INFORMATION AND ENTROPY: KNOWLEDGE STRUCTURES IN THE AGE OF ARTIFICIAL INTELLIGENCE

Dissertation

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Submitted by

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Abstract

Andreas Chetkowski: Information and Entropy: Knowledge Structures in the Age of Artificial Intelligence

This dissertation focuses on the epistemic nature of information and changes in its status historically. It is divided into three chapters. The first chapter deals with the concept of information and its various approaches. On the one hand, information has its background in the Greek philosophical tradition of *eidos*. On the other hand, the term information was quantified by Shannon and Weaver in the context of communication theory. The second chapter is dedicated to entropy. Since Shannon's information theory is mapped onto mathematical probability theory, information is strongly related to entropy. Entropy as a measure of *disorder* or information content in a system is investigated using complex structures. The judgment about order or disorder is about meaning. The attribution of order or disorder is a hermeneutic decision. The focus of the third chapter is on information processing. Inspired by Wilhelm Dilthey, a hermeneutic form of information processing of consciousness is presented.

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Introduction

The increasingly widespread use of artificial intelligence (AI) is a process that can no longer be stopped. More and more fields of work are being carried out by AI, people are communicating ever more frequently with AI, and knowledge acquisition through AI is playing an increasingly important role. In recent years, information and computer technology has developed so rapidly that the resulting ethical and social questions have barely been formulated, let alone answered. There is currently a debate taking place about automated decision making, which is being held in many areas: in public administration, healthcare, business administration, education, law, transportation, media, and entertainment. A second aspect of current debate concerns the possibility of emotional artificial intelligence. Computers are expected not only to be able to process explicit human signals, such as clicks and text input or the content of a voice command, but also understand the emotional context of an interaction. As a result of interaction on attention platforms, for example, AI should be able to understand how the person in question is feeling at that moment, so that the AI can make appropriate recommendations. If a sufficient level of success is achieved in this regard, such that language and feelings become technically objectified, then the question arises as to what distinguishes human thought from the information-processing of the computer.

Before we show the relevance of artificial intelligence in the philosophical context, let us first outline our understanding of the concept. Artificial intelligence is supposed to emulate aspects of human behavior in order to be able to act “like a human” without being one. This includes characteristics and abilities such as solving problems, explaining, learning, understanding language, and the flexible reactions of a human being. Roughly speaking, artificial intelligence can be divided into two larger segments: so-called weak AI and strong AI. Depending on the interpretation, a third classification can be added: artificial superintelligence. According to Bostrom, the term ""uperintelligence” denotes a degree of expressed intelligence

that can be used in virtually any area, including areas of "scientific creativity," "general wisdom," or "social skills."[1]

Weak AI is what has long been commonplace on computers and smartphones today. This encompasses quasi-intelligent systems that have been trained and taught and designed for actual execution in a defined task domain. What is generally understood by a strong AI encompasses all approaches that show a broad spectrum of application of intelligent thought and action. In contrast to weak AI, it has the same intellectual capabilities as humans or even ones superior to them. Strong AI no longer acts only reactively, but also intelligently and flexibly on its own initiative. The AI should be enabled to make generalizations and abstractions and given other cognitive abilities. Capacaities such as consciousness or empathy are constituted characteristics. Technologies and applications that can be classified as strong AI cannot yet be achieved, according to experts.[2] Currently, in weak AI, the aim is no longer to imitate human thought processes, considerations and creativity but to develop algorithms for specific, delimited problems. In this context, learning ability is an essential requirement, and not only for strong AI but also weak AI. Current practical applications fall within the realm of weak AI. Both strong AI and weak AI require software and hardware, which have their foundation in information theory and communication engineering. Against this background, the question arises as to whether an information theory might be possible that encompasses all areas of reality, as well as the question of what information theories can achieve. In this regard this dissertation is an attempt to assess the possibilities and limitations of the concept of information.

