23rd Gathering in Biosemiotics, Copenhagen, August 2023

More Constraint, More Freedom

Revisit Semiotic Scaffolding, Semiotic Freedom, And Semiotic Emergence

Li-Qian Zhou

Department of Philosophy, Shanghai Jiao Tong University

Outline

1. Introduction
2. A paradox of semiotic emergence
3. Dynamic emergence
4. A paradox of dynamic emergence
5. Two types of freedom
6. Solving the paradox of semiotic emergence
7. Conclusion

Introduction

- Living processes are distinguished from physical processes in that they are semiosis. Novel semiosis has kept emerging in biological evolution. With the emergence of novel semiosis, organisms acquire more semiotic freedom.
- A task of biosemiotics is to explain how increasing semiotic freedom is possible.
- Semiotic scaffolding plays a crucial role in the emergence of novel semiosis.
- Semiotic scaffolding is interactional constraints and possibility biases and thus reduces the degree of freedom. (Favreau 2015, 237)
- As we can see, there is a conceptual inconsistency in explaining semiotic emergence: the increase in semiotic freedom comes from the decrease in freedom. I call it a paradox of semiotic emergence.

- In this presentation, I will argue that the paradox of semiotic emergence is a species of a paradox of dynamic emergence: The more constrained the micro level is, the more freedom the macro level has.
- The paradox can be solved by classifying the level of constraint and freedom, and articulating the dialectics of possibility and probability.
- The paradox of semiotic emergence can also be solved in the same way.

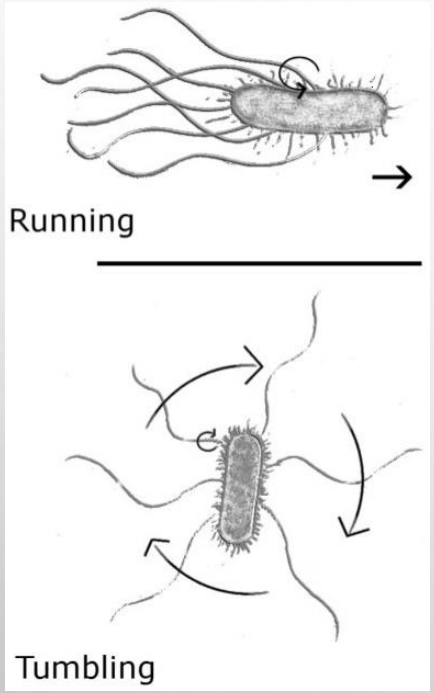
Sebeok's Thesis

- "Semiosis is what distinguishes all that is animate from lifeless." (Sebeok 1988: 1089; cited from Kull, Emmeche, and Hoffmeyer, 2011)
- The thesis implies that,
  1. semiosis is different from a physical-chemical process;
  2. biological phenomena are semiosis, or meaning-seeking-making processes, in nature.
- How can we know that semiosis is not a physical-chemical process?

Minimal cognition

- If we examine the physical-chemical processes realizing a unicellular orgasm like *E. Coli*, a physical-chemical process may not only be regulated by other physical-chemical processes but also some meta-processes called meta-metabolism that do not directly participate in the metabolism. Meta-metabolism is minimal cognition.
- Minimal cognition (Van Duijn, Keijzer, and Franken 2006; Godfrey-smith 2016)
  - "This concept, when unpacked, has two features. One is functional; minimal cognition adapts organisms to the *distribution* of metabolic resources, rather than aiding in the processing of those resources themselves. Second, the system's output involves motion, either of parts or the whole, rather than biochemical change. Motility or physical manipulation of the environment is achieved." (Godfrey-Smith 2016, 779)
- Minimal cognition is semiosis. Why?

