though a constituent acts in the exact same way because the interaction among the constituents is chaotic. So, for emergent properties among complex systems, there is no such general pattern for emergence. As Wilensky (Complexity Explorer, 2018) says, we can be predicted neither the emergent pattern of the system from the constituents' capacities for actions nor the capacities from the emergent pattern.

Although the term itself is ambiguous, the emergence allows the system to exist where the system is located physically. As a field of interaction among others, the environment keeps changing too. The system must adapt to the surroundings in accordance with the environmental transition. The single agent would not be able to adapt to alteration because the constituents' functions are too simple to deal with the environment of the system to which they belong. For instance, an organism may not adapt to radical environmental change; however, as a species, it could be possible to deal with the change through evolution. An individual agent is too simple to deal with the change, but as a whole species, in this case of a whole system that the individual agent belongs to, it might be possible to adapt to the radical alteration by changing itself toward bodily morphology fitting to the environment, although each agent's response to the environment is essential for the adaptation.

As well as adaptation, the following characteristics are the special features of complex systems. These are possible because of emergence owing to the numerous constituents interacting with others.

4.2.2 Self-organization

According to Camazine et. al., self-organization is defined as follows:

> Self-organization is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system's components are executed using only local information, without reference to the global pattern. (Camazine et al., 2020; Prokopenko, 2013)

As defined above, a complex system consists of numerous constituents interacting with each other. Self-organization is to develop a pattern in the system not depending on the system's properties or functionality. The emergence of the pattern in the system is thoroughly the result of interaction among the constituents; moreover, there must not be a top-down force from the system to its constituents to specify how to behave for interaction.

In the scale of thermodynamics, self-organization occurs owing to a dissipative structure. At that level, the most interesting point is that not only the system is organized by the constituents but also the outside and inside of the system emerged. Due to the development of the ontological nature of a system, the concepts of robustness, adaptability, and scalability become valid (Prokopenko, 2013); and the system may show the demeanors relating to those concepts.

4.2.3 Adaptivity

Ezequiel Di Paolo defines a system’s adaptivity as “a system's capacity, in some circumstances, to regulate its state and its relation to the environment (Di Paolo, 2005, 2009)” At first, a system has to adapt to the environment for the sake of maintaining its identity as a continuum. If keeping a state regardless of the environmental change, the system will be outside of its viability-set and lose its fundamental function, such as its facility to be autopoietic, to be a system, which means that the system will disappear ontologically.

To adapt the environment for the system, it is essential not only that the system acts upon the environment but also that the system takes balances its alteration upon the environment with its previous condition. In other words, the form of the system after adaptation to the environment depends not only on the environmental factors, such as fluctuation, perturbation, or disturbance but also on the system’s current form.

Let me bring Bénard cell as an example. Bénard cell is the representative example of a dissipative structure. In the case of Bénard cell, the media of energy or agents that develop the structure are the liquid or its molecules. The energy gradient between the bottom and the upper defined by gravity makes the condition far from equilibrium. Owing to the given condition, the medium's fluidity, and perhaps most importantly the role of every particle as the agent, the cell structure emerges. Even though being incomparable to the adaptability of living organisms, Bénard cells also adapt while changing “their geometry depending on the temperature difference between the upper

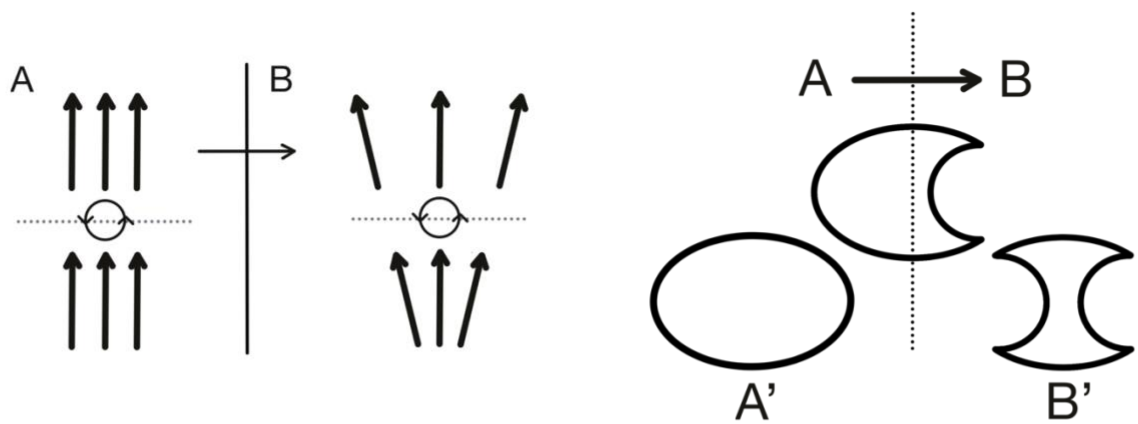


Figure 10. *Perception" of Bénard Cell*

In the left figure, the circle in the center in each case, A and B, is a cell developed by Rayleigh-Bénard convection. The vectors represent the directions of heat. The cell is going to alter its form, which fits situation A, to another form for situation B. However, it does not mean that the ideal form in each situation can determine the form of the cell at a moment; the cell takes the form in accordance with what the cell's previous situation is and what the cell is going to be. In the right figure, it is depicted where the cell transits to situation B from A. The ideal forms in situations A and B are, respectively, A' and B'. The cell would take the form in the center as the system passing situation A and transiting to B. Therefore, even the primitive system takes the self consisting of the former than the current moment, the current moment, and the latter than the current moment. Or even, in other words, Bénard Cell can alter its form, or state, while holding information about its own locus and sensing the (following) situation.

and lower layers of the fluid" (Kupervasser, 2017). Therefore, it can be said that the cells are acting or changing their demeanors upon the change of the condition where the cells are located.

Figure 10 describes the situational difference between A and B where a Bénard cell is located. The cell keeps changing its shape upon the change in the energy flow of the situation. However, the relationship between the cell and its surrounding is not instantaneous. The form of the cell is not determined by the instantaneous relationship of the cell at the moment; rather, the determination of the form is intervened by the previous form of the cell. Therefore, it can be said that the cell "perceives" the gap between the situation where the cell is embedded, not each situation and disturbance at a moment.

Even a most primitive self-organize system derived from the environment due to far from equilibrium conditions shows adaptivity when adapting to the environment. The system's alteration of the form or the state upon the environment is not thoroughly dependent on the environment; the system estimates the relationship between the current system's state and the environment to maintain its continuity as a single existence. Of course, the Bénard cell is not capable of consciousness as we have; however, it can be said that the cell could even exist and transit upon the temporal range between the former and latter than the current moment while estimating its situational gap between previous condition and the estimated (anticipated) condition for transition.

4.2.4 Robustness

Robustness for a complex system, in short, is the bridge between a system's states. Complexity Explorer organized by Santa Fe Institute suggests robustness as "the ability of a system to maintain a certain behavior, trait, or characteristic regardless of changing environmental conditions" (Santa Fe Institute, 2023). If a certain characteristic of a system is robust, the characteristics would not change when the system transits to another state. Therefore, the robust characteristic holds the potential to be common between previous and current states of the system. Hence, the states of the system would be chained by the commonality of the robust characteristics, and the system can be a continuum consisting of the states.

Robustness of a part of a complex system emerges also due to self-organization. Additionally, it requires the scalability of complex systems to develop robustness on characteristics of a system that emerged owing to self-organization. This is the significant aspect to be why complex systems can be the origin of various phenomena in this physical reality, including cognition.

First, I would like to show an example of how morphological functionality emerges within the system against a disturbance. The study by Gunji et al. (Y.-P. Gunji et al., 2020; Y. P. Gunji, 2013; Y. P. Gunji, Murakami, Niizato, Sonoda, & Adamatzky, 2012) of the swarming simulation can be considered as an indication of the capacity of a self-organizing system to gain a bodily morphological facility while facing and adapting to a constant disturbance. In this study, each agent composes the swarm does not have the capacity to store information about its past. For this reason, the simulated swarm does not show a robust property. The most significant point is, however, that depending on the distance from the stationary type stimulus, localities of the system for a specific function occur.

The simulation can be interpreted as the study case showing an emergent property in a swarm of soldier crabs as a complex system. The soldier crabs' swarm can enter and cross over water when the swarm becomes highly concentrated due to inherent turbulence (Y.-P. Gunji et al., 2020). An individual crab agent cannot enter to water by itself because the water holds a threshold not to make it enter. However, in the simulation, same as the case of actual soldier crabs, when agents develop a swarm, the swarm may enter to water because of its anticipation network that makes each agent stick together and also can provide the agents confronting the water higher threshold than the threshold of water avoiding the agents (see figure 11). By overcoming the confrontment of water, the swarm could keep its own form to a certain degree; otherwise, the swarm would dismantle itself and loses its own nature as a swarm. This swarm demonstrates self-organization and adaptation, the representative characteristics of a complex system.

The significant point here is that it becomes clear that the functional differentiation within the swarm to show the emergent demeanor is defined in the space. The following aspects of computer simulation luckily make this fact obvious: 1. each agent does not

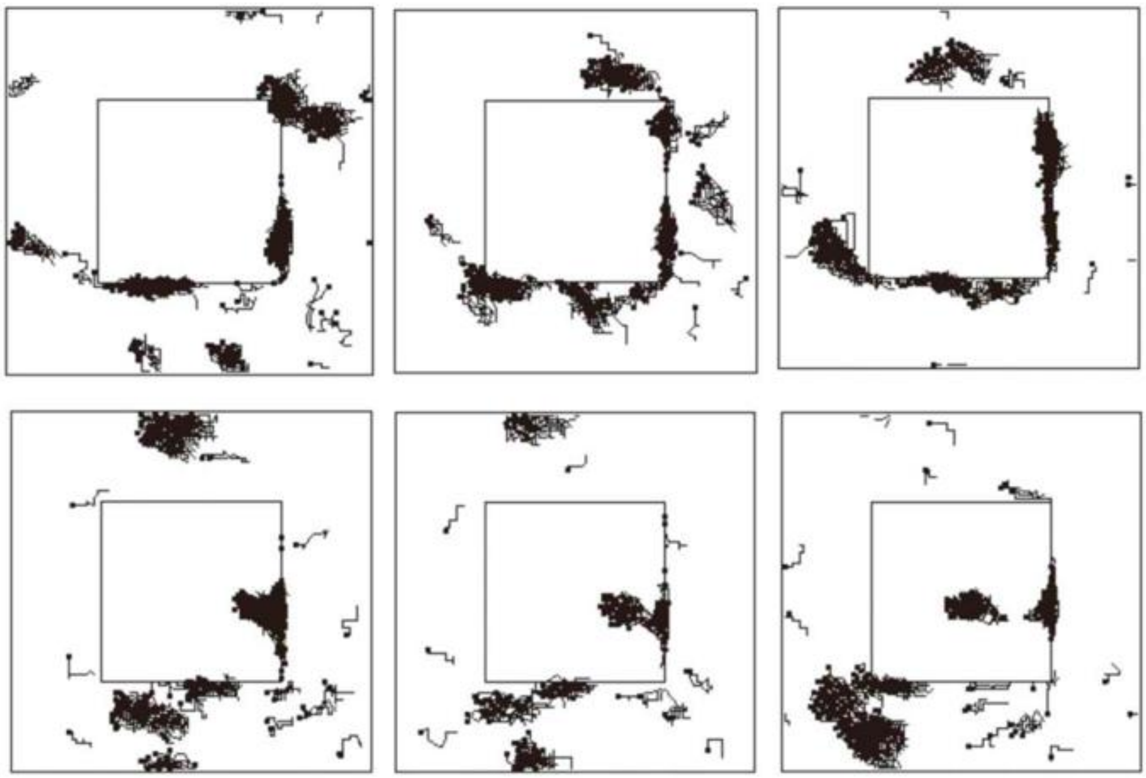


Figure 11. *Simulation of crossing water by anticipation model (Gunji, 2011).*

It starts from the upper left to the right. After the upper right, it shifts to the down left and continues to the right. The field is a torus, and the smaller square represents water. We may see that the swarm is wandering around the water at first. Later, when the density of the swarm gets higher while being sandwiched by the waterside and the direction of agent movement, a part of the swarm facing the water enters the water. Moreover, the part entering the water drags the other part of the swarm to the water.

