FOUR APPROACHES TO THE STUDIES OF INFORMATION PHILOSOPHY

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Abstract: *Since the pioneering work of Shannon and Wiener in information science and technology in the mid-20th century, philosophical inquiries into the nature of information have been explored to varying degrees across different philosophical traditions. To better understand this emerging field and the fundamental nature of information, it is essential to systematically categorize and analyze these philosophical efforts. Such a classification allows us to highlight the distinctive features of various approaches within the philosophy of information. Drawing from the foundations of different philosophical schools, we can organize, compare, and evaluate the diverse perspectives on information. In doing so, we can better grasp the conceptual relationships and theoretical implications involved. In summary, four main approaches can be identified: the semantic approach, the postmodern approach, the phenomenological approach, and the naturalistic approach. While each offers a unique perspective on the essence of information, they also share certain commonalities. Collectively, they reflect the philosophical challenges and demands posed by the information age, each from its own distinctive viewpoint.*

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Introduction

Philosophical studies of information were widely engaged by various philosophical schools in the second half of the twentieth century. The initial

motivation or origin of this topic of research can be traced from Norbert Wiener's famous statement [Wiener, 2019, p.182]:

> "Information is information, not matter or energy. No materialism which does not admit this can survive at the present day."

Cybernetics emphasizes the role of information in control processes, particularly in signal processing and decision-making in noisy environments. However, this assertion reflects Wiener's profound contemplation on the nature of information beyond the technical domain, which has, to some extent, spurred continuous exploration into the essence of information within both scientific and philosophical communities. In the same year that Cybernetics was published, Claude Shannon introduced the foundational paper of modern communication engineering [Shannon, 1949], proposing the theory of information.

Both Wiener and Shannon recognized the role of information in communication processes. Information theory focuses on the quantification, transmission, and processing of information, using Shannon entropy to measure uncertainty and average information content. Cybernetics, on the other hand, emphasizes the control and regulation of systems. While it does not directly quantify information, it indirectly involves information processing through concepts such as state space models and control errors. Despite their different starting points, both explore how information is acquired, processed, and utilized to guide system behavior or optimize communication efficiency. Subsequent information science research has built upon the work of these two pioneers. Philosophical studies of information aim to critically examine the understanding of the essence of information from the perspective of information engineering, approaching this inquiry through four avenues.

Approach One: The Semantic Approach. This approach establishes an *a priori* philosophy of information centered on semantic information through logical analysis of it, starting from the foundational paper by Rudolf Carnap and Yehoshua Bar-Hillel, and culminating in the work of Luciano Floridi. Fred

Dretske's views play a pivotal role in bridging earlier and later developments within this approach.

Approach Two: The Postmodern Approach. This approach is dedicated to cultural reflection on information technology from a value dimension. The perspectives of Jean-François Lyotard and Michel Foucault will be examined in this paper; both start from the interplay mechanisms between information technology and political power, leading to a comprehensive critique of the epistemological attributes of information society.

Approach Three: The Phenomenological Approach. Gilbert Simondon is the most typical information philosopher within the phenomenological tradition. He philosophically reflects on cybernetics, analyzing the role of information in the construction of the conscious subject and its interpretation of the essence of knowledge, thereby forming his distinctive individuation theory. Rafael Capurro’ s Angeletics, built from existentialist and hermeneutical perspectives, opens up a viewpoint for information studies within the German phenomenological tradition.

Approach Four: The Naturalistic Approach. This approach aims to develop an information research paradigm closely integrated with science, focusing on dissolving the transcendental attributes of information and constructing a philosophical foundation for unified information science. Compared to the other three approaches, this one has generated rich, multidimensional, and varied ideas, theories, and perspectives in terms of depth and breadth. Therefore, this paper primarily examines the main viewpoints of key members associated with the Foundation of Information Study (FIS) conferences and the International Society for Information Studies (IS4SI). Below, I will analyze these four philosophical research approaches to information respectively.

1. The Semantic Approach

1.1 Carnap and Bar-Hillel's Quantification Scheme for Semantic Information

Carnap and Bar-Hillel argued that the quantification of information in engineering and technical fields does not target genuine information, lacking focus on "meaning" [Carnap&Bar-Hillel, 1954]. Semantic information is central to human thought and can be understood and manipulated through the formalization of language. Therefore, they proposed a quantification scheme for semantic information based on information theory, wherein the amount of information depends on the formal structure of linguistic expressions rather than their actual meaning, implying a closer relationship between information quantity and the structural form of sentences. Regarding the calculation of information quantity, they believed it was impossible to formulate an equation for information content that satisfies all intuitive requirements due to inconsistencies among these requirements. Thus, they provided multiple cont function formulas, each corresponding to different linguistic forms and combinations.

a. For any atomic sentence B, cont(B) = 1/2;

b. For a disjunction Cn of n atomic sentences with n distinct primitive predicates, cont(Cn) = (1/2)n;

c. For a conjunction Cn of n atomic sentences with n distinct primitive predicates, cont(Cn) = 1 - (1/2)n;

d. For any Q-sentence i, cont(i) = 1 - (1/2)k (where k is the number of different atomic propositions appearing in i). (A Q-sentence refers to a proposition that contains only one quantifier and one predicate.)