On the one hand, information has its background in the Greek philosophical tradition of *eidos*. In the Platonic sense, the concept of information is derived from the term idea. In its literal sense, information denotes bringing something into form. What is thereby formed then

[1] Nick Bostrom: "How long before superintelligence?," *Linguistic and Philosophical Investigations* 5, no. 1, (March 2006): 11.
[2] Markus Christen: *Wenn Algorithmen für uns entscheiden: Chancen und Risiken der künstlichen Intelligenz*, (Zürich: vdf, 2020), 72.

comes into appearance. It becomes visible. "Information is a difference that makes a difference."[3] Information is the bridge between the environment and the mind. On the other hand, the foundations of the AI technology are based on information. The term information was quantified by Shannon and Weaver in the context of communication theory. With a view to technical applications in the transmission of message flows, problems of coding and redundancy are the subject of their investigation. In everyday language, the focus is usually on the aspect of the meaning (the "semantic level") and purpose ("pragmatic level") of a message. In Shannon's information theory. the term information is restricted to the aspect of the "novelty value" or "surprise value" of a message. This aspect is linked solely to the probability of occurrence (the "statistical level") and not, for example, to meanings that are attributed to a message by the recipient. Hence, information theory is mapped onto mathematical probability theory. Against this background, information is strongly related to entropy. The statistical interpretation of the concept of entropy links entropy and probability. A macroscopic state of high entropy has a higher probability than a state of low entropy. As an illustration of this fact, it is often stated that increasing entropy means increasing disorder. However, the attribute of order or disorder constitutes a subjective perspective. For example, if there is a cleaning person who enters my working room and sees papers, documents, books, coffee cups, etc., distributed in a disorganized fashion, he or she would assume there is disorder in the working space, yet, from my point of view, since I have a perfect orientation within the space, there is order. Hence, the judgment about order or disorder is about meaning. The attribution of order or disorder is a hermeneutic decision, and the concept of entropy underlies a hermeneutic approach. Hermeneutics is understood, in the sense of Wilhelm Dilthey, as the art of interpreting written expressions of life. The hermeneutic approach is vivid and open. What looks like disorder today

[3] Gregory Bateson, *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*, reprint with new preface (San Francisco: Chandler Publishing Company, 1972; repr., Northvale: Jason Aronson, 1987), 460. Page numbers refer to the reprint edition.

may turn out to be the order of tomorrow. This has happened before and will probably happen again in the future. Yet, that does not absolve us of the responsibility to diagnose disorder when it is present to the best of our knowledge and belief. The terms order and disorder are imprecise and by no means objective. A precise, and quite descriptive link, can be made with the concept of information and entropy. In this sense, the connection with information is of central importance for thinking but cannot be reduced to or explained by the acquisition of information alone, as there are many other components of thinking. However, it is to be regarded as a basic category of being, alongside the categories of matter, energy, substance, and event.

This dissertation focuses on the epistemic nature of information and changes in its status historically, and is divided into three chapters: Information, Entropy and Information Processing. The first chapter deals with the concept of information and its various approaches. There is a broad spectrum of informational phenomena that we deal with on a daily basis. The rapid growth of available information and the use of different information channels reflect the current digital zeitgeist. Never before in history have people had access to such a vast amount of information as they do today. On the one hand, never before have we had to process such quantities of information. On the other hand, each individual decides for himself what he perceives as information and whether it is true or not.

After an outline of what can be understood by information society, the origin of the term information is examined in more detail, the roots of which can be traced back to the Greek and Latin languages. The etymological development of the term provides an understanding of its various meanings and reveals the changes in these over the course of history.

In a naïve perspective, the idea of the information society refers to the Internet and cell phones, to digital networks and the decoupling of work from a place. More precisely, information functions as a fixed point in the order of knowledge. We are now talking about a revolution; after the Industrial Revolution came the Digital Revolution.