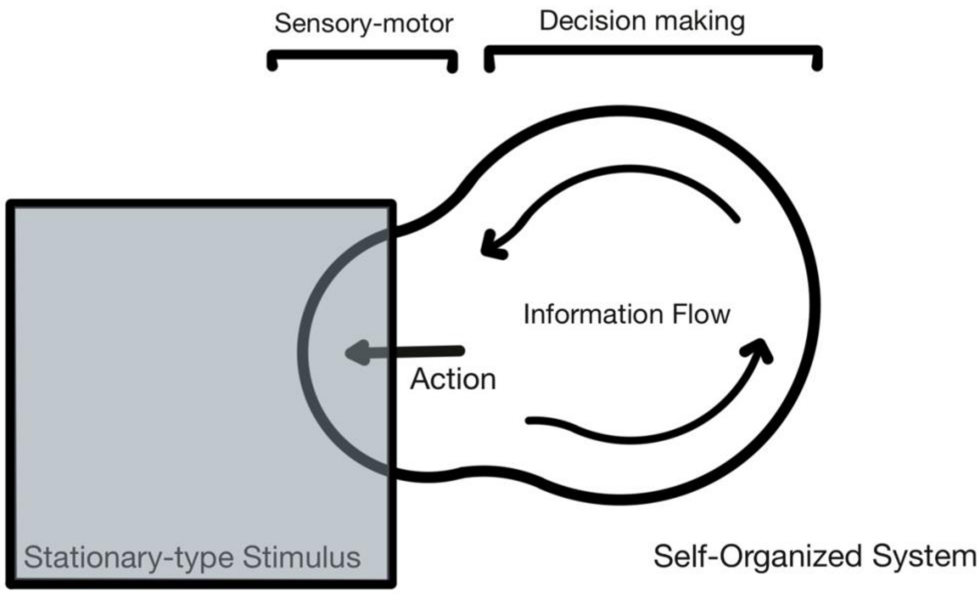


Figure 12. *Simplified figure of swarm system in simulation of Gunji's study*

When entering to water, the swarm passes the information about facing the water throughout its own body. The network among the agents makes the informational flow possible. The agents are moving within (or sometimes in and out from) the swarm so each agent is not differentiated, but the differentiation of the functionality in the swarm emerges depending on the distance from the stimulus. The part contacting the stimulus directly can be compatible with the facility of sensory-motor, and the part receiving and sending back to the sensory-motor can be compatible with the facility of decision-making.

have the capacity to store information of its previous state and to differentiate itself to a specific role and 2. the agents are flowing inside of the swarm like cyclosis.

Figure 12 is a simplified figure of Gunji's simulation of soldier crabs. The figure indicates the differentiation within the system. The grey area represents the water area in the simulation. The water in the simulation is the area providing disturbance to the system of the swarm. To act upon the stimulus, the swam perceives the area as demanding a higher threshold to enter. The information that a part of the system confronts to the area holding a higher threshold distributes to the whole system through the anticipation network[5]. In the end, the system sends back the information to the edge facing the stationary stimulus and acts upon it.

The process of this complex system by the emergent property is compatible with what we call cognitive processes in the context of functionalism. However, each agent in this computational simulation is not capable to hold a fixed role in this process. The agent does not have the capacity to differentiate like a biological cell. This functional process can occur only when conditions are met, and the definition of functionality is grounded on the space (see figure 13).

Then, what if the agents are capable of 'evolution'[6]? Because the relationship between the system's ability to act upon the environment and the feature of the

[5] Another interesting point of Gunji's simulation here is that the clock of agents is not synchronized. This asynchronized clock among the agents allows a swarm to have a width in the clock of the swarm as a whole system. This is compatible with the width of the present that I mentioned in the previous section. In this case of the swarm in this simulation, the temporal single unit would be from the lower scale unit of when a certain agent perceives the water to the unit of when the first agent enters the water—if the system must cross the water.

[6] Gunji's simulation cannot evolve because the rules for actions are concretely set a priori. These rules will never be modified during the simulation. Therefore, the agents are computational, not complex systems; so they cannot store the information about their locus to reach the current state. The computational agent succeeded to present pseudo complex system; however, the computationality of the system blocks the scalability. Being complex systems, they could obtain their own robust properties through their local levels of interaction that might be different in each higher-scale locality. They could obtain a robust property through the interaction in the area confronting the disturbance, whereas the other might develop different ones through the interactions in the area only receiving information. The morphological difference among the agents would be the morphological properties of the global system.

environment does not change at all in this situation, the system is in a steady state. If it is possible and necessary, the phenomenon that would happen next would be optimization by alteration of morphology in the system. Supposing that the average reaction speed of a system to water is higher when it obtains a rigid form than when the system has a fluid form and that the speed is important to maintain the system itself, the system would obtain the rigid form by transcribing space grounding morphological robustness. The system, thus, may make the morphological robust properties optimized to a certain stationary disturbance portal by the agents' evolving capacity.

The robustness in a system obtained by the steady-state between the system and the environment is synonymous with computationality. The function of the system and the environmental stimulus become one by one relationship in a robust relationship. Since this is the result of optimization of the system upon the stationary stimulus, the action can be done in the near most efficient process. However, this efficacy is a trade-off for flexibility. When the changes its state or the system's range of the self changes, which is the constant phenomenon, and if the robustness in the relationship breaks owing to the alteration, the system would decompose its own robust property that does not function computationally anymore. If it is possible to consider memory as the roust property of a complex (cognitive) system, the forgetfulness of human beings is the representative phenomenon of the decomposition. The self-decomposition is, perhaps, another aspect of self-organization and adaptation.

In this simulation case, the stationary disturbance for the system is just one; however, in normal conditions, the system would be exposed to several stationary stimuli from the environment. See figure 14. As this figure represents, stimuli cause localities within the complex system according to the distance from the stimuli. In the specific spatial range of the system, the stimulus would provoke an irregular interaction, though the demeanors of the agents are still according to their rules for actions in each agent. This is as we observed in the interpretation of Gunji's study above. However, the case of figure 14. is more complex. It represents where the system is exposed to several stationary stimuli. The system's demeanor and the eventual robust properties coming from therelationships with the stimuli would be the results of not only the flow of information but also influence from the other localities.

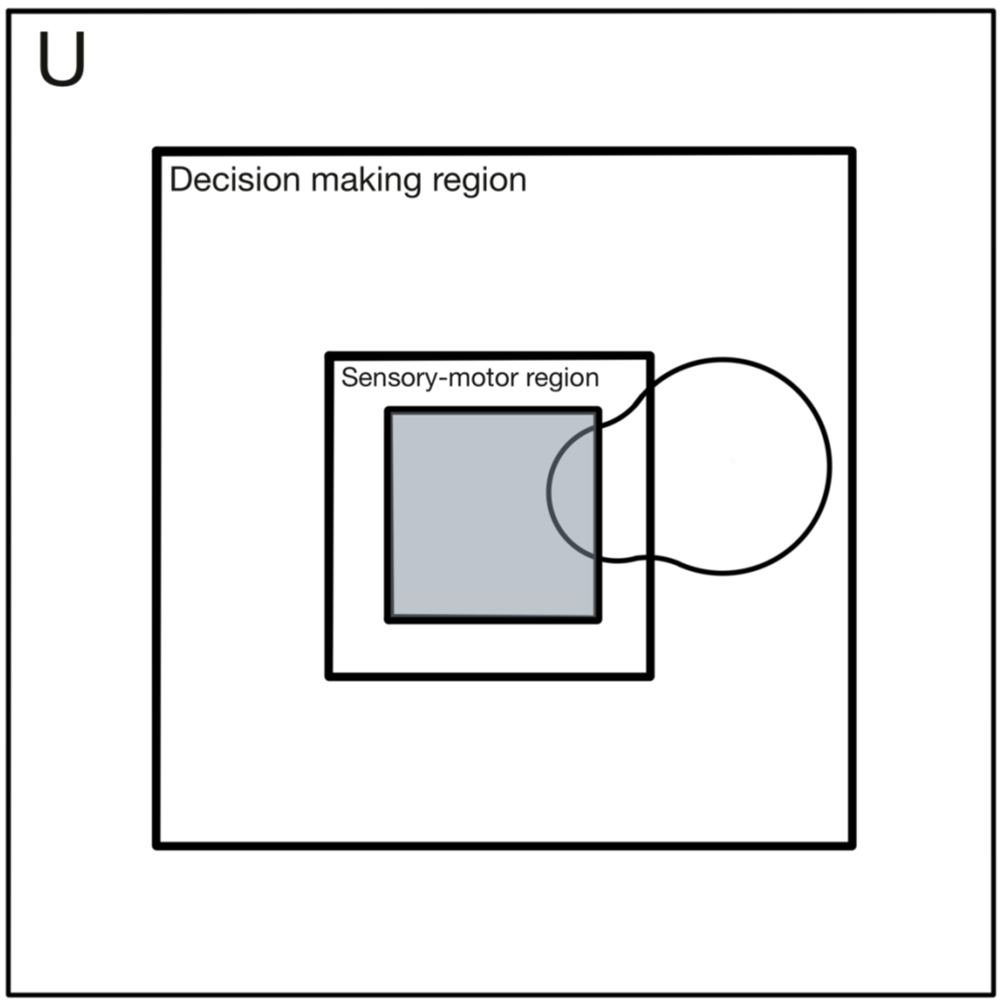


Figure 13. *Spatially distributed definition of robust property*

This figure represents the world of the simulation in figure 4.2. and the visualized area defining functionalities of the swarm's parts. The biggest square U indicates the whole world, and there are the areas providing definition to a complex system, inside of the world. When the swarm is contacting the stational stimulus, some parts of the world, depending on the distance from the stimulus, become areas defining the functionality of the swarm or a complex system. Gunji's simulation can be interpreted as a demonstration of how a complex system can relate to its surroundings and of how a system takes an action while modifying itself and evolving functionality.

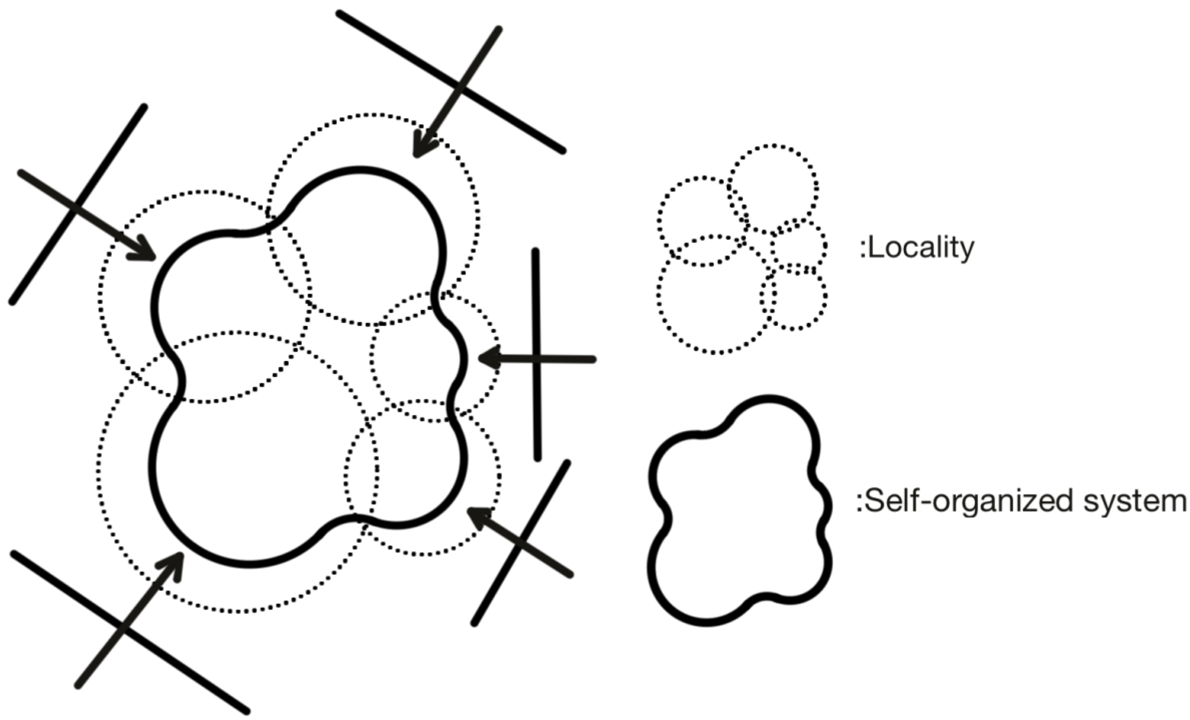


Figure 14. *Self-organized system exposed to multiple stationary disturbances*

This figure represents how a self-organizing system would obtain its morphology according to stationary or constant disturbance. The parts exposed to disturbances would develop localities due to far from equilibrium conditions between the environment providing disturbance and the condition within the system. The development of localities is similar phenomena to the development of the dissipative structure; structures emerge within far from equilibrium conditions to be distinctive from both sides. When exposed to multiple disturbances, the system would obtain several distinctive localities, which are morphologies or facilities for specific functionalities as the results of adaptations to corresponding disturbances. When responding to the situation as a whole, the system would become the field of interaction among those localities in order to take an action for adaptation.