The cont function can only satisfy a partial set of requirements. Another partial set is satisfied by the inf function, although these two sets overlap. The inf function represents the measure-of-information. The relationship between

measure-of-information and amount-of-information can be expressed by the following formula.

$$\text{inf(i)} = \text{Log}\frac{1}{1-\text{cont(i)}}$$

The cont function is defined based on conditional entropy in probability theory, allowing it to measure the information content of a statement given another statement. In contrast, the inf function is defined based on the negative log-likelihood in probability theory, enabling it to measure the information content of a statement independent of other statements. Therefore, the cont function is more suitable for situations where contextual information is considered, whereas the inf function is better suited for assessing the information content of individual statements. This formula can be derived as follows:

$$\text{inf(h,e)} = \text{Log}\frac{1}{c_p(\text{h,e})}$$

Here, c_p(h,e) represents the confirmation degree of hypothesis h based on evidence e. This c_p(h,e) can be expanded as follows:

$$c_p(\text{h,e}) = \frac{m_p(\text{e.h})}{m_p(\text{e})}$$

Furthermore, they also derived an estimation formula for the amount of information conveyed by experimental results. When H = {h1, h2, ..., hn} is a complete system relative to e, the estimated information content of H with respect to e is given by the following formula:

$$\text{est(in,H,e)} = \sum_{p=1}^{n} c(h_p, e) \times \text{in}(h_p/e)$$

Clearly, the est function is primarily used to predict the amount of information conveyed by future experimental results, taking into account the impact of multiple possible outcomes and evidence.

1.2 Floridi's Informational Structural Realism

About fifty years later, Floridi developed a quantitative theory of strong semantic information (TSSI) [Floridi, 2004]. Floridi argues that TSSI can resolve the Bar-Hillel-Carnap semantic paradox (BCP) inherent in the classical weak semantic information theory (TWSI) based on probability distributions. According to this paradox, a contradiction contains the highest amount of semantic information, i.e., CONT($\perp$) = MAX. TSSI effectively addresses BCP by supporting the assumption that semantic information includes truthfulness, thus false information cannot be considered as information.

Floridi argues that the primary goal of TSSI is to provide a quantification of semantic information that is mathematically successful like TWSI but also better respects our common-sense intuitions about information. That is, TSSI satisfies the following three conditions:

a. Avoid any abnormal inequalities similar to BCP.

b. Treat the truth value of σ as an intrinsic feature of information rather than supervenient to it, and relevant to the quantitative analysis (similar to Dretske's position).

c. Extend the quantitative analysis to the entire family of information concepts: information vacuity and inaccuracy, informativeness, misinformation/false information, and disinformation.

Here, the symbol "σ" refers to an "infon," which is a discrete unit of information. An infon is a discrete item of information that is independent of its semantic encoding and physical realization, commonly used in artificial intelligence, computer science, and information technology. Below, I will first examine the formula for calculating the quantity of semantic information provided by Floridi, and then explore the implications of this formula.

$$\iota^*(\sigma) = 1\mathrm{sbit} - \vartheta^*(\sigma)$$

In the formula, "sbit" is an abbreviation for semantic bit, representing a unit of semantic information in the TSSI theory. One sbits corresponds to the maximum amount of semantic information that can be conveyed by an infon σ when ϑ=0 under a fixed situation ω, and its semantic information quantity is linearly equivalent to $Log_2 2/3$.

According to the model constraints, it can be derived that:

- When $\vartheta(\sigma)$=0, then $\vartheta^*(\sigma)$= 0 and$\iota^*(\sigma)$=1sbit. This indicates that σ is a fully accurate, precise, and contingent truth.
- When $\vartheta(\sigma)$=1, then $\vartheta^*(\sigma)$=1sbit and $\iota^*(\sigma)$=0. This indicates that σ is a tautology.

