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Methodology of Information Science

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Abstract： *In this paper, the authors introduce separately the "Reduction" methodology, which is mainly applied in the traditional Material Science, and the "Emergence" methodology, which is mainly applied in the Information Science. With analyzing the application scope of "Reductionism" and its restriction, we discuss how "Emergencism" is apt to improving the development of information science, and suggest a conversion from reductionism based on paradigm of material science into emergencism based on paradigm of information science.*

Keywords： Information Science; Material Science; Methodology; Reductionism; Emergencism

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1. Introduction

Scientific methodology is the theory on general method, is the theoretical system on the property, peculiarity, internal relation and development of the general method, and is the systematic theory on general procedure of obtaining scientific cognition. Any discipline will need special research approaches because of its special study object, and there is no exception to Information Science. If we said, the basic method of the whole Material Science is the Reductionism method，and that of the whole Information Science is the Emergencism method. That is to say, the general methodology of Theoretical Informatics is the Emergencism.

2. The basic thought of Reductionism method and its restriction

The main method of Material Science is Reductionism method. "Reducibility" means "decrease", "abbreviation", "transforming one form into another simpler form", "translating one kind of language into another", etc… Descartes, who laid a

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foundation for the Reductionism, emphasized that we must study the parts first, and then we can understand the whole. According to this, Reductionism method is a way of mastering the whole, it is just the Analysis-Reconstruction method. In this method, analysis, division and reduction take the dominant place：first dividing the whole into different parts, then explaining the whole according the different parts. Oppenheimer and Putnam had proposed four principles of Reductionism in the book of “Science Unity Supposed as a Job”: (1) a reducibility concept with very good development is not contradictory with the view of part-whole relation; (2) the different, good order branches of Science have described different substantial levels, and the thing at the particular level is made up of simple elements belonging to the lower-level; (3)The scheme of science unity is building on the most basic level of science --Physics; (4)in the procedure of universe evolution, the objects at the given level mutually combine, and form the whole which locates at the higher-level; the things that appear at later time can be explained according to the things and courses happened at earlier time.

Reductionism method acts very well in the traditional material word, but its restriction appears more and more severe in the information word, in which the “information” is becoming more and more important. The Reductionism method advocates: there are no other things in the universe except for material and the movement of material. It only admits the existence of material, and only studies the movement of material. Its theories are just about material and material movement, and its methods are only suitable for material and material movement characteristic. The community of Material Science only acknowledges the system that just seeing material entities as its elements (such as the cosmic galaxies, the physiological system of human body), refuses to acknowledge the system that seeing information as one of its elements (such as Human Intelligence, social culture). In fact, all the things in Universe include both material and information; the difference just lies in the different forms of material structure and the different ability of information processing. The movement of things always includes two respects of the matter movement and the information movement, and the difference only lies in the different forms and courses of the movement. In the universe evolution, these two respects depend upon one another, promote each other. For example, the carriers of life information can only be the biological material, while the appearance of human brain will inevitably create characters symbol, science and technology, etc.

The non- reducibility is widespread in the nature, especially in the fields of life, society and thoughts. Once a great deal of parts form the system according to a certain way, some attributes, characteristics, behaviors, function etc. that the system has while the parts or the sum of parts have not, will appear; once the whole is reduced to the irrelevant parts, these attributes, characteristics, behaviors, functions, etc. will disappear. The thing (or property) that the whole has while the part has not is named the Emergent Property, or abbreviated as “Emergence “. It is the Emergencism or the Scientific Methodology about Emergence,

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not the Holism, that really acting on revising and supplementing the Reductionism[1].