A case study: *E. Coli*

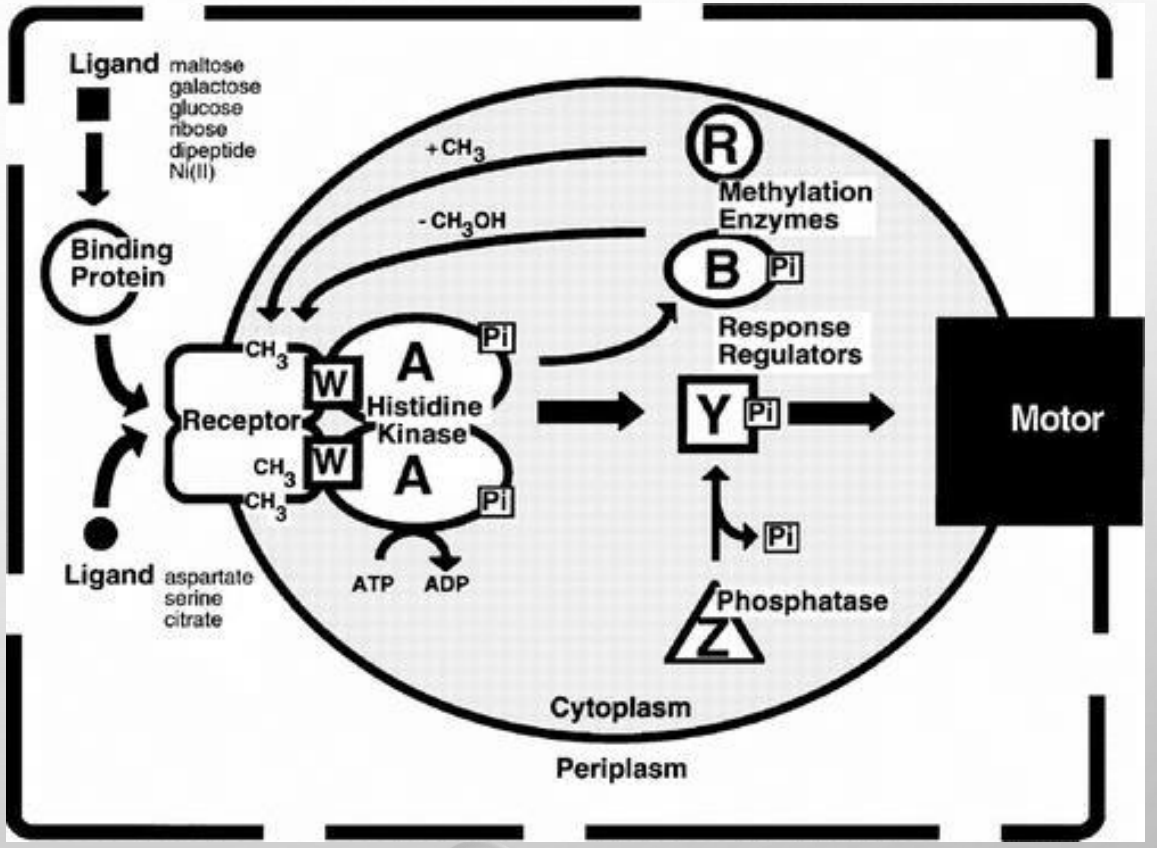


van Duijn, et al. 2006

- *E. Coli* has two modes of action to travel along gradients of attractant and repellent chemicals, running and tumbling.
- The detection of the changes in gradients of chemicals by temporal comparison causes the actions.
  - When there are high levels of concentration of attractant chemicals, *E. Coli* runs toward it; when there are repellent chemicals, it tumbles.