In this formula, $\vartheta^*(\sigma)$ represents the amount of vacuous information within a σ, calculated by the following formula:

$$\vartheta^*(\sigma) = \frac{\int_0^{\vartheta} \iota(\sigma)\mathrm{dx}}{1\mathrm{sbit}}$$

$\vartheta^*(\sigma)$is obtained by calculating the definite integral of the function over the interval $[0, \vartheta]$ and taking its ratio to 1sbit from the maximum quantity of information "MQI". The value of MQI can be derived from the degree of informativeness "DI" by calculating the definite integral of the function over the interval [0, 1]. The formula for calculating the degree of informativeness is:

$$\iota(\sigma)=1-\vartheta^2(\sigma)$$

Thus, based on the calculus calculations of truth values and degrees of discrepancy in specific situations, the quantitative theory of strong semantic information (TSSI) is established. TSSI posits that semantic information includes truth, and false information cannot be classified as information. Therefore, TSSI defines semantic information as the semantic discrepancy between a proposition and its truth value. The semantic calculation formula can also be succinctly expressed in the following form [Floridi, 2011, p127].

$$ı^*(\sigma)=\alpha-\beta$$

Here, α represents the maximum amount of information that can, in principle, be carried by σ, which is 1 sbits. β represents the actual amount of vacuous information carried by σ, and the quantity of information in σ is determined by referencing its truth-oriented properties. This method of calculation avoids the BCP issue present in TWSI.

Based on this, Floridi established the ontological doctrine of Informational Structural Realism (ISR), which is a critique of digital ontology. As a form of realism, ISR acknowledges the existence of a mind-independent reality that is described by our knowledge but also constrained by it. The reality we can understand is necessarily structural because knowledge itself has structure. However, unlike other forms of structural realism, ISR supports a semantic information-dependent structural reality, since semantic information is the building block of knowledge construction and a crucial foundation for the implementation of technologies like artificial intelligence, as well as the starting point for constructing the cognizable real world. This is why Floridi posits that semantic information plays a central role in his philosophy of information. Moreover, from the standpoint of ISR, all existence is informational.

In addition to the pioneering work of Carnap and Bar-Hillel, Floridi was also inspired by developments in situation semantics, which TSSI utilizes some foundational concepts and principles from. However, his discussion and evaluation of Dretske's work are more detailed and extensive, highlighting the compatibility between his approach and Dretske's semantics of information. This compatibility is evident in their consistent views on the relationship between information and knowledge. Dretske argues that knowledge is an information-dependent internal state, with its content corresponding to the information that produces that state; in other words, knowledge is a belief caused by information. Unlike Floridi, however, Dretske holds that the amount of information in a σ would directly equate to the conventional, nomological, or

analytic information content embedded within it. Next, we will examine Dretske's views and their influence on Floridi.

1.3 Drestke’s Information Semantics

Dretske's semantics of information is based on the naturalization of intentionality within information theory [Dretske, 1981]. His understanding of the nature of information takes a naturalist stance.

However, Dretske's presupposition of objective information serves only as a premise for his naturalized epistemology; he does not construct an ontological doctrine as Floridi does. Therefore, Dretske’s affirmation of the reality of information does not lead him to question the reality of the material world but rather to view information as a fundamental and pervasive existence in nature, akin to the material world. This differs from Floridi's affirmation of the ontological status of information, where ISR is established based on TSSI research and by bracketing the material world. Thus, Floridi considers his interpretation of information to be a step further than Dretske's, rejecting naturalism while constructing a Platonist information ontology. Dretske's proposal of the "zombie problem" [Dretske, 2003] and his understanding of the relationship between information and knowledge have, to some extent, informed Floridi's epistemological research and definition of the essence of information.

Based on the ubiquitous nature of objective information, Dretske interprets intentionality as a process of information processing. Thus, the thoughts and behaviors of not only humans but also other biological, chemical, and physical systems can be viewed as the handling and utilization of information. All information-processing systems possess certain low-level intentional states, meaning that describing a physical state as carrying information about its source is to describe it as being in a specific intentional state relative to that source. However, for a system to have cognitive properties, it must be capable of having higher-order intentional states. Therefore, Dretske distinguishes between three orders of intentionality.

Dretske believes that although these three levels of intentionality differ in degree and nature, they are all based on the flow and processing of information. Because information is objective, intentionality can be reduced from philosophical abstraction to nature, transforming it into operable informatics concepts, thereby achieving the naturalization of intentionality. Dretske's theory of layered intentionality aligns well with Wu Kun's theory of information classification, which allows his theory to provide an epistemological basis for naturalistic philosophy of information.

Based on the naturalization of intentionality, perceptual knowledge is viewed as an information-dependent internal state that corresponds to the information produced by external stimuli. Concept learning is a process through which internal structures, such as neurons, acquire the capacity to carry certain information. Knowledge is an internal state formed through the flow of information, with its content corresponding to the information that generates it. Therefore, knowledge is informational-caused belief.

The naturalization of intentionality necessarily implies the naturalization of meaning. That is, it's not just intelligent agents that can generate and assign meaning; meaning exists within nature itself. The concept of natural meaning was first introduced by Paul Grice in his 1953 philosophical distinction of meaning[Grice, 1953]. In the discussion of the fifth section, we will find that Tom Stonier's information physics philosophy and Joseph Brenner's logic of reality have both extensively and systematically addressed natural meaning.