This complexity of the procedure to develop robust properties indicates that the robustness of the system's morphologies coming from these procedures would also become complex. As I mentioned above, the simple robust properties would be decomposed when alteration of the situation breaks the relationship between the system and the disturbance. Especially, the situation breaking the relationship would provide "allelism"—a form or state that cannot stand at the same time with another—for the target relationship. However, in the case of complex robustness, procedures of not only development but also the decomposition of the robust property would not be a linear relationship. Because the property has been developed under the constant relationship between the system's current situation and the disturbance, the robustness is vulnerable to alteration of both the system's situation and the environment. Or, it can be said that, since a certain robust property involves the relationship to develop the other robust property, it must be robust as long as the other properties hold robustness. Because of the complexity of robustness in a complex system, the concept of viability-set that I will discuss as follows is significant to argue how a complex system is compatible with a cognitive system.

4.2.5 Viability-set

Referring to the idea by Di Paolo (2009), I would define viability-set as follows: the range where a system may maintain its identity while functioning its capabilities such as self-organization and adaptation. The set is defined by the system; however, if the system can be inside of the set or not depends on the transition of the ambient condition.

The system with its own set of functionalities for adaptation and self-organization gains its own unique identity, which it will show the tendency to maintain, when it functions to go through the subjective temporal sequence for the sake of maintenance of its own existence. However, the environment is an open field for interaction, so it keeps altering to another state while providing disturbance to the system. For this reason, the system also has to adapt to the environment; otherwise, the system would be collapsed and assimilates into the environment. Viability-set is, thus, the range for tolerance of the contradictory situation, where the system has to maintain its own identity while adapting to the fluctuated situation by self-organization and self-decomposition. However, if the alteration of the system's surroundings is radical as the system cannot catch up, then the system would cease its existence. Therefore, viability-set is defined by the side of the system, but, if the system can maintain its identity upon the environment while keeping the properties determined by the set depends on the environment, at least partially.

From another point of view, viability-set can be also interpreted as the set of standards for self-decomposition. Self-decomposition is an essential and fundamental functionality of a system to maintain adaptivity. As I have discussed above, a complex system would gain robust properties through interaction with its surroundings. The robustness of the system's property or ability contributes efficacy to the establishment of a relationship with the environment; however, it provides vulnerability to the system's properties and abilities themselves too. Suppose a system completely composed of robust properties—though this system is not complex here on according to the definition mentioned above. The system can deal with an environmental feature or a set of the features that had formed the system as such, efficiently. However, once the environment becomes where the system may not deal with, perhaps even partially; the system as a whole becomes dysfunctional. To avoid this loss of elasticity, a complex system keeps decomposing a part of itself for the sake of maintaining complexity within the system itself.

It might sound that the viability-set defines the system's identity according to what I have discussed here. Depending on the definition of identity, it might be true. I refer to "identity" here as the system's nature or a set of facilities, between given two temporal points on the locus of the system, to make itself a continuum. In this sense, the viability-set may define the system's fundamental nature. For instance, for systems based on the structure and functionalities of complex systems, ultimately, their identities would be due to their nature to be complex systems because their nature makes them viable in disequilibrium reality. This would be the strictest definition of viability-set for complex systems. However, the identity of a system is not simple as ending up with a reference to basic functionalities. If I could interpret broadly viability set relating to the identity of the system, the identity would be not defined only by the basic principles. Depending on the type of system, it would be difficult to explicitly define the viability set of the system for a monistic perspective observing the target system as a phenomenon in a single layer or on a single field where the agents interact. It is because the system could belong to several fields or systems as an agent and because the conditions to exist there as an agent would be different depending on the field.

Having desire to comprehend nature of a system defined by viability set as objective observers, we have to decide what situation the target system for the observation is. In other words, depending on where the system as the object of study is observed from, the system's nature or what the principle—although the basic physical principle would be fixed—the system functions upon would differ. A matured complex system has established its identity as a part of its surroundings through time. The environment for physical systems in general is the most basic and fundamental layer as the simple field of matters and energies flowing and interacting, but the set of objects and systems with certain robust properties would form a peculiar layer, where those objects and systems establish relationships and interact with each other, on the basic layer.

The situation of the system is peculiar owing to not only the system's condition but also those layers and their constituents. To exist as a constituent of a given layer, the robust properties that the system has obtained are crucial for the system. Therefore, the system located in the formed environment would not decompose the facilities to make the persistence to exist within the formed environment smooth, even though it might be possible to exist as simpler systems even in the case that the system abandons the robust facilities specialized for the given situation. This is because there is the viability-set interpreted broadly that defines the identity of the system against the given situation.

4.3 Cognition

So far, I have demonstrated a brief sketch of thermodynamics and complexity theory. The most interesting point of those ideas is that only the condition holding thermodynamic gradients and the existence of interacting agents could provide explanations for the automation of functioning and development of systems. Dissipative structure emerges from ubiquitous thermodynamic gradients, and the structure may evolve new facilities upon exposure to the disturbance. Also, because the dissipative structure is a basic form of a complex system, the demeanors of dissipative structure might hold scalability. For this scalability, as rising the scale, a complex system could obtain the computational or robust properties that are specialized for a certain relationship between the subject system and its surroundings. Cognitive systems in common sense, such as human beings and other organisms, would be a good example of the systems existing on this scale.

Here, I would discuss more explicitly cognitive systems as physical existences. First, cognitive systems function similarly to the demeanors of dissipative structures under far from equilibrium. Owing to this basis, cognitive phenomena could be reduced to physical phenomena, and the cognitive systems can be temporally seamless existences. This principle may be applied not only to the physical aspect of a system to relate to the environment but also such as to the social aspect of a system to relate to its social environment. A cognitive system could exist as a pile of subjects to relate to each corresponding layer. The basis of the relationship between the subject and the corresponding environment in the layer would be similar to or even the same as the far from equilibrium condition and dissipative structure. Moreover, cognitive systems may obtain robust features owing to the scalability of complex systems' nature. This scalability also allows a cognitive system to have the initial condition for the transition throughout its existence as a complex system. On contrary, cognitive systems cannot lose their characteristics as their complex aspect; otherwise, their existences would diminish gradually owing to losing the capacity for adaptation to the following situation. In order to maintain their "flexibility" for adaptation, cognitive systems have to decompose their robust features. The contradiction between maintaining the existence and decomposing its own part is allowed by the viability-set. This set should also exist in each layer and Umwelt that the subject has developed. Therefore, a cognitive system might show demeanors for the sake of not only existing here but also not losing a given role for a layer.

In this section, as I showed above, I would like to make some comparisons between thermodynamics, complex systems, and cognition to defend myself suggesting that, owing to thermodynamic drive, cognition can occur physically. Of course, for each case of a specific cognitive system, we have to comprehend it differently. For the cognitive facilities of single-cell organisms and ones of human beings, there must be differences between the mechanisms and structures playing the roles of adaptation and the faculties relating to adaptation. However, if we say that cognition is not a peculiar phenomenon in human beings but it is the demeanors also shown by a primitive organism as followers of the biogenic approach (Lyon, 2006) have been suggesting, we have to find the fundamental common aspect among them. To do that, I have focused on physical principle because it would make cognition a secular phenomenon rather than a thing explained by the notions attached to subjectivity such as qualia. I would not deny the notions intertwined with subjectivity; however, thermodynamics might provide how subjectivity and the system's individuality have emerged from a field. The things considered as special features of cognitive systems with subjectivity demand the subjective systems be distinctive from their outside. Thermodynamics and complexity theory are considerable because they may contribute to how cognitive systems emerges and, moreover, how they gain their peculiarities under the principles.

4.3.1 Far from equilibrium, Self-organization, Adaptation in (explicit) Cognitive System

Far from equilibrium of thermodynamics is an important notion for the scale of cognition, also. Rather, a cognitive system to exist in far from equilibrium conditions is a precondition to be cognitive for a system. Why a cognitive system keeps functioning without explicit inputs from outside is that there is a sufficient gradient between the system and the environment. Moreover, I believe that a cognitive system is an existence between the gradient of the two different temporal moments. As I demonstrate in figure 10., the system that has emerged as a dissipative structure and been organizing itself may 'sense' the gap between the current situation and the following situation. The following situation includes the disturbance of the relationship between the system and the current situation. The self-organizing system is capable to be in a seamless temporal sequence because the clocks of the constituents are asynchronized (see the footnote about Gunji's contribution). For this asynchronicity among the constituents, within an individual system, some part that may establish a stable relationship with the current situation comes out, and other part orients to change of the environment for adaptation. This separation in the constituents allows the system to be in-between the situations, where a part has adapted and where a part orients towards, or its own current moment.

This is to say that the self that I have discussed is a higher order of the dissipative structure keeping confronting disturbance or fluctuation occurring in the current situation. As I mentioned in the previous chapter, the self consists of three temporal sections: the former than the current moment, the current moment, and the latter than the current moment. On the other hand, due to the asynchronicity of constituents' clocks in the complex system in far from equilibrium conditions, alienation among them in terms of their states occurs. Considering the structure of the self and the asynchronicity among the constituents' clocks that allows the subject system to be in the temporal sequence seamlessly, the theoretical model of the self would become rooted in the more secular and physical realm. In other words, the location and transition of the self that is "in-between" of two temporal points could be explained not only theoretically—or philosophically if we want to call it—but also physically.

I would not say that a system only characterized by self-organization and complexity like Bénard Cell is capable to store information or having the self relatively temporally large scale. Thus, most probably, primitive systems do not have the faculty for so-called memory, which is one of the faculties that allow us to be existences between the former and the latter of the current moment. However, the magnitude of the self is relative. The form or condition of the systems is not determined thoroughly by the relationship between a given form of the systems and a given environment at a moment. Therefore, the faculty of memory just allows the systems with it to be temporally larger scale. In any case, the previous form or condition should intervene for the form at the current moment because it is the result of a transition from the systems' previous states (see figure 10). For example, Bénard Cell alters its form dependently not only on the flow of the energy at a moment but also on its initial form of the cell. This means that even one of the most basic structures is influenced by its own locus of being.

The latter section is the closest part to the disturbance. Adaptation to the situation with those possible causes of collapse would be started by perceiving the situation. Owing to the exposition toward the stimulus, the part would show the emerged demeanors, from the same set of rules for the behavior in each constituent, but different than the stable condition due to the influence of the stimulus. From the objective perspective, we may comprehend how each constituent would behave if we focus on the system as a whole, although the constituents must be also a complex system if this physical world is open for the scales. When considering a macro scale system, the micro-scale demeanors would seem mechanical phenomena. For instance, when considering our psyche level phenomenon and trying to explain it, we observe and analyze the matters in the levels of biological mechanism and the level of chemical components and physical principles as the bases of the mechanism as deterministic phenomena, whereas the phenomena in those levels cannot be taken as deterministic once looking at the micro and super micro world closely. In other words, when observing a system, the objective perspective reduces the constituents to nodes with a set of rules developing the macro-level system. However, the network developed by the relatively simple patterns contributes emergent properties to the system. Emergent properties and emergent demeanors are not forecastable from the objective perspective. On the other hand, most significantly, these characteristics provide the system possibilities to transit to various states and to adapt to the following situation.

The system could have numerous options to be upon the following situation by its own nature. At the same time, the transition of the system's state would be optimized or constrained by the locus or the initial form of the system itself. The state between where the system had adapted to the environment and where the system has sensed the disturbance and has been orienting toward the following condition is the current moment for the system. Owing to the self including these three temporal sections, the system can transit, not definitively but still adaptively, to the following state upon the situational alteration and can be a seamless continuum.

The equilibrium state between a system and where the system is located is the situation where the system does not have any drive to function because there is no distinction between the system and its surroundings anymore. It is the situation where the system has assimilated to the environment. On the other hand, owing to the far from equilibrium between the system and the surroundings, the system would take an action to maintain the order of its inside upon the surroundings. The boundary from the environment is vulnerable to fluctuation in stable disproportionated conditions. Thus, the cognitive system that is complex and self-organizing has to keep running away from this fluctuation and disturbance; otherwise, the system is going to fall into equilibrium with the surroundings, where the system cannot be distinguished from where it used to be located. As a complex system under the thermodynamics principle, a cognitive system can keep evading the condition where there is no distinction between the system and its surrounding. Although the system as a whole in a stable relationship with its surroundings does not mean that the system's existence ceases immediately, it becomes vulnerable to situational alteration. A constant stable relationship would become a robust property of the system, so it leads to the loss of flexibility for adaptation. By having a separate part for adapting the condition due to constituents' asynchronized clocks, a system as a whole may keep adapting to the surroundings while not establishing a stable relationship as a whole system with one single situation.