3. The basic thought of Emergencism and Information Emergencism

Emergencism means something (or property) that possessed by the whole but not the portions. The thought of Emergence has a long history, and Plato distinguished the whole “as the total of parts” and the whole that “comes from partial entity, but is different from the sum of parts”. Mill distinguished two kinds of mixture formed by association of the causes. For the former one, we can take the synthesis of strength in Mechanics as an example to prove that the general outcome of all the causes equates to the sum of their own results. For the later one, we can take chemical reaction as an example to prove that, the result of all the causes is heterogeneous to each partial cause. The example that hydrogen and oxygen can combine into water was quoted: “The properties of oxygen and hydrogen have not reflected in the water, their compound, at all.” There is no test which is separately about oxygen and hydrogen, or any knowledge about their respective laws, which can make us have the conclusion that the combination of them can produce water. The properties of compound formed by two different components were known as Resultant and Emergent later. Mill’s narration had put forward three criteria of Emergent: First of all, the Emergent characteristics of a whole is not equal to the sum of characteristics of its every parts; Second, it is completely different between the kind of Emergence characteristics and the kind of component characteristic; Third, Emergence characteristics can not be derived or predicted just according to the exploration to the behavior of every component.

The core of the concept and the view of Emergencism is the" structure model "of the system, formed by material elements and information elements. The structure here, including hardware structure and software structure, which can be space structure, time structure, and also logic structure, algorithm structure. For the convenience to discussion, we name the theory regarding the Emergence caused by material structure as Material Emergencism, and the theory regarding the Emergence caused by information structure as Information Emergencism. The former discusses how the material structure of certain system emerges new material attributes, characteristics, behaviors and functions, while the latter discusses how the information structure of abstract system emerges new information attributes, characteristics, behaviors and functions. In physical world, the structural model of material is the key factor of determining the characteristic of the system. For example, the different permutation way of the carbon can cause totally different material shapes and characteristics such as the graphite, diamond. In information world, the success-failure and efficiency of the communication, controls and computing process all depends on the structure model that how the system elements form the whole, including the hardware structure model, but mainly the software structure

[1] Li Jian-shan. (2002). *A Conspectus of Scientific Methods.* Science Publishing Company, 7.

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model. While paying attention to the structure characteristic of system, we still should pay attention to the dynamics characteristic of system[2]. In the material system, the memory, transmission and processing course of material are linked to the memory, transmission, transformation, enlargement and work course of Physics energy, in other words, the movement of material is closely related to the movement of energy. In the information system, the memory, transmission, processing, creation of information are all linked to the memory, transmission, transformation, enlargement and work course of various Informatics energies, we must discuss the information together with the movement of information energy.

The main method of Information Science is Information Emergencism that means; we can discuss the mode or model that how the new properties of information system emerge in the process of observation, experiment, hypothesis, and reasoning. Studying the process model of information is to study its structural characteristics and Dynamics principle. Thus, we can understand the mechanism that how the new information attributes, characteristics, behaviors and functions in system can emerge. So, it is the basic thought of Information Emergencism of paying close attention to the semanteme structure of the elements of information system and the Dynamics mechanism of information energy. For example, what we pay attention to in the discussion of computing system is: (1) the elements participating in "calculation" (signal or symbol); (2) the "structure" among the elements, or the semanteme relation among them; (3) the "rule" realizing calculation (symbol transformation or signal transformation). Once this system is "started ", it will run according to the rule until been "stopped". It is just centering on computing system that Turing and Von. Neumann proposed distinctive information elements, structures and rules, so a Turing machine and a Von. Neumann computer could "emerge". In the general meaning, communication and control can both be regarded as a form of "calculation", and also need the discussion about the elements, structures and rules. In fact, any subject related with Informatics has its own unique "thought model", and unique Information Emergencism. These models regarding information structure and information energy often become the foundation and core of all the knowledge of that subject. The basic concepts, principles and methods regarding these structure models will be the basic theories of such subject, even be the common ideas and faith of experts in such subject, and will be the "paradigm" of relevant subject. The basic paradigm in common of the whole Information Science is named the Information Science Paradigm.

4. Information Science Paradigm based on Emergencism

The word, Paradigm, appears in Latin firstly, and its original meaning is the rule of suffix variation in grammar; Kuhn used it to express "example", "model", and "mode". Particularly, the word of "Paradigm" indicates three kinds of fundamental elements in the cognition of scientists group:

[2] Li Jian-hui. (2002). Reductionism, Emergencism and the Unity of the Universe. *Science, Technology and Dialectic, (10),* 5-8.

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First, as the symbol generalization adopted by the group; second, as the model of offering the analogy for the group and giving inspiration to people; third, as the example of the concrete answer to certain question. For the members of scientific community, the paradigm is their faith in common and the model or frame that they adopt in common in theories and methods. Then, what is the Paradigm of Information Science?