2. The Postmodern Approach

2.1 Lyotard's Reflections on the Properties of Knowledge in the Information Age

In the second half of the twentieth century, while contemporary analytic philosophers were still deeply engaged with foundational issues of knowledge, French postmodern philosophers had already begun to reflect on the essence

of knowledge. That is to say, in what is called postmodern society, whether the essence of knowledge remains what we once believed to be truth. Thus, their inquiry was not fact-oriented but value-oriented. This value-oriented exploration of the essence of knowledge is grounded in a reflection on the information technologies that dominate the construction of postmodern society. As Lyotard posited[Lyotard, 1984], postmodern philosophy of science is closely tied to the informational characteristics of the post-industrial era; in postmodern society, knowledge and power are merely two sides of the same issue: who decides what counts as knowledge, and who knows what decisions need to be made? In the age of computers, the question of knowledge has become more than ever a matter of governance.

When knowledge is translated into the language of information, that is, into a coded form within transmission and communication systems, the logical form it takes will determine what truly constitutes "knowledge." The pervasive spread of information technology in both breadth and depth can lead to the fragmentation of knowledge and the complication of the value dimensions embedded within it. Consequently, the production of knowledge may increasingly resemble commodity production, oriented towards the demands of the market (or audience). This marks the beginning of the "degeneration" of knowledge exploration enterprise.

In the postmodern society driven by information and communication technologies, knowledge no longer remains "value-neutral" but is inevitably intertwined with politics, which is the reason for its "degeneration." Specifically, the economic arrangements and social management of the information age require the leverage of IT means, a process that necessarily comes with a transformation of state functions. During this transformation, roles such as regulation and reproduction are gradually shifting from traditional administrators to information systems. Thus, who can access the data stored within these systems becomes a critical issue. In this scenario, experts will hold the rights to access data, and the ruling class will consist of information decision-makers.

This is specifically manifested in the fact that scientific research in the information age often requires substantial funding and large-scale equipment. Therefore, in information society, scientific power has become an integral part of government authority. Governments intervene in the development of science by funding research and controlling the direction of scientific studies, particularly so for public universities. At the same time, science exerts significant influence over government as well; advancements in science and technology not only alter the ways of social life but also profoundly impact political decision-making and the forms of social organization.

In postmodern society, all scientific achievements are inevitably altered by information processing systems in a coded form. This condition of scientific research serves as the empirical basis for Floridi's assertion that "knowledge is grounded in semantic information." In modern society, scientific knowledge has taken a dominant position, while narrative knowledge has gradually been marginalized. In postmodern society, the development of information technology further reinforces the authority of scientific knowledge, which may lead to the neglect of other forms of knowledge. Moreover, this form of knowledge transformed by information processing systems has become increasingly difficult to maintain the original intentions of knowledge inquiry. Without stringent oversight and constraints, those who judge the legitimacy of knowledge or set the rules might be influenced by their own biases and interests, leading to unjust outcomes. Their power could even be abused, resulting in power concentration and the suppression of dissent. Therefore, Lyotard cautions us to seriously consider the interdependent relationship between science and governmental power so as to better address the challenges posed by the information age to the legitimacy of knowledge.

2.2 Foucault's Reflections on the Power Structures of the Information Age

Foucault precisely observed the intertwined dependency between knowledge and power in postmodern society, which led him to advocate vigilance against scientism. Similar to Lyotard, Foucault offered a profound critique of the state of

knowledge in the information age, particularly concerning how knowledge is transformed into information and influenced by power relations during this process. While Lyotard focused primarily on the legitimacy of scientific knowledge brought about by information technology in postmodern society and its impact on society, Foucault paid more attention to how social control is achieved through information technology in the postmodern era. In his view, the development of information technology has reinforced power structures and can be used to monitor and control individuals. For instance, in “Discipline and Punish: The Birth of the Prison” [Foucault, 1995], Foucault argues that there is a close relationship between power and knowledge. Power is not only exercised through violent means but also constructed and maintained through knowledge and discourse. Knowledge can be used, for example, to manage and control inmates within prisons. Foucault's analysis underscores that as information technology advances, it not only facilitates the dissemination of knowledge but also embeds mechanisms of power that can regulate and surveil individuals, thereby shaping societal norms and behaviors.

In the information age, the production, dissemination, and reception of knowledge are always influenced by specific power structures. Knowledge and discourse are rapidly spread, replicated, and new knowledge and discourse are promptly generated through feedback mechanisms, all facilitated by information technology and various media. This enables highly efficient social control that relies on IT means, which is more subtle and pervasive than in any previous era. Governments, social institutions, and corporations increasingly leverage data to manage populations. For instance, individual behaviors and thoughts can be comprehensively recorded and subjected to detailed analysis through digital means. Contemporary big data technologies exemplify this prophecy perfectly. These channels for the spread of knowledge and discourse make people increasingly transparent within information society. Thus, Foucault's analysis of how power achieves self-discipline through the surveillance enabled by information and communication technologies prompts us to reflect on how IT impacts personal freedom and social structures. His insights suggest that as

individuals become more visible and traceable through digital records and analyses, the boundaries of privacy and autonomy may shift, raising questions about the extent to which individuals can remain free agents in an increasingly surveilled world.