Considering human beings as cognitive systems, exposure to physical threats might not be so often. However, we should exist in-between the temporal moment while establishing the self. Our bodies as wholes must be complex systems with various robust morphologies allowing various types of faculties to function with optimization, but one of the most representative facilities characterized as a complex system is the brain and neural structures of our bodies (Mitchell, 2009). Brains consist of many neurons having the same set of rules to interact with others. Then, the functions of the brain itself appear as what the researchers have not revealed the nature, yet. These functions are the emergent properties of the brain as a complex system. Therefore, I assume that similar phenomena to what I have argued here could be happening in our brains, though the scale and complexity would be much higher in ones in a brain. Our brains are in the state in-between one with the current situation and one oriented toward the following situation causing fluctuation in the system. I cannot go to the details of the arguments; however, since we have several different modalities and if the brain has the specialized parts for specific faculties including ones dedicated to the modality-specific type of information—modularity (Carruthers, 2006; Jerry A Fodor, 1983), the self can be developed in each modularity, even. Supposing the process of the brain is compatible with the demeanors of the system with dissipative structure, it is natural that robust properties within the neural structure have emerged both ontogenetically and phylogenetically. Rather, because the physical structural relationships between the brain and sensory systems are fixed, modularity-like specialized sets of facilities could emerge easily more than any other systems with fluidity.

This might be nonsense spoken by a person who is agitated by dabbling in the complexity theory; however, what I am curious about is what could have been happening within the gradient within these selves. Within the self, there should be a gradient also between the former and later than the current moment. If a form or system would be established owing to this gradient, what does it contribute to our beings? Moreover, if this self-organization would happen in each specialized faculty, the set of phenomena at a moment of the self as a brain might be strong enough to appear to the subject, as something like a subjective feeling of consciousness. Of course, this question has many problems before being questioned, such as the issue of the media to form the phenomenon, in the case of Bénard Cell, which is water. Also, there would not be a gradient strong enough to let a form occur between the former and later than the current moment. However, the important point is that, when considering far from equilibrium as the starting principle, I could deduct the occurrence of phenomenon possibly causing our subjectiveness.

A sophisticated cognitive system exists as the piles of layers of the relationships with corresponding aspects of the environment—roughly, there should be two main layers for human beings: social layers and physical layers. Layers are the fields for interactions developed with certain aspects of systems and corresponding aspects of the environment. A system would be reduced into a set of corresponding abilities for the layer; however, it remains the distinctiveness as a set as the subject of interaction within the layer. Both the system and environment exist as piles of these layers. You may consider the layer that I discuss here as Umwelt by Uexküll; however, precisely, layers inclusively refer to what a species has developed through its history other than what in the environment we may relate to with our bodies. For instance, we live in the fields of a workplace, school, family, etc. by being embedded in the field as an element, at the same time, being distinctive from the other constituents. There are gradients between those social situations as the exteriors and us as subjective interiors. Like the physical layer where actual gradients such as far from equilibrium occur, the gradients in social layers would drive our cognitions together with the physical gradients. In other words, against given societies, we keep distinctiveness from them while adjusting them to the environments.

Notice that the difference among layers is not about the difference among the scales. When I say scale's difference, the system's position is in the relationship, for instance, between the subjective system and the environment. Thus, focusing on a system; the system could be a constituent for its exterior environment from the relatively macro-scale perspective or could be the environment for its constituent from the relatively micro-scale perspective. Scales' difference is to talk about how to observe a target system as a whole, whereas layers are the aspects composing the system and its surroundings.

4.3.2 Robustness and Viability-set in (explicit) Cognitive Systems

Robust characteristics are fundamental aspects of cognitive systems. To say in an extreme manner, simple complex systems like Bénard Cell also have a relatively robust aspect. The section represented as the former than the current moment is "robust" within the close enough previous moment and the current moment. Owing to the robustness, the states in the previous moment and the current moment can share robust characteristics. This common feature bridges a moment-to-moment seamlessly, and also the system can identify itself, if necessary.

Especially for sophisticated cognitive systems, the representative phenomena as robust characteristics are knowledge or memory and bodily morphologies. Later, I would detail; that the robust property of organisms could be characterized into two types: ones provided from the bigger scale system as the results of the system's cognition and ones gained by the subject systems through the locus of its own cognition. However, the properties and the abilities of the system to relate to its surroundings can be counted as the robust characteristics of the subject system. As I mentioned above, the robustness of these characteristics allows the system characterized by robust features to be identified as a single entity.

The basic principles of how a cognitive system obtains robust characteristics would be the principles of demeanors of dissipative structures in far from equilibrium, as I mentioned above. In short, a complex system would differentiate its own part for a specific role to respond to disturbance. If this disturbance would be constant, the differentiated part would gain robustness for the sake of efficiency to establish a relationship with the environmental feature. In other words, constant disturbances for a system would become its surroundings without meaningfulness. Here, meaningfulness refers to the quality of phenomena, what the subject system has to confront as stimuli, requiring the subject to be intentional. The acquisition of the robust characteristics, if it is the acquisition by the system as the species, would be actualized as the bodily morphology or natural properties of a system belonging to the species, and, if the acquisition happens within an individual's life span, would be the abilities or knowledge upon the constant environment. Owing to the structures in the realm of chemistry, explicitly genetic information passed through genealogy by genes, storing information as species is easier for organisms. Moreover, owing to neural structure, keeping informational robust features is also easier for the system having the structure.

For instance, I believe that the attraction towards the ground owing to gravity could have been a disturbance for a system. However, for the cognitive systems living on the ground, it is natural that they have developed legs or other compatible morphological structures to establish a relationship with the environmental feature in order to take an action upon it efficiently. Of course, the emergence of the morphological structure cannot be simplified as this explanation because there are several morphological forms as responses to the attraction. Human beings move on their two legs, dogs run on their four legs, and even birds fly with their wings. Those varieties might be because of influence by the set of disturbances that their ancestors have been exposed to simultaneously, as I mentioned above in figure 14. In other words, each species has been different disturbance other than the attraction; one may confront the necessity to give up speed for the necessity to utilize objects to avoid other disturbances or one may confront the necessity to leave the ground for the necessity to avoid another.

Moreover, abilities, memory, acquired bodily morphologies, or other what we would gain as robust features through our life span are the embodiments of the exposition towards a certain disturbance constantly. I assume that the process—that might be called the process of 'learning'—to obtain the robust features that are unique in each individual should be similar to the other scale of compatible processes such as evolution, at least at the principle level. The learning process is, of course, owing to the system's capacity for self-organization. However, what the system may learn about depends on Umwelt that the species, to which the system belongs, lives. A set of facilities that a species has for the establishment of a relationship with the surroundings develops Umwelt as the collective of functional cycles. In other words, due to the innate set of facilities, stability in the given environment is promised to a certain degree. In Umwelt, out of the promised stability would be a meaningful disturbance for the system. Owing to the relational basic structure, the system can be intentional about the disturbance. If the disturbance situationally stands out, it would be going to be a content of experience. Finally, in the case that the system has to repeat the experience upon the disturbance, the system would obtain the embodiment of the fact that the system has gone through the experience. The basic Umwelt established purely by the bodily facilities would be the range with the least constraints for the system. In other words, the set of constraints is the initial condition for the system. Therefore, due to the Umwelt defined by the body, the range that we could experience had been set up already—for instance, we cannot experience swimming like fish or flying like a bird with our bodily morphology, though we could do one qualitatively near them by "extending" our body.

In contrast, what would be if there is no constraint by this? A system can adapt to a situation with disturbance because the system may sense the disturbance or fluctuation in the system caused by a disturbance. In the latter case, it might not be necessary to sense the disturbance causing the fluctuation, but it still has to adapt to the situation with the disturbance. As the basis to sense the disturbance or the fluctuation occurring inside of the system, the system must be under some stable relationship with the given environment because the disturbance and fluctuation are the phenomena that could destroy the stability between the system and the environment. This stable relationship is possible because the system has the body. Therefore, the body is the basis to sense the disturbance. Conversely, the disturbance is meaningful because it can cause a collapse of the stability between the system and the environment. If there is no constraint in a given environment for a system, it means that the system does not have a body in the given environment. Emerging a system with a certain bodily form means that the system's existential range is defined within the whole world. Without the constraints or definition, if the subject would exist, it would be equal to the whole world or exist as nothing since it completely assimilated with the given location.

In concluding the messy arguments here, the body that is the result of a constant relationship with the environmental disturbance as a species is, at first, robust property of the individual cognitive system that emerged as a constituent of the species. Then, owing to the body, the system has the initial condition. Owing to this condition of where the system could establish a relationship with the environment, the self of the system may have a section of the former than the current moment that plays the role of constraints for transition.

I consider this development of morphology or so-called evolution as a type of cognitive phenomenon by a species as a cognitive system. Spinning a bodily morphology with the constraints of its previous morphological state but still in order to adapt to the following situation should not be a mechanical process. The reason that I believe so is as follows. First, a species should be a complex system that each individual plays the role of its agent. The individual behaves according to a set of rules to organize or maintain the existence of a species. Second, the evolution of a species is to adapt to the alteration of the environment that is the field of chaotic interactions among the existences there. The process of the adaptation must be similar to or even the same as what I discussed here. Then, third, from the first and second, this cognitive process should be creative. Evolution is the process of the transition of a system's state to another for the sake of adaptation to the current environment while being under constraints on the states for the transition. The state here refers to a species' morphological forms and facilities. The transition and adaptation would be executed by natural selection according to the classical notion of evolution.

Explicitly, the basic principles of the cognitive process of the simple complex systems like Bénard Cell, the sophisticated complex systems like human beings, and relatively large scale systems like a species of organisms are the same; though the scale of the temporal sequence, how the constituents may actualize the interaction network, and how a feature of a system keeps robustness have to be understood differently in each case. For instance, human beings' learning process is, explicitly, similar to the process of evolution of a species in terms of procedural structure, as I have shown above.

In other words, to learn something for an individual human being is to gain a robust feature in its life span as the individual, whereas gaining a bodily morphology for a species is to gain a robust feature in the life span of a species as a system. However, although the procedural structure of each scale shows the fractal structure with another scale's compatible phenomenon and shares the fundamental principles with others, each phenomenon completely differs from the other. For this reason, we have to comprehend the nature of the process in each case if possible and if we want to comprehend it.

A cognitive system, by definition, must be characterized by its complex aspect. A complex system must transit corresponding to the transition of where it is located. Therefore, being complex in order to have the faculty for self-organization is the fundamental characteristic of cognitive systems; otherwise, it is impossible for them as cognitive systems to transit from their state to another according to the following situation. So, together with the establishment of robust characteristics, the decomposition of their own parts is crucial for the systems. The body of a system provides Umwelt of the species to the system. Additionally, focusing on an individual system, it is exposed to the environmental change within the Umwelt defined by its body. By adaptation, the individual system also establishes its own unique Umwelt while obtaining robust properties upon constant disturbances occurring in the system's own subjective world. The facility making this adaptation possible is the part undifferentiated as the robust properties. If the losing this part, or in other words, if consisting of only robust properties, the system is no longer able to adapt to a given situation and would cease its existence. To avoid the malfunction as a cognitive system, I believe that it decomposes its own properties.

This decomposition can be seen in not only the sophisticated cognitive system like human beings but also in the most basic complex system. As I mentioned at the beginning of this section about robustness and viability-set, Bénard Cell can have robust properties. Owing to robust properties, the system can exist as the same existence. Conversely, during a certain sequence of time, if a system holds the same property, the property can be called a robust one. For Bénard Cell, robust properties are, first, its body as a cell and, second, its shape as the result of adaptation to the current thermodynamic energy flow. The body as a cell defines the existential range of the cell, so losing this robust property means the cell's disappearance as existence. On the other hand, the robustness of a form of the cell is relative. This robust feature will be decomposed when the system adapts to a new situation if necessary. For human beings, the representative phenomenon possibly compared with decomposition must be to forget. Semantic memory, for instance, is about facts about the world independent from the subject (Tulving, 1985). Why the subject can obtain this kind of "knowledge" is that either individual has been exposed to the contents of the memory or, for human beings as natural language users, a group of agents have been exposed to it and passing the memory among the group as symbols. Perhaps, both would disappear when a given situation has altered. Especially, for adaptation, when the subject needs to obtain a qualitatively compatible robust property with the existing property, they would be allelism, and the existing one would cease more likely.