At information age, the knowledge system of the whole science, like economy, life and society, is facing a course of overall informationization. It has the same significance with the "Physics – Mathematics" of the subjects in Industrial Era. When the principles and methods of Information Science are used for solving the problems in traditional science and technology, it is just the course that the Information Science Paradigm carries on infiltration, impenetration and expansion, and also the course of transforming and reconstructing the concepts, methods and knowledge system of traditional subjects. In the course of traditional subjects' informationization, the Information Science Paradigm is replacing the Material Science Paradigm progressively.

In 1948, Shannon published a book named "Mathematics Theory of Communication", marking the births of communication model and communication information theory. In the same year, Wiener published the book titled as "Cybernetics", which proposed the information control model and explained the control theory systematically. In the 1930s, there is a breakthrough in the research about calculation model. Kurt Godel, Church, Turing, Poster et al. proposed a set of calculation models, such as recursive function, λ calculation, etc. of which Turing machine studied the calculation from the general course of calculation, and was closer to the thinking way of ordinary people. In 1946, Von Neumann, et al. issued the research report of "A Survey of Logic Structure of Electronic Computer Device" according to the first electronic digital computer ENIAC, and confirmed the basic structures and operation principles of the electronic digital computers with modern storage program. Shannon's communication model, Wiener's control model and Turing's and Von Neumann's calculation model represent respectively the basic process of three kinds of information phenomena (transmission, utilization and generation). In the fields of communication engineering, automatic control and calculation, the above three models concisely generalized the basic concepts, basic theories and basic methods that Information Science Community insist on in common. They form the "Paradigm" of Information Science.

Based on this Paradigm, the workers of Information Science have the common faith in the cognition, and have the common models and the frames of solving problems in the method. Since the 1940s, though people proposed the modification and supplement to Shannon's and Wiener's model, even someone opposed Von Neumann's calculation model, the common faith of Information Scientist group on the three models has never been wavered. Fundamentally speaking, it is the very Information Science Paradigm, as most

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common, general theory and method, taking Information Science experts and engineers as the carriers of transmission and innovation, that constructs information economy, expands the information consumption, and welcomes the new era of information civilization.

5. Conclusion

The two great theoretical systems of "Reductionism" and "Emergencism" may seemingly be different form each other, however, the inner relationship between them should be looked on correctly. Both of the "Reductionism" and "Emergencism", which are respectively the theoretical foundation of tradition material word and information word, are the theory about the relation of the whole and the parts. According to the Informatics view, the above two are two different theories on partial information and integral information. According to "Reductionism", the integral information equals to the sum of the partial information, however, "Emergencism" uncovers the dialectic relation between the partial information and the integral information: On the one hand, the integral information is not the sum of partial information, but the whole will emerge new information and eliminate the unreasonable information after integrating the partial information; On the other hand, once the new information was emerged in the whole, it will reflect in each parts, as a result, the parts belonging to the relevant whole are different from that disassociated from the whole. So the part must contain some information that belongs to the whole, studying the parts will do help to study the whole. Meanwhile, we must realize that new emergence characteristics of the whole will cost much, such as, some characteristics of the parts may disappear after been integrated into the whole system, only when the integral system was break into parts, the characteristics we mentioned before will reappear. So, elimination and emergence always goes together. In a word, it's not right to see the "Reductionism" and "Emergencism" as a pair of opposite categories, "Reductionism" and "Emergencism" should be studied and applied together. Both of the two theories are right in their own applied fields ("Reductionism" will work well to study the parts, and "Emergencism" will work better to study the integral system.)[3] So we should not abandon the Material Science Paradigm when we are studying the Information Science Paradigm, which needs the "Emergencism" but can't part from "Reductionism", either. The above two improve the development of the other, and play great roles in their own applicable fields.

[3] Miao Dong-sheng. (2002). *System Science is on the Emergentness of the whole. System Science and Project Research.* Shanghai Science and Technology Education publishing company, 167-182.

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[3] Miao Dong-sheng. (2002). *System Science is on the Emergentness of the whole. System Science and Project Research.* Shanghai Science and Technology Education publishing company, 167-182.

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