In summary, although Foucault did not directly and systematically critique information technology and the information civilization, he provided a theoretical framework for understanding how IT can be used to guide values and exert social control. Therefore, Foucault's thought is crucial for analyzing the relationship between power and information technology in contemporary society. It prompts us to pay attention to the value orientations of knowledge in the information age and to maintain a cautious attitude toward information civilization. His insights encourage a critical examination of how power dynamics shape the development and application of IT, influencing societal norms and individual freedoms in profound ways.

3. The Phenomenological Approach

3.1 Simondon's Theory of Individuation

The philosophical study of information within the tradition of phenomenology begins with Simondon's theory of individuation, which emphasizes the uniqueness of individual entities' experiential processes. As a student of Merleau-Ponty, who stressed the role of the body in perception, Simondon was provided with an important theoretical backdrop for his exploration of the individuation process of technical objects. The formation of an individual relies on perception, which requires the subject to continuously interact with the external world, thereby gradually forming an understanding and interpretation of it. Thus, Simondon's theory of individuation can be seen as an application and development of Merleau-Ponty's ideas on phenomenology of embodiment. As Simondon wrote on the dedication page of his seminal work [Simondon, 2020], the book was made in memory of Merleau-Ponty.

In the realm of science, the theory of individuation has been inspired by cybernetics. This theory emphasizes the self-organizing and differentiation processes of life. Cybernetics provided Simondon with philosophical insights into the internal feedback mechanisms within living organisms, revealing how they self-regulate and adapt to external environments, as well as how they achieve individuation through social interactions and cooperation. Consequently, concepts such as systems, feedback, control, and information have been integrated into the theory of individuation. By adopting the methods of cybernetics, the theory can uncover the intrinsic structures, behavioral patterns, and evolutionary processes of life. While information is a core concept in cybernetics, Simondon's understanding of information carries a greater philosophical transcendence. Simondon saw information not merely as a tool for control or communication but as an element that participates in the very process of individuation, influencing the emergence and development of both living beings and technical entities. His approach thus transcends the functionalist perspective of cybernetics, offering a deeper philosophical inquiry into the nature of individuation and the role of information within it.

In summary, Simondon's theory of individuation emphasizes relations and interactions, as well as the process by which individuals emerge within these contexts. The core concepts of this theory are "form" and "information." Form refers to the structure and organization of entities, while information pertains to the interactions between entities and their environment. Individuation results from two concurrent processes: the differentiation of matter and the selection of form. During the differentiation of matter, individuals separate from their environment and begin developing specific properties, gradually forming their own structures. The selection of form further shapes the individual as it adapts to its environment by choosing different forms, thereby acquiring more information and attributes.

Simondon posits that information is a key factor in the self-realization of technical objects, allowing them to continuously perfect and develop themselves

through interactions. Information serves as the basis for interoperability between technical objects and facilitates the conversion between abstraction and concreteness within them. Thus, Simondon views information as a "transitional" entity: it is not the entity itself but the relationship between entities, yet it remains a real existence. The theory has a tendency towards the naturalization of information and is similar to Brenner's understanding of information. However, the latter promotes a more thorough naturalization without relying on a priori elements and extends beyond the domain of living organisms. In contrast, some *a priori* elements remain in Simondon's philosophy. For instance, he considers individuation an *a priori* process that precedes specific experiences and forms the foundation for individual existence. This process provides the conditions for all individuals to come into being, serving as an *a priori* framework.

Furthermore, the philosophical analysis of information by the contemporary French philosopher Gilles Deleuze within the phenomenological framework is somewhat concealed. His interpretation of Simondon overlooks many technical concepts, including information. Although Deleuze does not specifically address the philosophical issues of information, his theories can be applied to philosophical reflections on information. For instance, Kane X. Faucher uses Deleuze's philosophy to discuss topics such as information itself, Simondonian information, and Deleuze's black box white noise. In his works, Faucher also introduces Deleuze's theory of multiplicities and network theory, proposing an information science approach based on Deleuze's philosophy [Faucher, 2013].

3.2 Cappuro's Angeletics

Angeletics is an information philosophy research approach proposed by Rafael Cappuro at the end of the last century. In collaboration with John Holgate, they systematically described the overall framework of this research direction in their co-authored monograph [Capurro&Holgate, 2011]. Angeletics is an information study within the tradition of German phenomenology, drawing particularly on the works of Heidegger and Gadamer.