The generalized relationship among the robust characteristics, adaption, and decomposition of a system is presented in figure 15. S (bigger) refers to the system that the subject system, s (smaller), belongs to. Note that S (bigger) is not necessarily single for each s (smaller). For instance, an individual human being as a cognitive system belongs to several different larger-scale systems—in other words, the layers on the basic layer where the subject involves as a physical system—such as given surroundings, biological species, and social systems. When S (bigger) transits upon the alteration of S's surroundings, s (smaller) is going to transit its state for the sake of adaptation to the transition of S (bigger). The alteration of S (bigger)'s state relies on the constituents' transition, but the constituents' transition occurs owning to fluctuation in S (bigger) and its direction towards a new state upon its surroundings. In other words, s (smaller) and S (bigger) are similar, and their relationship is scalable. S (bigger) is a smaller scale for a system that S (bigger) belongs to so that its transition would contribute to the transition of the system. On the other hand, s (smaller) also includes systems as its constituents. Hence, s (smaller) would alter its state owing to the transition of its constituents as well as the relationship between S (bigger) and s (smaller). This scale-openness of cognition or other physical complex phenomenon makes them creative.

Viability-set of a system determines maximumly how much the system can compromise for its own state for the sake of adaptation to surroundings' transition. Umwelt established only by the body might be viability-set in the strictest manner. The

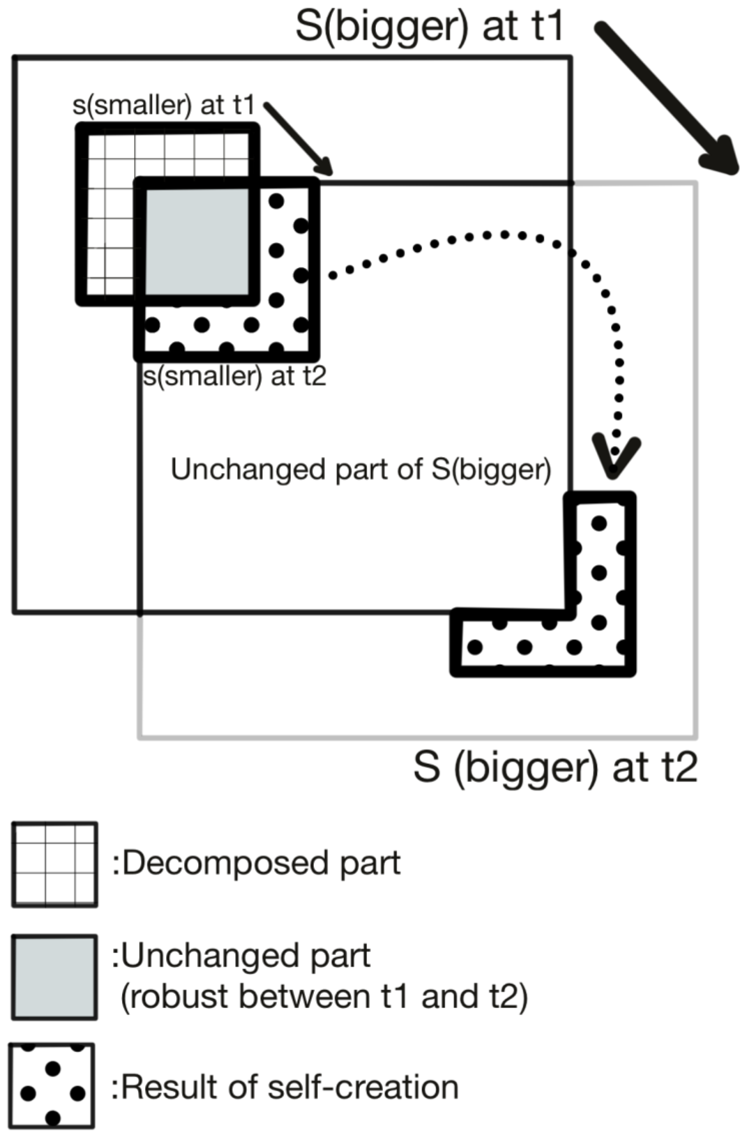


Figure 15. *Relationship between systems in different scales on the occasion of transitions*

Systems in physical reality altering their states to others are complex systems. Because of the nature, when transiting its states, the systems and their constituents act mutually. When systems on a smaller scale actualize transitions, a system on a bigger scale can create its own new state. Conversely, when the system on the bigger scale transits its state, the systems on the smaller scale are forced to alter their state. Note that the systems' relationship is not one to one; the system on the bigger scale can maintain its existence owing to the actions of the smaller systems as agents, and the systems in the smaller scale are influenced by the demeanors of the system on the bigger scale.

transition of S (bigger) forces s (smaller) to decompose its parts. This is because S (bigger)'s state depends on the state of the aggregation of its constituents' states, or in other words, aggregation of a number of s (smaller)'s states. Systems cannot keep holding robust properties because they have to maintain the flexibility to adapt to the following situation. However, for instance, if the system has to give up the facilities to relate to its surroundings fundamentally, it leads where the system is no longer a part of the surroundings. Cognitive systems must transit their current state to another state by creating the part of the state, but, at the same time, they have to lose their parts for the sake of maintaining their flexibility for adaptation. For this contradictory situation, the viability-set determines the range of this creation, decomposition, and robustness for the bridge between two temporal moments.

I argued that the viability-set may have a strong relation to a system's identity. An identity, here, means the system's common nature or a set of facilities to make itself a continuum, between given two temporal points on the locus of the system. For instance, even though it would be for a moment, Bénard Cell between the previous moment and the current moment could be identified by the form of the cell that is the result of the previous situation. For such a case of phenomena with the life span of a single system, robust characteristics would play the role of embodied identities between certain two temporal points within the life span. Or, the faculty for the adaptation is the ultimate case of identity for a cognitive system or the other complex systems. This case of loss of flexibility for adaptation would be the definitive loss of identity for cognitive systems or other complex systems. Thus, the most fundamental viability-set should be for the sake of maintenance of this flexibility for adaptation. However, as I mentioned briefly above, sophisticated systems could have various aspects for their identities and follow the rules to maintain their existences as agents in the layer. Therefore, a single system makes a transition according to several different sets of viability-set. The identity as a system is not sharply defined as one referring to the functionality to keep the system to be formed physically. Explicitly saying, the identity of a sophisticated cognitive system, such as an individual human, consists of the identities in the layers, where the system belongs. The identity in a layer is defined by the viability-set to be an agent within the layer. When a system cannot be or does not have to be within the viability-set for a layer, it would cease its existence as a constituent of the layer, although it does not lead to the end of the system's ontological existence.

We live as a physical system while adapting to following new situations as well as, for instance, social existence to follow the rules—though not necessarily stipulated rules. Most probably, the viability-sets in layers other than the basic layer to maintain the system itself to be a cognitive system would be extensions of or emergence from the set for the basic one. However, we still constrain our own potentials due to the viability-set in social layers, even in the case when not being in a certain layer would not cause the end of our lives. Therefore, the range of transition is not determined only by the fundamental viability-set; rather, the transition with the decomposition of its own part would be executed within the viability-sets of where the system belongs to.

Referring to figure 15., the color parts of s (small) are the aggregation of S1, S2, and S3 in figure 16. corresponding to their colors. Thus, some of the constituents of s (small) could be categorized into the three types—and the other would be in between the sections. Cognitive systems are the aggregation of those parts being in the corresponding state to the colors due to this gradual transition corresponding to the S (bigger)'s transition. I hope that figure 16, where systems are in extreme cases, would contribute to the comprehension of cognition as a transition of a cognitive system.

When the alteration of the surroundings or the system that a subject system belongs to is too radical as much as the subject system cannot catch up for adaptation, or when the subject system keeps robustness and loses flexibility; the system would be the condition of S1 at figure 15. Through the transition of the surroundings or the system that the subject system belongs to, the subject system would cease its existence, at least, as a constituent. This ceasing of a system is a type of decomposition that I have discussed here. The decomposition does not have to be always systems' disappearing. As I mentioned, for individual human beings as a cognitive system, the representative phenomenon of decomposition is forgetting. This is a loss of robust property, not its constituents—it does not have to be a loss of neurons to lose memory, for instance. However, since complex systems in the physical world should be scalable, the constituents should be complex. Thus, the disappearance of systems in micro scales should relate to a loss of robust properties.

Conversely, S3 in figure 15. represents where a system occurs as its constituent. The occurrence of a system can happen when a dissipative structure occurs under far from equilibrium conditions or when a compatible phenomenon with the emergence happens. However, a system cannot emerge without any previous condition. In this figure, S3 comes to appear all of the sudden; however, this emergence without sequence is because of the phenomena on a smaller scale. The emergence of this new part in the scale of the figure is literally the result of the emergent property of a complex system on a smaller scale, and it comes up to be as S3.

An example of the occurrence of a constituent of a system is the evolvement of multicellularity from single-cell organisms under predation (Becks, Ellner, Jones, & Hairston Nelson G., 2010; Boraas, Seale, & Boxhorn, 1998; Herron et al., 2019; Ratcliff et al., 2013). An eco-system of a scale, for instance, would gain a new constituent as the emergent property of the system when a collective of single-cell organisms gains multicellularity. Moreover, this phenomenon is a remarkable example of the rise of scale by the system's adaptation as a complex system. The evolvement of multicellularity not directly indicates the emergence of a system under far from equilibrium; however, it can be interpreted as that predation is the disturbance of the local group of a species of single-cell organisms. Moreover, borrowing words from Herron et al (2019) about the article by Bell (1985) "filter-feeding predators are common in aquatic ecosystems, and algae that are larger than a threshold size are largely immune to them." This means that, for the cognitive system, a way to adapt to the situation is to connect to make themselves the bigger individual. In this case, the transition of single-cell organisms to gain multicellularity in order to adapt to the situation with predation as a disturbance is not a simple alteration of state; rather, it helps the system to rise to another scale.

Finally, S2 indicates a system that does not have to transit its state to another because it is within the intersection between the two situations: before and after the transition. S2 does not do anything or cannot do anything because the system here cannot sense anything. The sensation would happen when there is something different from the current situation of the subject system. However, on the macro scale, it does not mean that S2 does not play any roles in the system. By containing it as the constituent,

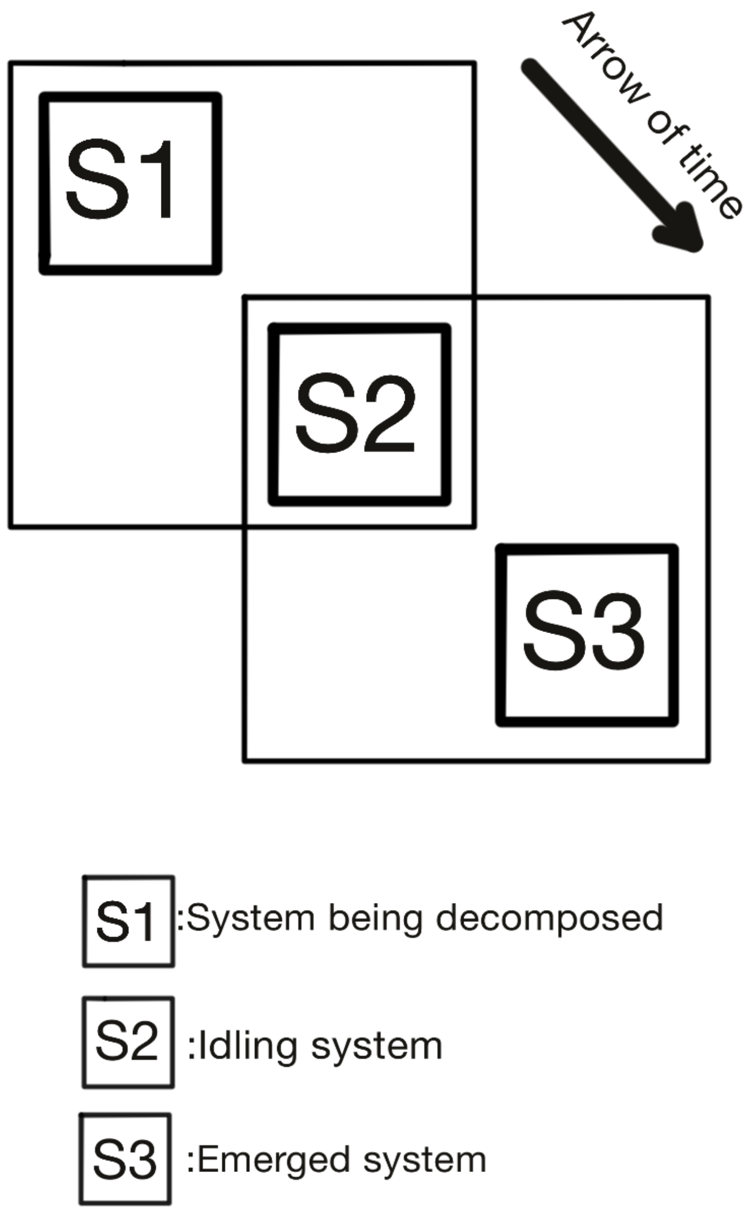


Figure 16. *The conditions of systems as constituents of a system on a bigger scale*

A system on a bigger scale consists of numerous agents, and they are roughly in three different states: being decomposed, idling, and emerging. The system can be seamless within a temporal sequence for holding constituents being in each condition simultaneously.

the macro-scale system can obtain the temporal seamlessness as Gunji's soldier crab's model does.