In science, there is no universally valid definition of information that combines all its aspects, and things become more complicated when we consider information in relation to entropy. Different explanations, therefore, refer to different conditions and objectives. On the one hand, information appears as an irreducible difference between zero and one, as a transmission technology, as a fact, as knowledge, as a message. Another explanation of the concept is associated with attributes such as syntactic, semantic or pragmatic qualities. From the perspective of epistemology, information is at the center of explanations for thought and being. The analysis of the concept of information in the next sections shall focus on the beginnings of information theory and its consequences in disciplines such as communications engineering, linguistics, cybernetics, cultural studies, and the natural sciences. This is a broad field. However, the basic controversy relates to one simple fact: information is primordial. In everyday life, we associate the concept of information with a specific human intellectual or mental action. At the same time, in connection with the development of modern communication technology and its influence on other sciences, a naturalization of the concept of information is taking place. This means that information can be observed and explained scientifically. This gives rise to far-reaching controversies, which initially relate to methodological issues but soon also affect the self-image of humans and their relationship to nature and to the computers they produce.

We will then analyze information and communication theory in relation to the concept of entropy, as introduced by Claude Shannon after preliminary work by Ralph Hartley. Since, in information theory, information only has a syntactic function while semantic aspects are ignored, we will look at information from the perspective of semiotics, based on the theories of Charles Peirce and Charles Morris. The semantic aspects of information are discussed by Yehoshua Bar-Hillel and Rudolf Carnap. Their semantic theory of information views language objectively. Their argumentation follows an inductive logic, which is critically discussed by communication scientist Donald MacKay. In cybernetics, the term information is defined in a

similar way as it is in the context of communication technology. Norbert Wiener, who gave cybernetics its name, sees information as a selection process without reference to semantics and pragmatics. The cyberneticist Heinz von Foerster follows Wiener's argumentation and defines information as a measure of states of order. The cyberneticist Gregory Bateson provides a general interpretation of information; by following a binary logic, he considers information as a difference that creates a difference in the system in question.

We will also look at information from the perspective of self-organization theory. Humberto Maturana and Francisco Varela developed a cybernetic theory of biological processes by examining autonomous structural changes in organisms. In his theory of self-referential systems, Niklas Luhmann sees information as part of the communication process. Information contains a difference from what is already known. The last section of the first chapter deals with the discussion of the concept of information in selected works of the physicist and philosopher Carl-Friedrich von Weizsäcker. In his interpretations, he refers to the process of formation or "shaping" that is inherent in the word "information" itself and explicitly makes use of the Latin and Greek origins of this word for his information theory. For Weizsäcker, information is a fundamental concept that must be distinguished not only from matter and energy but also from consciousness.

The second chapter focuses on the concept of entropy. The discovery of entropy in thermodynamics and the findings from this field is the subject of the investigation at hand and will be discussed in the first section. Newtonian physics assumed the exact predictability of the laws of nature. Physical insights at the microscopic level show the impossibility of such an assumption. Entropy plays a decisive role in describing this phenomenon. Entropy describes emergent properties of a macroscopic body, which is always derived from a microscopic state. Since no exact statements can be made about atoms, probability theory was introduced into physics. When Herrmann von Boltzmann introduced probability theory into thermodynamics, entropy was developed as a measure for describing states of order and disorder in closed

systems. In information and communication theory entropy and information always appear as a pair of terms and are always considered together. This is the topic of the second section. The information theory concept of entropy defines it as potential information whose probability can be measured quantitatively. This contradicts the cybernetic view of entropy, which is investigated in the third section. In cybernetics, information is interpreted as negentropy. After the investigation of different approaches of entropy, the next section deals with structure and order. With regard to the second law of thermodynamics, structures are irreversible, and, because of their marginal conditions, they have an identity and a history, which allows potential for interpretation. The basic concepts of information, entropy, and structure are closely related. The representation of information in the form of structures and networks captures relatively abstract properties. For this reason, it is transferable to other systems and enables analogies to be drawn. The concept of structure and the description of structure make a fundamental contribution to knowledge recognition, as set out in Carnap's *The Logical Structure of the World*. Carnap deals with the construction of a comprehensive constitutional system of concepts, whereby the concept of structure is particularly emphasized. Pattern recognition is a basic aspect of machine learning. In terms of artificial intelligence, a neural network (deep learning) is the underlying technology of machine learning. The computer processes information that is modeled on the human brain. The strength of a neural network lies in its ability to process large amounts of information faster and more accurately than the human brain. Today, information theory plays a role in many scientific fields that have social and ethical consequences. Automated decision making and emotional artificial intelligence are two keywords here. As a result, the concept of entropy went beyond the scope of thermodynamics and developed into one of the basic concepts of science. The particular strength of these more abstract considerations of entropy lies in information theory, which provides a theoretical basis for our digital age. I would like to show that the concept of information from the information and communication sciences has a significant influence on the understanding of information in