Two-component signal transduction (TCST) system

- The TCST system is a molecular sensorimotor mechanism that is made up of three parts, (1) receptors, (2) a transmitter, the protein histidine kinase (CheA), and (3) a response regular, the protein aspartate kinase (CheY).



van Dujin, et al. 2006

Tumbling

- “High levels of repellent chemicals at the bacterial receptors cause CheA……to auto-phosphorylate, creating a phosphate-derivative of the CheA protein (CheA-P), subsequently leading to the phosphorylation of the response regulator (CheY-P) and the methylation enzyme CheB-P. By becoming phosphorylated, the response regulator (CheY-P) is able to bind with the flagellar switch protein, thereby increasing the probability that the flagellum switches its rotation, inducing tumbling behavior. CheY-P is often said to act as a ‘tumbling signal’ within the bacterium, as it regulates the overall tumbling-frequency.” (van duijn, Keijzer, and Franken 2006, 162)

Tumbling as semiosis

- The TCST system is a signal detection/regulation system. It is a second-order regulation that differs from but regulates first-order biochemical processes to achieve adaptation.
- To put the analysis in biosemiotics terms, the TCST system is a functional circle constituting the Umwelt of *E. Coli.*
  - The distribution of chemicals in the environment is meaningful for *E. Coli.* It means life or death for it.
  - The TCST system works through semiosis: CheA-P is a sign representing the changes in gradients of repellent chemicals (object) creating CheY-P (interpretant).
- It does not aid in processing the repellent chemicals but adapts the *E. Coli* to their distribution. That is to say,
  - there is a divorce "between the deterministic coupling of the material-mechanical dynamics of a systemic process and the observable causal outcomes of that process" (Bruni 2008). Divorce is named semiotic freedom as we know it. This is the independence side of semiotic freedom.
  - The other side of semiotic freedom is its causation on first-order biochemical processes: environment cues can be used as signs by an organism. (Hoffmeyer 1996; 2008)
- How semiotic freedom is possible?

Semiotic scaffolding

- The primary mechanism behind semiotic freedom and semiotic emergence is semiotic scaffolding.
  - "……The core property of a semiotic scaffold remains that of focusing the energy flow (behavior) of the concerned system or subsystem upon a rigidly limited repertoire of possibilities, or in guiding the system's behavior to realize a definite sequence of events." (Hoffmeyer 2007, 156) .
- *E. Coli* again.
  - As we all know, organic molecules composing unicellular orgasms like *E. Coli* are very reactive. They have the potential to react with many other kinds of molecules. That is to say, they have lots of possibilities. In other words, the degree of freedom is very high. However, the possibilities are highly constrained or biased in the TCST system. Only a definite sequence of reactions is possible in the system. Correspondingly, other alternative possibilities are eliminated by semiotic scaffolding. Technically, when the possibilities of a system are reduced, its degree of freedom decreases.
  - Therefore, semiotic scaffolding creates new semiotic freedom by reducing freedom.

A paradox of semiotic emergence

- P1. Semiotic scaffolding leads to the emergence of novel semiotic freedom.
- P2. Semiotic scaffolding is a kind of constraint.
- P3. Constraint is the reduction of freedom.

- Therefore,

a) Novel freedom comes from the reduction of freedom, or,

b) the reduction of semiotic freedom leads to the creation of semiotic freedom.

- What a paradox!

The paradox

- "……A general principle pertaining to emergent processes—i.e., That in emergent processes, freedom of possibility will always be constrained at the simpler level to allow an altogether new kind of freedom to appear and unfold at a more complex level." (Hoffmeyer 2007, 258)
- "Semiotic scaffolding consists in biologically instantiated sign relations interlocking with and reinforcing one another, and by so doing, providing directionality towards and away from other sign relations in the network, through the dynamic emergence and canalization of semiotic pathway biases and constraints. Such ongoing semiodynamic re-adjustment enables new scaffoldings and new pathways within and between scaffoldings to arise, increasing semiosic capacity exponentially." (Favareau 2015)
- Then, how to solve the paradox?