4.4 Conclusion

I assume that the goal of cognitive science is to understand the cognitive phenomena in human beings. The analytical view is the perspective to observe a certain functional frame that is closed and to understand the mechanism within frames. It will contribute to the comprehension of human beings or other cognitive systems by analysis of the target object while alienating it from where the object is located and from the temporal sequence that generates the object's current state. A matured cognitive system has developed solid facilities according to relationships with constant disturbances, so the functional frame defined such as the robust properties might be revealed by this analytical perspective. However, if human beings and other cognitive systems only consist of those functional frames, we cannot organize ourselves while following up on the alteration of our surroundings. We must have complex aspects allowing ourselves to be flexible for changes; otherwise, it leads the malfunction as existences in the field that holds far from equilibrium conditions as precondition and keeps altering its state.

This flexibility as complex systems allows the system to be cognitive in the sense to capable to transit its own state to another state upon the total relationship with the spatiotemporal locations where the systems are. However, analytical views could not capture the demeanors of cognitive systems with flexibility because the systems are scalable both existentially and functionally towards both macro and micro scales. To look at a specific system, to analyze it requires setting the frame to define the system's ontological nature and functional demeanors or role. This means, on contrary, that to define the system from analytical perspective demands, at least, several different natures revealed by one focusing on different scales. Hence, to cover up what a cognitive system is, we need to comprehend how the system would play a role for a system on a bigger scale as a constituent and how the system's constituents form the system. Additionally, sophisticated systems could belong to several different systems on the same scale. Everything consisting of the system's unique Umwelt will influence the way to be of the self of the system at the present. Moreover, the state of the system keeps changing for the sake of adaptation, so I consider that it is impossible for the analytical perspective to define the existence that functions cognitively.

Supposition to put thermodynamics and complexity theory as the basis of the discipline of cognitive science might seem to make it more complicated or even impossible to reach a thorough understanding of human beings' cognition and its process because the conventional view considered as the most trustworthy ideology could not work anymore to observe the subject matter of the discipline. However, the most fruitful matter from what I have suggested here should be that the discussion of cognition becomes secular and physical matter by my suggestion. Our existences as sequences of cognitive phenomena are not mythical or happening in a different world. We must be equally constrained by physical principles, which are the precondition to exist physical matters.

Cognition is a transitional demeanor by complex systems that have emerged and exist in this physical world. The physical world is where a far from equilibrium condition is ubiquitous. The ubiquitous condition of the physical world is the precondition for the emergence of cognitive systems and the occurrence of cognition. Of course, I would not say that the subject matter of cognitive science could be thoroughly explained with far from equilibrium and phenomena developed from the condition. For instance, we could probably never comprehend the quality of our feeling by the methodology derived from thermodynamics. It might help researchers to comprehend how a cognitive system could have its subjective attitude toward the world; however, to have an attitude or to be intentional must be different from qualia or the quality that the subject may feel for the contents of experience by confronting the world. Moreover, considering a cognitive system is embedded in the structure holding complexity that is open to scales would generate another issue, which is where the end of the structure in micro and macro scale is.

However, the issues are not critical for comprehension of the nature of cognitive systems. In terms of qualia, even though we cannot discuss the qualities of the states and experiences, we could do so about cognitive phenomena themselves, as transitional movements of the systems, and their subjects' states before and after the phenomena.

The only way to “apprehend” them is to communicate with the subjects of the experiences if possible. Also, for the scale issue, if the point of view is too far away from cognitive systems in scale, even though systems and phenomena in the scale where we focus on now demonstrate partially aspects of the target systems, the aspects would be trivial in order to talk about the target system’s nature. For instance, the condition of the climate should influence an individual human’s action, and vice versa. Yet, the relationship between an effect from the climate and an action would be a discussion where the subject of action could be reduced into a computational system that simply functions upon the input. Moreover, whereas the condition of the climate should be the result of the chaotic phenomenon in the field, meaning that an individual human’s action must play a role to reach the result as long as the individual exists in the field as a cognitive system; the effect from the side of the individual would be too small or would not be necessary to take it into account as an effect.

This might mean the problem of science or the limitation of our human being’s “cognition.” I understand the aim of science, as the collective activity by human beings, as to thoroughly comprehend the object of study; however, even though we know that some aspects of the object of study are there, we ignore them since they are too “small” for considerations to study the nature of the object of study. This is an open question. Even before being a question, several of my suggestions here should be proven by science. Therefore, I do not have any words for this matter, unfortunately. However, I consider that the issues of cognition become capturable because of the perspective putting thermodynamics and complexity theory as the basis to observe them.

5. Architecture of thinking

As the closing chapter, I would like to present my study about the architecture (Nakano & Vallverdú, 2022), showing the fact that our existence as complex cognitive systems plays the role of agents for complex systems on a larger scale. The systems are the social systems formed for the sake of the enhancement of individuals' survivability. For the systems, the disturbances are primarily the climate condition and, when the climate condition is mild enough, also invasions from other societies—neighbors if calling them with the sense of Christianity. Against these constant disturbances, societies have been developing robust facilities, manifested as their cultures or epistemological attitudes towards the world.

As I discuss in the previous section, robust facilities allow the systems to establish functional cycles, which also means that the constituents composing the facilities function in certain ways for the sake of the functional cycles. Thus, the robust properties influence how the constituents behave in a top-down fashion. Of course, the influence from the properties is not definitive for the agents' demeanors; however, for a certain stimulus, it would show a strong effect on how the agents would deal with it.

The most obvious example of the robust facilities of societies as cognitive systems is natural language. The development of the natural language is due to the necessity of interaction through the formation of society and is through cognitive phenomena at the social level in accordance with environmental conditions. Importantly, as the Sapir-Whorf hypothesis or the hypothesis of linguistic relativity suggests, each society with different natural language usage would have its own way to deal with its surroundings. In other words, "common knowledge" about how to face the world is distributed among the members of a community owing to the usage of a common natural language. The knowledge would be not only explicit but also implicit; the knowledge is not utterable in some cases. With the distribution of knowledge among the agents, society as a complex cognitive system may react to the disturbance mechanically, but differently from the other social systems.

This study is to suggest that architectures, especially sacred ones, also play a similar role with natural languages, as the robust facility of a system. Also, I would like to state that human societies or tribes are complex systems that develop robust facilities within their own bodies. The equivalency between complex systems in general and the systems consisting of human individuals is as follows:

i. Human individual ~ agent
ii. Society or tribe ~ complex system
(*~ refers to the relationship of similarity)

The subject of the study here is the role of sacred architecture, which we have considered as robust properties for complex systems in general. Hence, I suggest the following compatibility based on the premises above:

iii. Religion ≈ (bodily) morphologies for stable relationships or functional cycles of a social system with constant situations that the system is located
iv. Sacred Architectures ≈ and the informational storages for the establishment of morphological features of the society functioning to make its own agents obtain a feature to facilitate response towards constant disturbance as a whole system

5.1 Precondition

The agents develop a social complex system in order to maximize the survivability of the individuals under a given condition. In the case of human beings, it is obvious that social activities done by a unit allow not only the unit but also the individuals as its members to sustain their existences as continuums. Maintaining their existence or their lives in the middle of nature demand various necessities for such as food and protection of their bodies. Once they could get together to form a tribe, they may distribute tasks to produce the necessities among the members. Hunting and cultivation for the provision of food are obvious examples. Hunters and farmers supply to all the members of the tribes while the others may produce other necessities.

By stabilizing the internal economy and the conditions of agents, the system could obtain a network of interaction among agents and a more distinct membrane, defining the outside and inside of the system. As I mentioned in the previous section, this distinction makes phenomena meaningful to the system because the emerging complex system would maintain its own existence. To deal with the perturbation caused by the meaningful stimuli or disturbance, the system's state would transit to another state.

The form of tribes should be the natural tendency because, if "stray" individuals meet with others, they must form a tribe. The formation is the adaptation to the current situation. For an individual human being, the wild itself is the disturbance, which is almost impossible to deal with by itself. Upon the disturbance, the option to get together to deal with should be the most feasible when it sees others communicable. Moreover, being considered the history of the species, only societies and tribes, not stray individuals, remains in the scale of the system. In other words, although getting out of the system in a very short period of time is theoretically possible, it is hard to imagine that there is an individual completely out of the interaction network of people. Especially, for the scale of the social complex system, there is no individual ontologically comparable with these types of complex systems in the scale. Therefore, I would say that formation of a social complex system can be the precondition for the argument to suggest how the society would develop the facilities with robustness.

5.2 Emergence of religion and common sense

In a nutshell, I consider religion as the set of abstracted manners of a society or tribe to accept what its members commonly confront and cannot comprehend the cause of and cannot deal with. Owing to a religious ideology distributed within a society or tribe, the agents could find the reasons of and—as the whole social system—take a certain action upon the disturbance or internal perturbation to adapt to it, even when the agents could not rationally understand the mechanism of them. The primary cause of perturbation within social systems is the climate or the environmental features of where systems are located.

The relationship between social development and the environment is well discussed by a Japanese philosopher, Tetsurō Watsuji, in his book, *Fudo—Ningen-gaku teki kousatsu*[7] (Watsuji 1961; Watsuji 2013). He analyzes our phenomenological feeling of "coldness," which is to say that, when feeling the coldness, the subject of feeling itself is embedded within the coldness and the target of intentionality to say, "(it is / I am) cold," is the embedded subject. Then, based on this analysis, he suggests the mechanism of commonsense as follows:

> [A]s we have been able to use the expression "we feel cold", without any contradiction, it is "we", not "I" alone that experience the cold. We feel the same cold in common. It is precisely because of this that we can use terms describing the cold in our exchange of daily greetings. The fact that the feeling of cold differs between us is possible only on the basis of our feeling the cold in common. Without this basis it would be quite impossible to recognise that any other "I" experiences the cold. Thus, it is not "I" alone but "we", or more strictly, "I" as "we" and "we" as "I" that are outside in the cold. The structure of which "ex-sistere" is the fundamental principle is this "we", not the mere "I". Accordingly, "ex-sistere" is "to be out among other '1's' " rather than "to be out in a thing such as the cold". This is not an intentional relation but a "mutual relationship" of existence. Thus it is primarily "we" in this "mutual relationship" that discover our selves in the cold. (Watsuji, 1961)

The statement here, as far as I understand, is that, when individual subjects have the same bodily morphologies or facilities as others and are in the proximately same location, the subject of the feeling of coldness would become the social complex system. The agents feel the coldness in common owing to their bodies. Moreover, they objectify subjectivity, as the common intentional object, to communicate with others. For social complex systems, the communication among the agents is one of the natures of interactions that defines the outside and inside of the system. Through the interaction, the

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[7] The English version, *A Climate: A Philosophical Study*, has been published by Printing Bureau of Japanese Government in 1961. The original text of the e-book is one with the same title, published by Iwanami Shoten in 2010. The original text is the same title published by Iwanami Shoten in 2010 (ISBN4-00331442-5). I have read the e-book in Japanese but refer to the English version for quotations.

subjects objectified as the targets of intentionality become the subject as the collective; in other words, the subject of the feeling of coldness becomes the one from the social complex system. Thereby, that where they are located is cold becomes commonsense among the agents. The degree of being cold is definitively different among the agents; however, as Watsuji mentions in the quote above, their own subjective judgments of the coldness occur owing to the commonsense. Thus, supposing there is an agent outside of the commonsense, it cannot even have the concept of "being cold."

Because the subject of the feeling of coldness becomes the society consisting of agents, the coldness also becomes a meaningful disturbance for that complex system. For the relationship between the system and disturbance, the society as a whole or its local that confronts the disturbance could take an action to adapt to the disturbance. As the embodiments of the adaptations, societies or tribes have been developing their own cultures; for the coldness as an example, the embodiments are the styles of clothes and of housing architectures, or the ideas held in their designs or process of creation as Watsuji suggests (Watsuji, 2013).