Cappuro believes that information and messages are closely related concepts but still have distinctions. Information refers to the meaning or value contained in data or signals, whereas a message is a specific type of information with particular purposes and meaning, typically transmitted from a sender to a receiver. Thus, a message can be seen as information that has been processed to have a specific purpose and meaning.

Angeletics is a theory about messages, and Cappuro posits that it will play a paradigmatic guiding role in the science and society of the twenty-first century. Angeletics is an interdisciplinary study because messages have multiple dimensions and exert profound influences on social activities such as culture, politics, and economics. Specifically, issues within society inevitably involve various aspects of messages, including their origin, purpose, content, power structures, transmission technologies and methods, the history of messages and their bearers, the encoding and interpretation of messages, as well as factors related to psychology, politics, economics, aesthetics, ethics, and religion.

The core question of Angeletics is to understand when, where, and how a particular form of message is accepted or rejected, and how receivers can become senders. Its philosophical significance lies in providing a non-reductionist approach to studying messages and the phenomena of their senders and receivers. Through Angeletics, we can better comprehend the transmission and exchange of messages at different levels, explore the impact of messages on our cognition and behavior, and gain a deeper understanding of language and other forms of symbolic systems.

Although it has an interdisciplinary nature, Angeletics remains grounded in a hermeneutic phenomenological approach, focusing more on the complexity of human message transmission rather than treating messages or information as merely objective entities. Instead, Angeletics tends to view information as a product of human activity and communication, a network collectively constructed by humans that requires processes of interpretation and translation

for understanding. Each interpretation necessitates a process of message transmission, which is key content that Angeletics aims to analyze.

4. The Naturalistic Approach

The necessity of the study of naturalistic philosophy of information(NPI) lies in the fact that scientific studies of information are dispersed across various disciplines without forming a unified framework [Wang, 2025]. The foundation for such unity is to construct a coherent logic and speculative model for interpreting information phenomena, thereby building mathematical models to establish a unified information science. The aim of NPI is to construct this unified logic and speculative model, developing a comprehensive qualitative description of information and achieving a fully naturalistic interpretation of the mind through the study of information's natural essence. Thus, this approach is necessarily an transdisciplinary philosophical endeavor. Under the wave of naturalism, Floridi redirects philosophical tasks toward semantic information, maintaining philosophy's transcedental characteristics based on the apriority of semantic information. In contrast, the NPI seeks to dissolve this apriority by naturalizing information. Therefore, this approach differs from the phenomenological perspective that examines the nature of information based on the transcedental features of consciousness. Additionally, it clearly distinguishes itself from the postmodern approach to information studies, which reflects on information civilization from a value-oriented cultural dimension.

The logical starting point of NPI is the recognition that information exists independently of consciousness and serves as the ontological foundation for the emergence and evolution of consciousness. From this premise, NPI develops an evolutionary model of the informational world, aiming to establish a philosophical basis for a unified information science. Research in this area has flourished since the late 20th century. This development has been particularly evident in the work of the Foundations of Information Science (FIS) international conference and the International Society for the Study of Information (IS4SI). Scholars such as Wolfgang Hofkirchner, Yixin Zhong, Mark Burgin, Gordana

Dodig-Crnkovic, Pedro Marijuan, Terrence Deacon, Marcin Schroeder, Daniel Boyd, Tom Stonier, Kun Wu, Joseph Brenner, and others have made contributions to this approach from diverse scientific and philosophical perspectives. Their work emphasizes information as a fundamental attribute of the universe and explores its intrinsic connections with life, intelligence, consciousness, and meaning.

Within the naturalistic framework, where the boundaries between science and philosophy are often blurred and mutually constitutive, I will now examine the three most representative philosophical theories emerging from the aforementioned research—each closely aligned with NPI.

4.1 Stonier's Philosophy of Informational physics

In his trilogy [Stonier, 1990,1992,1997], Tom Stonier constructs a philosophy of informational physics that posits information as a fundamental attribute of the universe, present across all levels of its evolution. From the most basic physical processes to the complex order exhibited by biological and social systems, this order is embodied as information. That is, any system that exhibits organization contains information. Changes in entropy (energy) represent changes in the system's organizational state, so entropy calculations can measure changes in the system's information content. There may be a quantitative relationship between information and energy: 1 J/K = 10^23 bits [Stonier, 1990, p.51].

The reason we overlooked information in previous scientific research is that changes in the state of the universe could be easily explained by energy, without the need to quantify information. In reality, information exists in structural form (contained within systems) and dynamic form (being transmitted, processed, or transformed). Given the ubiquitous nature of information, Stonier views intelligence as a natural attribute, an advanced function of information systems that inevitably arises during evolution. Thus, the development of intelligence can be understood as a spectrum of phenomena, ranging from primitive to highly sophisticated forms. Intelligence, according to Stonier, is the

ability of any information processing system to analyze its environment and respond based on this analysis to enhance its chances of survival or reproduction. Based on this definition, intelligent systems are pervasive. For example, DNA/RNA biological systems are intelligent because they can learn from their environment and adapt, similar to the learning processes in brains.