Emergence

- What is emergence?
  - It has two core features: dependence and autonomy. Briefly, emergent phenomena are dependent on but autonomous from underlying processes. (Bedau 2002) .
- How to deal with emergence?
  - We should begin our investigation with “a metaphysically acceptable and scientifically useful notion of emergence.” (Bedau 2002)

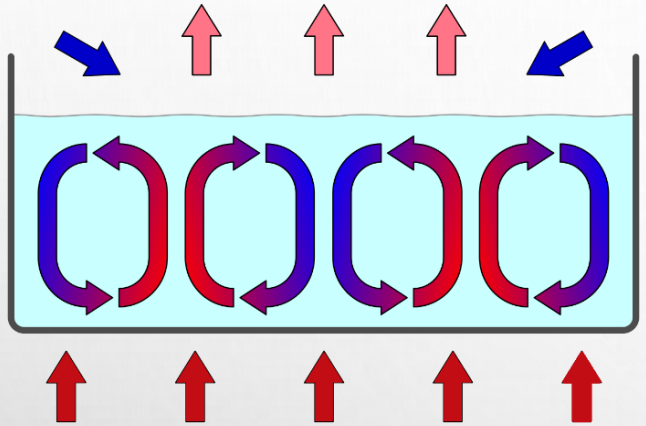
Dynamic emergence

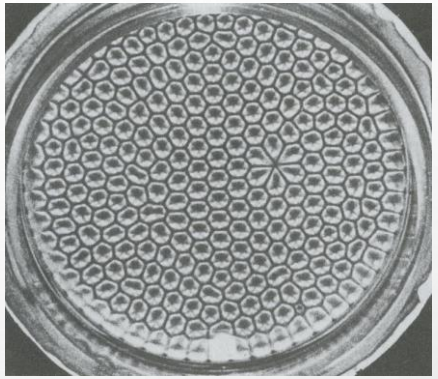
- Dynamic emergence concerns the emergence generated by dynamic systems.
- In physics, a dynamic system is composed of persistently interacting components whose states vary over time.
- The dynamic systems that generate dynamic emergence are non-linear dynamic systems.
  - When we say a dynamic system is non-linear, the system's global state at a higher level does not change in proportion to the aggregation of the changes of composing components at a lower level.
- Consequently, the global behaviors and properties defining the system's state are not just simple aggregation or additivity of that components. Epistemologically, the higher level state is unpredictable from the states of components at the lower level.
- The generation of a global state of a dynamic system meets the hallmarks of emergence: dependence and autonomy.

Some clarification

1. Dynamic emergence is a process conception of emergence. (Deacon 2012, 177) The conception differs from the mereological (part/whole) distinction conception.
2. Dynamically emergent phenomena are ontologically dependent on and irreducible to the underlying processes.
3. Dynamic emergence presumes causal pluralism rather than causal fundamentalism.

A case study: Bénard cell





- Rayleigh–Bénard convection is a type of natural convection in fluid thermodynamics. It occurs in a planar horizontal layer of fluid, e.g., water, being heated from the blow. A regular pattern of convection cell called Bénard cell spontaneously generates.
- When the system is far from equilibrium, the possibilities of dynamic states of molecules are highly constrained, and many are eliminated. Because molecules are highly correlated with each other due to the regulation/control of the emergent quasi-regularities, only a specific range of micro-level dynamic states can be realized. The degree of molecules' freedom is low. In turn, the emergence of quasi-regularities at the macro level is possible when the degree of freedom at the micro level is low.

A paradox of dynamic emergence

• The emergent global state at a macro level is possible with constraints upon the micro-level. More constrained the micro level is, the more freedom the macro level has. Then, we can see a conceptual consistency in dynamic emergence:

P1. Constraints upon processes at the micro level lead to the emergence of new macro dynamic freedom.

P2. Constraint is the reduction of freedom.

Therefore,

The reduction of freedom creates new freedom.

How to solve a paradox?

- The paradox of dynamic emergence can be solved through a strategy of denying apparent inconsistencies.
- The strategy claims that "what looks like a set of mutually inconsistent statements can actually all be true at the same time." (Cuonzo 2014, 48)

Two types of freedom

- The core idea of the paradox of dynamic emergence claims that the reduction of freedom leads to the creation of freedom. Then, what is the meaning of freedom, reduction, and creation?
- Freedom can be understood in two senses.
  - First, a system's degree of freedom is measured by the number of states it can be in. The more states a system may realize, the higher degree of freedom the system has. This sense of freedom concerns the possibility of the system. We call it freedom$_1$.
  - Second, a system with new freedom means accessing a state that once could not. That is to say, the state is not only possible but also highly probable. We call it freedom$_2$.