Religion holds robustness as the properties of the social complex systems and plays the role of the set of the manifestation for the relationships between the disturbances and the society. Primarily, the constant disturbances for local societies should be the climate. Also, disturbances could be epidemics and invasions from the outside. Then, as a result of those disturbances, instability of internal affairs or politics could occur within societies or tribes as the perturbations. Religion provides the "guidelines" for the agents on how to deal with or how to be ready for disturbances and perturbations. By the tenets, being embedded within a situation that may include disturbances becomes commonsense among the agents. Therefore, I could say that social complex systems as wholes are able to be intentional towards themselves within a such situation, as long as the religious doctrines are distributed in the system, if borrowing the idea of Watsuji.

It also can be said that religions are similar to the abilities of individual cognitive systems. In the case of individual cognitive systems, the memories of the experiences in the past contribute to the self of the system at the current moment. As this case, the memories of the systems come to the current moment as the religious doctrines. As the parts of the selves, the doctrines may play the abilities to get related with the disturbances, and the relationships would provide the potentials for the latter than the current moment.

Owing to this rigid relationship between a given condition and the social system, the systems have let their agents obtain unique attitudes toward where they live. The attitudes are observable not only within the contents of the religion and the natural languages or dialects but also in the agents' cognitive activities. The uniqueness and the difference are obvious when comparing the attitudes in the so-called West (Europeans, Americans, and Citizens of the British Commonwealth) with the ones in the East (people of China, Korea, and Japan) (Nisbett, 2003). The range that "West" and "East" cover is large so that, in terms of the relationship for the emergence between religious views and attitudes towards the world, it is not feasible to say dualistically in a strict manner if the relationship is top-down (religion develops the attitudes) or bottom-up (a suitable religion may take root in the system with a compatible relationship with the condition)—though I believe that the origin of the religions should be the collective attitudes developed by the relationship between systems and situations. However, the fact is that the difference is observable, so I show the two representative differences between Western and Asian attitudes here:

i. Ontology: the most radical difference between Western and Asian philosophers is the belief of first into the stability of reality (the noumenon, Ding-an-sich, …), while second ones consider reality as experiencing continuous change.
ii. Reality: directly related with the previous concept, Western thinkers considered that philosophy aimed to study such permanent entity, that is Being; on the other hand Asian thinkers following consequently their impermanent views departed from the pure inexistence or Nothingness (Heisig, 2001)

5.3 The role of sacred architectures

The question could be how robust properties, ontological views, and attitudes towards reality could be universal within a geographical range and period of time. Supposing that the common senses and their manifestations are thoroughly developed under the relationship between the social complex system and the climate situation where the systems are located, implicit demeanors could be different from the past because the

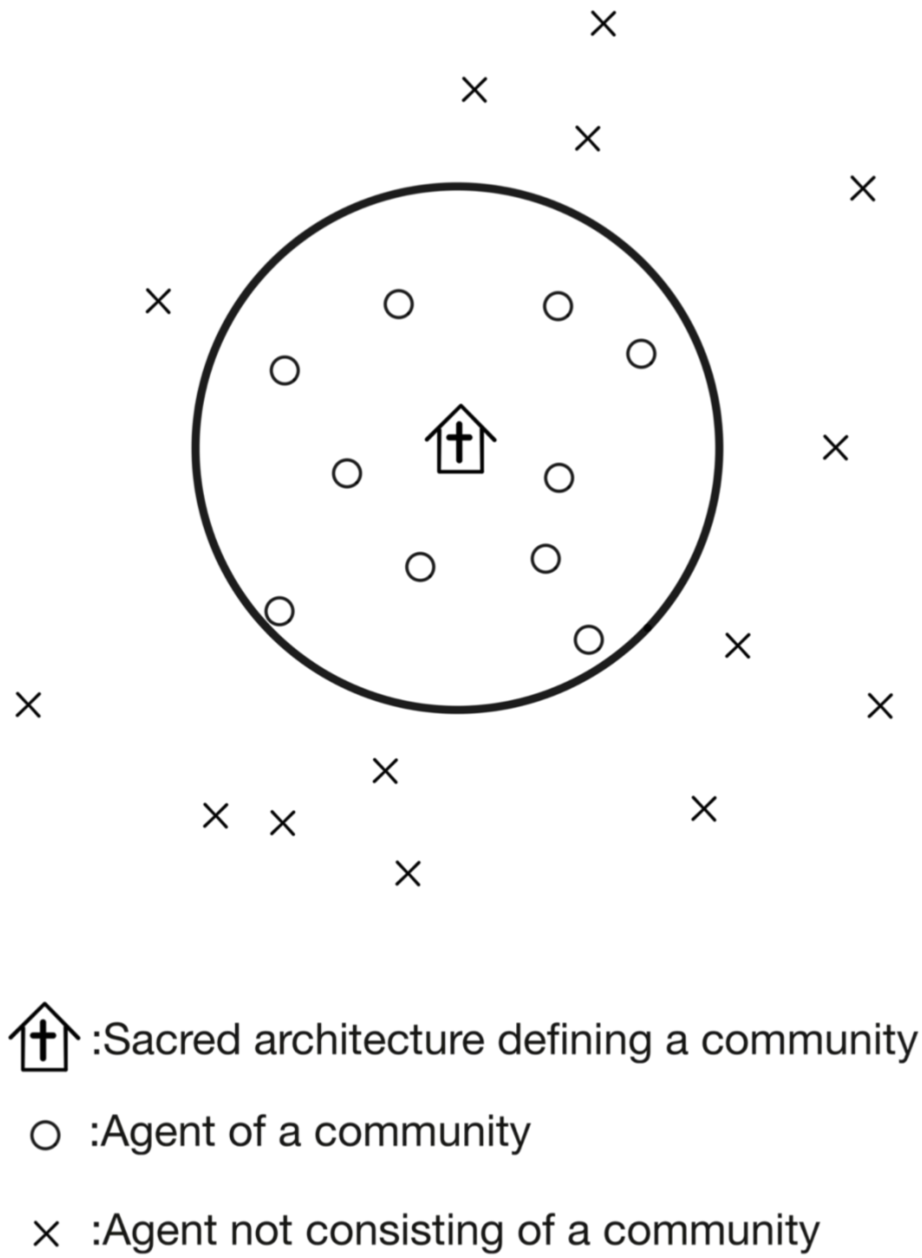

Figure 17. *Cell defined by the commonsense distributed by a sacred architecture*

The big circle in the figure represents the boundary of a society as a system consisting of human individuals. Owing to the device distributing a set of commonsense to the agents, the membrane of the system becomes more concrete. Also, the membrane is “semipermeable,” meaning that the boundary may allow the mobility of constituents of the system while keeping the sense of the outside and the inside. Owing to this semipermeability, the system can secure agents throughout the existence of the sacred architecture.

countermeasures for the environment must have changed largely due to the development of science and technology. However, according to Nisbett (2003), contemporary people's demeanors are compatible with the philosophical ideologies spun in the ancient era.

For this point, we strongly believe that sacred architecture in either West or East, as well as the religious tenets and rituals and also natural languages, plays significant roles of the media to spread and keep commonsense within a certain range and of conservation of commonsense within systems for a period of time. The thing in common among these robust properties of the systems is to provide similar subjective experiences to the agents. Hence, by providing experiences to the agents, these properties make the agents have a similar past contributing certain common abilities to their selves to facilitate responses towards constant disturbances as the systems. Thus, the agents commonly share what the disturbance is so the social system as the collective of the agents can be intentional toward it for the sake of adaptation. Moreover, sharing common experiences or affinities among the agents makes cellularity, in the spatial sense, of the system solid.

The existences of the sacred architectures are—even not completely—temporally along with ones of the systems where the architectures belong, not with the life span of individual agents. Owing to the embodiment of the system, the architectures influence the agents' tendencies of demeanors. The nature of the "existence" of sacred architecture is different between the West and East; their natures in the West are physical existences, whereas the ones in the East are more abstract. To discuss the difference, I would take the difference of the materials of the architecture: stone in the and wood in the East. As the premise to compare West and East, especially Europe and Japan, the climate in Europe is relatively stable, whereas the one in Japan holds disasters more often including earthquakes. Because of the stability of the climate, the usage of more concrete materials with a high tolerance for aging for construction is more reasonable. On the other hand, due to the high frequency of natural disasters destroying the architecture, the durability of the materials cannot be a single definitive reason. Woods are aging, but aging makes the existence of the architectures in Japan possible to be there longer. A representative example is *Ise Jingū*, which is reconstructed every 20 years owing to aging. Through this process, artisans pass their skills of creation of not only the architecture itself but also the furniture inside of the shrine to the next generation[8]. Therefore, the nature of the existence of architecture indwells in the skills of the artisans and passes through the generation along with the idea that nothing is being there as the same. Thus, agents of western social systems may share the commonsense towards the constant situation that the system is located by the western sacred architectures' definitive "being" there, whereas the agents in the Asian social systems share the commonsense while being aware of the transition of the architectures among "being," "not-being," and "being different." For this, the systems may prepare for adaptation to the disturbance even when the natural disasters have not occurred for a while.

5.4 Sacred architectures as robust properties of social complex cognitive systems

Robust properties or bodily morphologies contribute abilities and optimization to complex systems in adaptation. Religions, as these types of properties, allow the agents to commonly sense a certain constant disturbance. As the result of the distribution of commonsense among the agents towards the constant disturbance, the system consisting of the agents as a whole can respond to the disturbance. The sacred architectures representing the doctrines and tenets spatiotemporally distribute the commonsense within the systems. Owing to the commonality, the system can keep the optimal functional cycle made by the agents with the constant situation where the system is located (see figure 17).

Religions and sacred architectures are equivalent to the robust properties of the matured complex systems. By the fact that there is a religion in the system, it can keep knowing and relationship with the disturbance. This is compatible with the cognitive systems' abilities or bodily morphologies. The sacred architectures make the agents establish the functional cycles or facilities within the system. This might show similarity to genetic information for organisms as cognitive complex systems.

[8] According to an interview with Mr. Sōichiro Yokokawa from Shoko-Do (匠弘堂), on January 7th 2019 in Kyoto.

Considering the process of the emergence of commonsense and the roles of sacred architectures as robust properties, I would say that society and tribes consisting of human beings as their agents are complex cognitive systems, if my statement throughout this thesis is valid.

6. Conclusion

Throughout my study here, I have discussed that cognitive subject is a state at the present of a cognitive system, the transition of the state is the nature of cognitive and physical phenomena, and the non-equilibrium thermodynamics and complexity theory should be the key attitude to capture the transiting object of the study. Here, I would like to outline the shortly summarized achievement of each chapter again and would like to discuss briefly my own study. In addition to that, I would wrap up the conclusion with a prospect of the study.

Summary

The primary motivation for this study is my skepticism towards conventional science, especially as its methodology to study cognitive science or studies relating to the human psyche. I have doubted if its analytical attitude that is well organized by formal and natural languages can scoop matters before standardization up to our formal recognition. In other words, I have considered the possible problems in cognitive science as that science, so far, is the collective intelligence strictly formed only by our rationality and formality in manners that would not be able to capture or even define "cognition" because it includes some uncapturable aspects in the occurrence of cognitive phenomena.

For this motivation, I have started this study to define "cognitive subject"—which I had considered synonymous with "cognition" itself. Second, I suggested a definition of cognition as a transition of the self, which is the subject of a cognitive phenomenon. The self is a state of a cognitive system that consists of three sections, at the present. This theoretical structure of the self models the ontological view, the absolutely contradictory self-identity or unity of opposites, of Kitarō Nishida (Nishida, 1989). The self consisting of the three temporal sections supervenes upon the present that is the field of existences interacting with each other and one moment on the objective temporal sequence for its constituents. The scalable relationship for the emergent properties between a complex system and its agents does not contradict the supervenience; rather, it provides a clear explanation for how scalability could be developed in a complex system. Thus, supervenience in the two scales indicates that the state of the complex system is not a sum of the states of its agents, rather it is the result of the complex interaction among the agents. Hence, according to this relationship, it is possible that the states of the agents are identical in two possible worlds and the states of the system consisting of the agents are different in each world.

Although I could have suggested a possible theoretical model of the subject of cognitive phenomena, there is no reason that the self alters its own state to another, up to this point of argument. Then, supposing that the transitional movement is cognition and that it is a physical phenomenon; I questioned what drives the self to alter its state to another.

Before going to the principles of cognition, it is significant to define “to be physical.” In short, its definition is to be forced to alter its state to another by principles of the field. In this study, I have compared being physical with being virtual because of the following reasons. First, the terms “transition,” “states,” and “systems” have reminded me of the theoretical computer, automaton. Second, cognition including ours is considered as a physical phenomenon in order to respond to the mind-body problem; however, the meaning of “physical” is not clear enough. Third, contrasting to the statement that cognition is physical, nowadays it seems that it gets common to think that intelligence, which should be one of the core aspects of cognition, is reproducible by implementation in a computer.