Consistent with other naturalists, Stonier's naturalization of information also relies on the perspective of cosmic evolution. He believes that consciousness, intelligence, meaning, and understanding are phenomena that inevitably exist within the evolutionary spectrum. As information processing systems become more complex, these attributes of information systems develop into more sophisticated states. Therefore, we can begin to study these attributes from simple information processing systems, such as thermostats and biological systems (like single-celled organisms, sponges, and plants). For organisms with nervous systems, a new dimension must be introduced. Nervous systems enable individuals not only to learn but also to respond to stimuli in the environment by associating them with other environmental information inputs.

Furthermore, as organisms develop, their internal information environment becomes sufficiently complex to allow information to be metabolized, and "semantic metabolism" [Stonier, 1992, p.165] is a necessary condition for achieving consciousness. It is evident that, based on an information-driven evolutionary model, meaning is not exclusive to humans. Meaning can also be naturalized, with natural meaning existing within the internal information environments of natural systems. Stonier points out that humans and other organisms convey information through purposeful communication, and this information becomes meaningful according to the receiver's internal information environment. For example, metabolites that constitute a specific substrate are "meaningful" to the enzyme [Stonier, 1997, p.122] because enzymes distinguish only one particular type of molecule from thousands of different types as their substrate. Even if some information does not have direct meaning, it can still be

understood and interpreted within the receiver's internal information environment, thereby acquiring meaning.

4.2 Wu’s Dialectical Materialism Philosophy of Information

Wu developed his mature dialectical materialist philosophy of information over the last two decades of the twentieth century. His understanding of the essence of information also relies on the perspective of natural evolution. The evolution of the information world can be divided into four forms: in-itself information, for-itself information, regenerated information, and social information [Wu, 2012, p.165]. In-itself information is primarily physical information that exists independently of cognitive subjects. For-itself information exists within all natural systems with cognitive capabilities. Regenerated information mainly involves the abstract processing of for-itself information by conscious entities, currently found only in human consciousness and its extensions (such as artificial intelligence systems). Social information is a synthesis of the former three, characterized by complex information dynamics. Wu's description of the evolutionary hierarchy of information resembles Stonier's, both showing the emergence of intelligence and consciousness through the evolution of information. However, while Stonier emphasizes the mutual transformation between information and energy and attempts to find mathematical connections between them, Wu focuses on their dialectical interaction, an approach closer to Brenner's understanding of the relationship between information and energy. According to dialectical materialism's definition of matter, Wu's definition of information involves categorizing the real world under formal logic, which leaves traces of Cartesian dualism, a traditional philosophical method that reifies abstract concepts. Naturalist philosophy aims to discard the perspective of directly equating abstract formal logic objects with concrete reality. Based on this assertion, the Logic in Reality system developed by Brenner can provide a logical foundation for naturalist information philosophy and can be used to naturalistically transform the dialectical materialism philosophy of information.

In fact, although Wu's research is essentially a form of natural philosophy, it exhibits a clear tendency towards the naturalization of epistemology within his theory, embodying the philosophization of science and the scientification of philosophy. He opposes the traditional dichotomy between science and philosophy in knowledge studies, emphasizing instead their integration. In summary, under the naturalist approach, science and philosophy can address the same objects: one through quantitative research, the other through qualitative research; one via specialized disciplinary studies, the other through transdisciplinary studies, aiming to establish logical pathways for new specialized scientific research. Therefore, naturalist information philosophy employs transdisciplinary methods to provide a qualitative description of the essence of information.

4.3 Brenner’s Logic in Reality

Since the mid-twentieth century, French philosophy has approached the study of information in three directions. Besides Simondon's interpretation of information grounded in phenomenology and Lyotard's postmodern reflection on the information culture brought by information technology, there is also Brenner's naturalist understanding of information based on non-Aristotelian logic. However, Brenner's primary work was completed at the beginning of the twenty-first century.

Brenner's LIR system is built upon the non-Aristotelian logic studies of French-Romanian philosopher Stephane Lupasco. Research in quantum mechanics has revealed that some foundational laws of standard formal logic, such as the "law of non-contradiction" and the "law of excluded middle," do not apply to the quantum world. Therefore, Lupasco sought to re-establish a scientific logic, confining classical logic to the realm of abstraction. This research is highly revolutionary, as the formal logic system derived from Aristotelian logic has long been a tool for building scientific foundations.