Freedom at different levels

- The concepts of freedom in the paradox describe facts at two levels, micro and macro.
- Freedom_1 reduction happens at the micro level, while freedom_2 is created at the macro level.
    - That is to say, the possibilities of microstates are reduced while a state that almost could not be realized is actually realized at a higher level.
- In the case of Rayleigh–Bénard convection, the possible states of each liquid molecule at the micro level are highly reduced to a specific range of states. As a result, a convection cell, which once is incredibly impossible, is actually generated.

Solve the paradox of dynamic emergence

- The premises and the conclusion should be reformulated in light of the clarification.
- P2 should be reformulated as "constraint is the reduction of freedom$_1$". P1 explains what happens in a leveled system. Because the processes at the micro level are constrained, its freedom$_1$ is reduced while freedom$_2$ is gained. This leads to the emergence of freedom$_2$ (with a reduction of freedom$_1$) at the macro level.
- Therefore, the conclusion should be rewritten as "The reduction of freedom$_1$ at the micro level leads to the reduction of freedom$_1$ at the macro level; while, accordingly, the gain of micro-level freedom$_2$ creates freedom$_2$ at the macro level."
- As a result, the paradox is solved. This illustrates Favareau's claim that scaffold functions as "*interactional constraints and possibility biases*." (Favareau, 2015)

A clarification of semiotic emergence

- Semiotic freedom, scaffolding, and emergence should be understood from a temporal and historical perspective.
    - On the one hand, semiotic scaffolding constraints underlying processes to realize specific quasi-regularities instantly and spatially and thus helps the system to access states that once is almost impossible.
    - On the other hand, semiotic scaffolding also makes the emergence of adaptive characters possible in futural evolution.
- Therefore, semiotic causation scaffold biological systems in these two senses.

Reformulate the paradox of semiotic emergence argument

- P1. Semiotic scaffolding leads to the emergence of new semiotic freedom.
  - The type of semiotic freedom semiotic scaffolding leads to is freedom$_2$.
- P2. Semiotic scaffolding is a kind of constraint.
  - A semiotic constraint can be understood in two senses.
  1. Semiotic scaffolding constrains underlying physical processes through semiotic rather than physical interactions. It constrains physical processes to realize in a specific sequence.
  2. Semiotic scaffolding also constrains semiotic interactions, too.
- P3. Constraint is the reduction of freedom.
  - The degree of freedom$_1$ of the semiosis is reduced. While in turn, it makes the organism develop more convoluted semiotic systems and thus access more prosperous and diverse semiosis. Thus, the degree of freedom$_2$ increases.

Revisiting the conclusion

- With the new understanding, the conclusions of the paradox of semiotic emergence can be reformulated as,
  a) The reduction of freedom$_1$ at the micro level leads to a decrease of that at a macro level both spatially and historically.
  b) The creation of semiotic freedom$_2$ at a micro level creates both new semiotic freedom$_2$ at a macro level and in evolution.
- There is no conceptual inconsistency anymore. Hence, the paradox is solved.

Dialectics of constraints and freedom

- Since emergent quasi-regularities, no matter as forms/patterns/structures or semiosis plays the role of reduction and creation of freedom through their constraining power, I would like to call this logic the dialectics of constraint and freedom in dynamic emergence.
- The logic is recurrently and repeatedly performed in the natural world. Early classical works of biosemiotics, like the analysis of code-duality (Hoffmeyer and Emmeche 1991) and hierarchy of reference (Deacon 1997), also imply the very logic.

Thanks for your attention and patience!
Questions, comments, please!