other disciplines and is closely linked to the concept of entropy. Since entropy as a state variable for disorder or uncertainty is based on a probability calculation, it cannot ever be exact but, rather, is an interpretation. Order and structure are a necessary precondition for everything that the human mind is supposed to understand. A process or unit is said to be ordered if an observer can grasp its overall structure and the branching of the structure in some detail. Order makes it possible to focus on what is the same and what is different, on what belongs together and on what is separate.

The third chapter is dedicated to the relationship between meaning and information and how information is processed. At the same time, the question arises as to what distinguishes human thought from the processing computer. As mentioned before, meaning can only be created by the human mind. To give meaning to a structure or order is a hermeneutic decision. We shall take a look at the history of knowledge and will focus on the rational method. Using selected examples from the philosophical movements of humanism and the Renaissance, namely, Francis Bacon, Thomas Hobbes, René Descartes, Blaise Pascal and Gottfried Wilhelm Leibniz, we shall discuss their ideas and concepts as precursors to computers and artificial intelligence. From the mathematical logical method of *ratio*, as the foundation of information processing and knowledge recognition, a new image of man develops that is criticized by Friedrich Nietzsche, Edmund Husserl, and Martin Heidegger. In contrast to knowledge recognition as understood in information theory, which objectifies mental states and thus makes them mathematically accessible, a subjective human claim to meaning can now be seen. The connection between meaning and consciousness plays a decisive role in Wilhelm Dilthey's hermeneutic concept. Dilthey describes consciousness as a context of life that is summarized in memories. For Dilthey, the constitution of an autobiography is the highest level that human consciousness can represent. Dilthey's hermeneutic approach is subjective and integrates fictions or imaginations in order to recognize a higher truth. Crucial to the representation of life are the remembered events to which consciousness ascribes meaning. If the recognition of a

subjective truth is always an individual decision, this makes it difficult to make an objective statement about an autobiography.

Inspired by Dilthey's hermeneutic approach, two theses can be put forward in relation to information. If truth and fiction are no longer distinguishable for the human mind, the objectification of information and its mathematical coding cannot be fundamental. The objectification of an event as fact, or true, is not the decisive factor for human consciousness but is merely the meaning we attribute to that event.

Chapter 1: INFORMATION

The modern version of the term information used in information theory has a relative short history. It comes in many forms, depending on the perspective and scientific context one has in mind. The word information has its roots in the Greek and Latin languages and took on different meanings throughout history. Greek terms, such as *hypotypōsis* (meaning a model, particularly in a moral sense) and *prolēpsis* (representation), were translated into Latin using *informatio* or *informo*. However, these translations primarily intersect with fundamental Greek concepts in Plato's writings— *idea*, *typos*—and those of Aristotle—*eidos* and *morphē*—which are crucial to Greek philosophy, especially in the realm of ontology and epistemology.[4]

Plato views the *eidos* (idea) as the realm of Forms, which are eternal, unchanging and perfect representations of the highest level of reality. In this context, the *eidos* represents the reasonable or rational essence of things. According to Plato, the *eidos* is common and sharable in the sense that it can be rediscovered or imposed upon the dialogue partner.[5] Most of the dialogues of Socrates are about the question of being. Being is not a physical substance but the *eidos*.

[4] See ibid., 352.
[5] See Maria Dimitrova, "In Response to Jeffrey Andrew Barash: The Immemorial Time," in *Levinas' Trace* (Newcastle upon Tyne: Cambridge Scholars Publishing, 2011), 39.