However, the history of scientific development has been a continuous critique of Aristotelian science. The Copernican-Keplerian heliocentric cosmology critiqued Aristotelian geocentric cosmology; Galilean-Newtonian inertial physics challenged Aristotelian teleological physics; Boyle-Dalton's chemical atomic theory critiqued Aristotelian philosophy's four elements; and Linnaean-Lamarckian-Darwinian taxonomy and evolutionary studies critiqued Aristotelian natural history and the scala naturae. Additionally, since the Renaissance, developments in anthropology, embryology, genetics, and psychology have progressed on the basis of critiquing Aristotelian views. Yet, only Aristotelian logic has remained revered as an unquestionable truth. Therefore, Lupasco's research aims to break this dogma based on the development of quantum mechanics. However, this is not to negate Aristotelian logic but to place it within the context of natural evolution. That is, standard logic emerges as an abstract logical capability at higher levels of natural evolution, much like Einstein limited Newtonian mechanics to describe low-speed motion states and Prigogine confined the second law of thermodynamics to describe the evolution of closed systems. In summary, classical logic addresses the large-scale information processing modes of higher-level information entities.

Brenner developed Lupasco's ideas into a LIR system that includes information studies[Brenner, 2008]. Brenner advocates for a process-oriented interpretation of information, an approach that resonates with the perspectives of both Stonier and Simondon. Past scientific endeavors overlooked the focus on processes because physics based on mass and energy was sufficient to address the scientific questions of the time. Whitehead's emphasis on process did not gain widespread resonance in philosophy or science. Current science and philosophy need to further explore the focus on processes and the study of evolutionary logic because the Cartesian paradigm of mind-body dualism has led scientific research on the mind into a dead end. As Zhong calls for, we need a new paradigm for information science rather than one based on traditional physical science paradigms. Only under this new paradigm can the essence of information be revealed. Moreover, relying on this new paradigm, "information,

intelligence, meaning, and understanding" can be correctly examined. This requires rethinking the history of philosophy and science and attempting to reinterpret the nature of the mind from the perspective of information world evolution. Perhaps only by viewing information as a natural process that generates, encodes, transmits, and interprets meaning within an evolving information world model can a good general information theory .

Based on LIR, entities are potential processes, and processes are potential entities. Nature continuously evolves through the dynamic interaction between entities and processes, a concept described by the Principle of Dynamical Opposites in LIR, which outlines the dialectical evolutionary logic of natural entities and processes. This principle describes the dialectical evolutionary relationship between material existence and informational existence as noted by Wu. Drawing on results from systems science, control science, and complexity science, Brenner provides additional scientific descriptions of this dialectical logic's dynamic evolutionary form, ensuring logical consistency between the quantum world and the macroscopic world. As recognized by Stonier, Wu, and Dretske, among others, the information world of natural evolution offers a new perspective for explaining the essence of the mind.

Conclusion

This paper categorizes information philosophy research since the mid-twentieth century into four approaches: Approach One, the semantic approach; Approach Two, the postmodernist approach; Approach Three, the phenomenological approach; and Approach Four, the naturalist approach. In comparison, Approaches One and Three interpret information from a human-centered perspective, whereas Approaches Two and Four critique human centrism. Additionally, Approaches One, Three, and Four focus on factual studies of information, while Approach Two reflects on information science culture from a value-oriented dimension.

Currently, Approach One holds significant influence and theoretical coherence in the field of philosophy. This is primarily due to the mainstream status of semantic information studies in twentieth-century Anglophone philosophy and its continuity with transcendental philosophy. In contrast, Approach Four is closely linked with scientific research, demonstrating its stance against transcendental philosophy through the naturalization of information. This makes the qualitative and transdisciplinary studies under this approach more aligned with the goals of Unified Information Science. Indeed, the development of evolutionary sciences such as systems science, control science, and complexity science since the mid-twentieth century has continuously weakened and naturalized the a priori elements on which traditional philosophy relied. Therefore, I believe that Approach Four holds the most potential for information philosophy research, with naturalism likely becoming the dominant trend in twenty-first-century philosophy. Approaches Two and Three represent theoretical explorations by the continental philosophy tradition in the information age and exhibit distinct national characteristics. Although they lack a continuous tradition in information studies, they remain significant paths in information philosophy. Comparatively, Approach Two relies on relativistic views of value essence, opposing the objectivity of truth, which may face challenges from more extensive value naturalization studies in the twenty-first century. The fate of Approach Three will be influenced by advancements in consciousness science and cognitive science, as this approach places a priori property of consciousness at its foundational level.

It is worth noting that the breadth and depth of philosophical explorations of information in the aforementioned studies vary. In the naturalist approach, most contributions are philosophical views proposed by information scientists, with few fully developed theories or original ideas. Postmodern and phenomenological studies of information often do not place it at the core or as the sole focus of investigation. Only Floridi and Wu explicitly advocate for establishing a comprehensive philosophical system centered on information, guiding a philosophical shift to address the demands of the information age.

Naturally, such ambitious claims require further thought and evaluation by future scholars. Additionally, there are some achievements in information ethics and information aesthetics, which can also be categorized under these four approaches to information philosophy. Therefore, this paper does not delve further into these areas.

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