I concluded that, so far, digital technology does not have the capacity to replicate cognition. Physical phenomena and virtual phenomena exist as facts; however, the fields where systems alter their states and functions are fundamentally different from each other, precisely to the point where the virtual reality and the existences do not change their ontological states. Due to this fundamental difference, the nature of the systems in each reality and their transitions are also fundamentally different.

Finally, I have raised non-equilibrium thermodynamics and complexity theory as the most potential key perspective to comprehend cognitive transiting phenomena. Considering these sets of theories as the principles of transitions, I have suggested that cognitive phenomena are physical and non-linear demeanors occurred due to the condition of physical reality with maldistribution of matters and energy. As the general theory including the micro-scale thermodynamic phenomena, complexity theory could provide the explanation for higher-order systems such as organisms. Moreover, the theory could contribute to how the system could establish a relationship with meaningful matters in its surroundings for the sake of obtaining its morphologies.

The significant point of non-equilibrium thermodynamics is the unique phenomena occurring under far-from-equilibrium conditions. Because of this condition, a system can be independent, as a dissipative structure, of the location. The system obtaining its individuality would act upon the relationship with the other part of the world. Including this supermicro scale phenomena as the basis, complexity theory provides the general perspective to understand complex systems with higher complexity. Each system and each scale have a unique structure due to the way and rules of interactions by the agents; however, complexity theory tells the general framework of the structure of phenomena. One of the frameworks is what interaction among agents of a system could develop its property—emergence. The relationship between the agents' interaction and the system's state is supervenience. This structural relationship allows complex systems to hold scalability within their own structures and to obtain robustness within their properties.

Discussion

As the response to my first motivation, the skepticism inquiring if conventional science with an analytical attitude is proper for cognitive science; I have concluded that it cannot capture the cognition itself, though it is the most valid methodology to study the solid facilities and phenomena occurring upon concrete relationships between the system and its environment. These achievements of the methodology would show the validity of the facilities holding strong robustness, which has been developed throughout a long exposition to constant disturbance. However, since the attitude does not have a sense of temporality, even though it may analyze the nature of the robust properties of a system while dismantling it into parts, conventional science cannot take a transiting matter, which includes cognition.

Then, I have suggested the nature of the cognitive subject that can be comprehended without the temporal sense because it is theoretically fixed within the contradiction between before and after cognition. Conventional science would have difficulty accepting a matter existing within a temporal range holding contradiction; however, it should be easy to capture and study the subject of cognition for the conventional attitude once it can accept a matter consisting of elements ontologically rooted in (subjectively) different temporal sections. Thus, it could be possible to comprehend the nature of the subject or even might be theoretically possible to make its copy once the science overcomes the difficulty to take the subject existing throughout the temporal range because the subject is fixed within the range, not moving—though the subject comprehensible for the science is one that had existed in the past so it must be impossible to capture and copy the current state of the subject.

Capturing cognition itself, however, requires different attitudes than one to observe fixed matter because it is defined here as the spatiotemporal movement and alteration by the subject. For that, as the most possible candidate that I could think of from my knowledge, I have suggested non-equilibrium thermodynamics and complexity theory as the principles and the perspective to understand cognitive phenomena. Considering these innovative ideas as possible candidates for methodologies to study cognition, I personally believe that this study could have provided a possible but general hypothesis of not limited to the drive for alteration of the subject of the cognitive phenomena but including the origin of individuality and formation of own morphologies through the transitions of the states.

I also believe that I could have provided another approach of (cognitive) science to the object of the study, from the ideological level. Prigogine and Stengers state:

> It would be out of the question to "prove" that modern science could have originated only in Christian Europe. It is not even necessary to ask if the founders of modern science drew any real inspiration from theological arguments. Whether or not they were sincere, the important point is that those arguments made the speculations of modern science socially credible and acceptable, over a period of time varying from country to country. (Prigogine & Stengers, 1984)

The analytical attitude and modern or conventional science are based on the precondition that there are definitive and unchanging ontological natures in matters— “being,” for instance by Aristotle. It is true that this idea shows a high affinity with the absolute existence of “God,” and Christianity has cultivated the field to easily accept conventional science. However, the unification of the soil cultivated by Christianity together with the analytical perspective has caused the homogenous attitude in the activity to comprehend the nature and the stagnation in the activity due to discord between the observers and the subjects of study. The discord in cognitive science was my primary concern for the discipline.

In contrast to this Western convention, I believe that I could have provided the theoretical model of the subject of phenomena, the self, based on the Asian thought, the absolutely contradictory self-identity or unity of opposites, of Nishida. This model not only is based on Asian thoughts against Western tradition but also could show compatibility with innovative perspectives such as complexity theory. We can take a spatiotemporal range as a single matter by framing the phenomenon with the model. When the range is taken as the fixed object for the sake of analysis, the object supervenes upon its field of existence. One possible theory compatible with this theoretical model is complexity theory. Considering the relationship between the range and the field of existence from complexity theory with a sense of temporality and spatial movements, the matters existing as the ranges interact with others as the agents and the field becomes a complex system. The state of the system is, therefore, created by the agents as an emergent phenomenon. Hence, this model to understand physical reality, including cognitive phenomena, can be used as the tool to comprehend the creators, whereas analytical and conventional science is the tool to comprehend what was created.

The effect of the unification of science is still ongoing. The radical development of technology currently, especially the technology of AI, overwhelms us as much as some start concerning the end of humanity because of the infinity that the technology holds. However, the infinity is only a set of what has been created. It is already there, and we just keep finding things from what is already there. In contrast, cognitive systems in physical reality keep creating what has never been before. Perhaps, every moment, they are creating emergent property equal to or greater than the infinity of virtual reality. I hope that the Asian attitude could help to understand the creative process and to improve science as the sight of human beings to observe the reality.

Prospect

Lastly, I would like to propose a prospective study with the stance that I have presented here. Supposing the ideas presented here are valid, I could hypothesize that the robustness is just a relative notion and is decided by the temporal length of the response. Because cognitive complex systems hold scalability within their own structures, the fluctuation of the systems as wholes may cause another on a lower scale. This fluctuation’s infiltration would be chained into a certain depth of the scale. How deep the stimulus may infiltrate might depend on, let me say, the meaningfulness for the subject system. Of course, it is necessary to examine this statement, but the stimulus that is more different than the system might go into the system more. Moreover, the agents’ response would bounce back toward the surface. The temporal sum of this infiltration of the stimulus and bounce as the transition of agents in each scale might be thought of or measured as the durability of the robustness. It is necessary to investigate if the target property in the surface scale would alter its state at the moment that it perceives the stimulus. Moreover, it is necessary to observe the stimulus because, in the case where the property alters, there are two possibilities: my hypothesis is not true or the stimulus does not have the strength for infiltration into smaller scales of the system’s structure.

This study might provide an explanation for how a primitive system could evolve and obtain mobility to leave its “comfort zone.” The system located within the zone does execute transition as a cognitive phenomenon according to the situation, but it is not outside of Umwelt defined by its body. Perhaps, systems need to depart from their comfort zone for the sake of the development of the whole that they are located. This statement

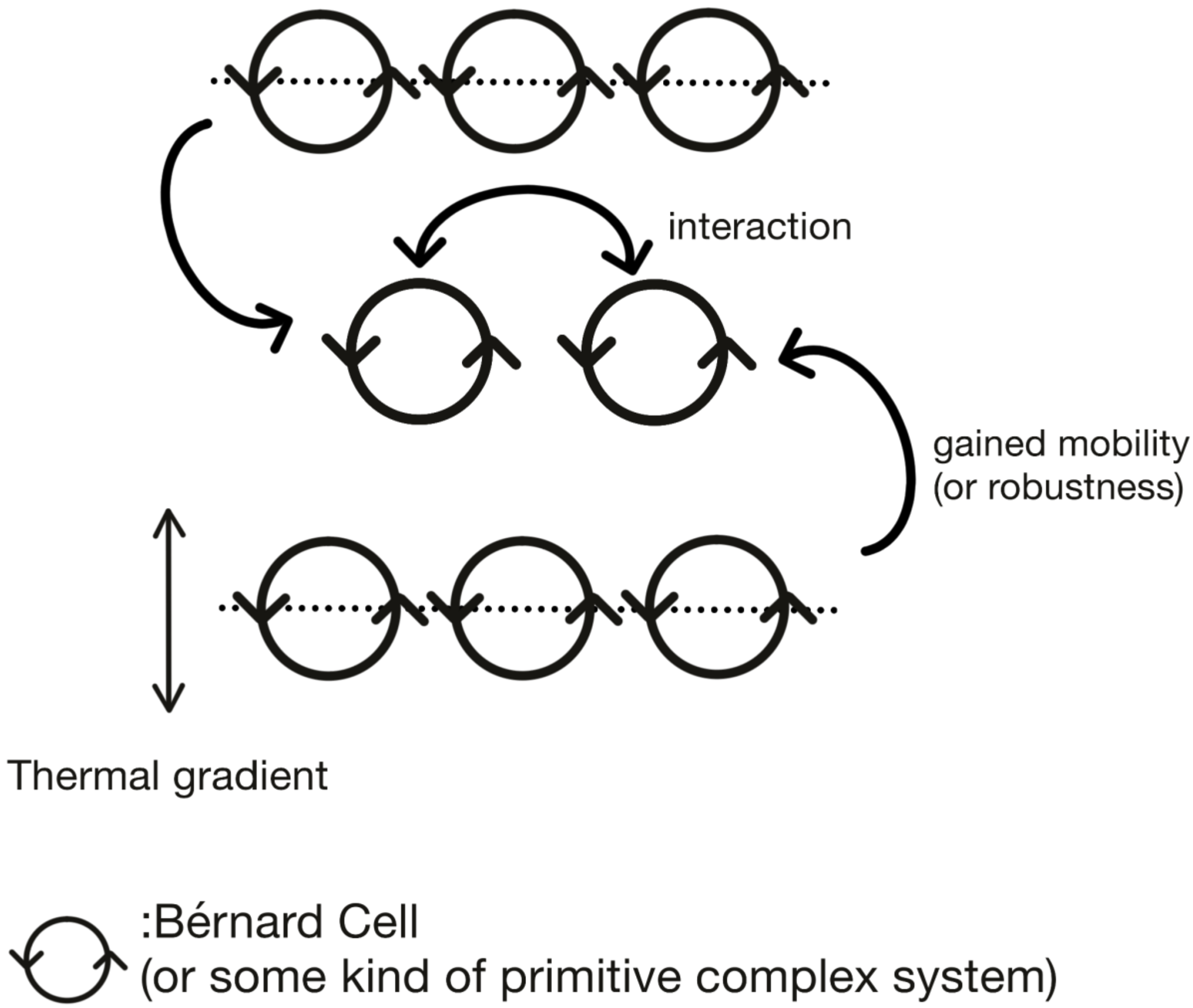

Figure 18. *Cells with mobility and their interaction*

Each case might have a different way to provide robustness to systems; however, I hypothesize that systems might leave their Umwelt to develop a new structure once systems could obtain robustness and could gain durability against the environment outside of their Umwelt. Outside of Umwelt, the system could be exposed to the disturbance that it cannot adapt to so that once being beyond the limit, which might be measured as the temporal sum of this infiltration of the stimulus and bounce as the transition of agents in each scale, the system would decay. However, since the situation where would be far from equilibrium for each system also, the relationship between the collective and the environment might be far-from-equilibrium. Hence, the group of the systems might form a cell distinguished from the environment. Then, this form of a new system on a larger scale might be a cognitive phenomenon for them to adapt to the situation.

is also just a conjecture, but the differentiation by the occurrence of a new structure from the whole would contribute to the development of the whole.

For instance, bénard cells occur and stay in a thermal gradient while altering their forms according to the flow of energy. This constancy including changing their forms to adapt to the surroundings is stationarity within the Umwelt for the cells. However, if evolving to or developing a higher scale system, they need to interact with other cells, according to complexity theory. It should be possible to interact with others, which have appeared to be in the same thermal gradient that the subject system has occurred also; however, the environment including the others might be the comfort zone already for the system.

If the general tendency is to increase complexity and to develop larger scales, the systems should obtain the robustness to maintain their own forms for a while in the severe situation where is difficult to adapt for them alone for the sake of interaction with others and development of a cellular structure with them. Holding the robustness, the systems could travel from their own Umwelt to meet with others for interaction (see figure 18). Additionally, if the interaction among the systems happens out of their comfort zone, then the environment should be “far” from the system’s conformity. so that, when interacting with each other there, they could establish a new structure distinguished from the environment. By interaction among the systems within the structure, the structure becomes a complex system on a larger scale and could obtain emergent properties that allow itself to adapt to the environment that is too severe to keep its own form for a single system.

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