Information in today's meaning, as we understand it in the context of information technology, consists of a sender that transmits information (a message) to a receiver. We therefore need an information carrier, such as bits and bytes. A binary digit (bit) is basically a yes–no decision (zero and one) and serves as a measure for information. The term information was quantified in this sense by Claude E. Shannon and Warren Weaver in the context of communication theory. Information denotes an open situation that has not been decided yet. It is a state parameter, a measure for a moment in which decisions (zero or one) have not yet been made. The measure of information refers to the probability of occurrence of certain characters. The sender encodes the messages in the form of signals, which must then be decoded by the receiver. During this encoding (e.g., in the form of zeros and ones), the signal can be disturbed by the channel. This illustrates the situation in mathematical probability theory. The receiver must know the probabilities of occurrence of the characters. The character sequence is encoded for transmission by the sender and then decoded by the receiver. Linguistic sounds (sound waves), for example, must be converted into electromagnetic waves and then converted back into sound. The transmission is generally subject to interference, which changes the information.

How can a probabilistic measure of the transmitted information be specified? There is uncertainty before the occurrence of a sign; its occurrence has a surprise value and, in this sense, constitutes information for the recipient. The lower the probability of occurrence, the greater the surprise value, the novelty value, the information. For the construction of an information theory, however, the following definition proves to be more appropriate: If one of the signs occurs with certainty, the novelty value will be low. Very rarely occurring signs, on the other hand, have a correspondingly high novelty value. Since it only makes sense to characterize the occurrence of future events with probabilities, information entropy is not a measure of existing (actual) information, but of future information. If we now look at the expression for thermodynamic entropy, we immediately notice the extensive formal correspondence with

potential (not actual) information. It is precisely because of this correspondence that Shannon called his measure of information entropy. In other words, Shannon has built a bridge between information and uncertainty. In his theory, information is coupled to entropy, which signfies uncertrainty or, more positively formulated, "freedom of choice".

With the development of computers and the cultivation of data, the concept of information took on a new meaning. It was given this new meaning by the fact that it no longer had a semantic meaning, but only a syntactic function.

For Claude Shannon, information is something taking place in the external world, independent of an observer or a cognizing or observing human subject. At the same time, he speaks of communication (messages) that must be selected from a limited repertoire. With the metaphor of objectivity, he tried to understand information as a material substance. Information is bound to a physical thing. It needs an information carrier. The selection metaphor stands in contradiction to this. Information is a choice made by a provider of information and a forced choice made by a receiver of information.

Information sent isn't necessarily equal to the information received. Choice always implies a comparison with a list of possibilities or possible meanings.

From a linguistic point of view, the concept has been divided into three different dimensions: syntax, semantics, and pragmatics. Syntax refers to relationships between characters. It represents the actual sign as a physical entity. Semantics constitutes the content and the meaning that is conveys. It is not presented in a physical entity. Pragmatics deals with the relationship between signs and their users. It is an individual understanding of a sign, the context in which they are integrated. Here, I follow Charles Morris, who focuses on the signs' effect on the receiver, the informative use of signs. Consequently, the informative use of signs is concerned not with truth or false statements, but effect.

In cybernetics, it makes no difference whether one is communicating a message to a machine or to a person. Humans perceive the world through their sensory organs. The

information they receive is coordinated by the brain and the nervous system. It produces an effect that has an impact on the outside world. Information is the name for the content of what is exchanged with the outer world as we adjust to it. Following Gregory Bateson's view, information is a difference that produces a difference in a system: the unit of information is a difference, just like the unit of "psychological in-put is difference."[6] Bateson defines information as the selective representation of reality and communication in the form of informatic concepts. He thus reduces human cognition and communication in the sense of cybernetics to a machine level. We are dealing here with an analogic concept of information in which categories from computer science are projected into sociology and communication sciences by means of analogical inferences.

Characteristic of self-referential systems is that the structure of the milieu interacts in the autopoietic systems, triggering structural changes in the system but not determining them, and vice versa. The result is a history of reciprocal structural changes. The reciprocal structural changes are what Humberto Maturana and Francisco Varela call structural coupling. This view of interactions in living things involves the notion of information in terms of an input–output system or transmitter–channel–receiver scheme. The systems remain the same, and the message should be transmitted as free of interference as possible. The systems themselves should remain unchanged in their structure. In contrast, structural changes take place in living things because of the interactions. Information is not a difference in the external world that is taken up by a system without changing; rather, it is a difference that, in turn, creates a difference in this system.

Based on the theory of self-referential systems, the sociologist Niklas Luhmann also defined the concept of information in terms of a system change caused by an external influence. Luhmann distinguishes between organic and mental as well as social systems. The latter are

[6] Bateson, *Steps to an Ecology of Mind,* 487.

systems of sense (*Sinnsysteme*). According to Luhmann, however, a message in communication is "nothing more than a selection proposal, a suggestion. . . . Communication is always a selective process."[7] Information is then, according to Luhmann, following Gregory Bateson, "nothing more than an event that brings about a linking of differences—a difference that makes a difference."[8] Luhmann detaches communication in social systems from reference to individual consciousness, although the latter remains a precondition for the former. Individual consciousness, however, is not the self-reference of social systems but is grasped as the environment of social systems. This logical step is necessary for Luhmann to estimate an independent theory of social systems. Communication is not based on consensus but on redundancy and difference: by producing redundancy, the system becomes more independent of (necessary) communication due to an individual consciousness. "Information is a difference that makes a difference" is understood by Luhmann in such a way that information must have novelty, otherwise it would not be information. If I receive the same information a second time, the second time, it is not new and, therefore, not information. Information thus contains a difference from what is already known, and this difference triggers cognitive structural change; for instance, a difference to the old structure is mentally established. Here the outside world constructs itself through a subjective selection process. Weizsäcker distinguishes information from matter and consciousness. For him, information is form or shape or structure. Matter has information; consciousness knows information. For Weizsäcker, it is not something that is a third dimension but the bases for matter and consciousness.

As we have seen, the term information is used almost universally, that is, in a large number of special disciplines, in everyday life, and in different contexts. That says little, though,

[7] "Die Mitteilung ist aber nichts weiter als ein Selektionsvorschlag, eine Anregung. … Kommunikation [ist] immer ein selektives Geschehen" (Niklas Luhmann, *Soziale Systeme, Grundriß einer allgemeinen Theorie* [Frankfurt am Main: Suhrkamp, 1984], 101).
[8] "Nur selbstreferentiellen Systemen erscheint eine Außeneinwirkung als Bestimmung zur Selbstbestimmung und damit als Information—a difference that makes a difference" (ibid., 103).

about how it is understood in the various fields. According to Rafael Capurro, there are only three possibilities for how to grasp the different concepts of information: the concept of information means in all areas: a) either exactly the same thing, or b) only something similar, or c) something completely different in each case.

Let us examine the first possibility: If the information terms used in the various sciences were synonymous, then what is called "information" would have to apply in the same sense in physics as in literature. However, there are good reasons against this, based on the qualitative differences between these fields. This possibility is therefore ruled out.

The second possibility is if we assume that the concepts are analogous. In this view, the question arises as to which of the various concepts of information should be the fundamental one. Moreover, on what grounds should the concept that allows others to be compared stand? If we were to choose the concept of information for a living human, we would have to accept anthropological aspects if we wanted to deal with non-human phenomena. This would lead to transferring conceptual contents from one area to another where they do not fit. If we wanted to start from a physical concept of information, we would end up with a physical reduction of the biological or socio-cultural information process. It would provoke false conclusions, because it does not take into account the complexity of the subject areas, of that which takes place in biology or culture. In terms of the information provided, this would be no different from the analysis of the physical realm and its physical methods. This conclusion should be rejected as well. The third possibility is that the terms are equivocal. The identical words would be used for incomparable designates. That would complicate the state of science. It would resemble the Tower of Babel, where disciplines could not communicate with each other clearly. That means that the last possibility is also unsatisfactory. This is a trilemma. We would have to assume that science has no choice but to either fail in its search for a world formula or abandon any universally valid claim to the subjective arbitrariness of projections between the most

diverse fields. There does not seem to be a way out of the trilemma; a uniform, unified, single concept of information seems impossible for logical reasons.

I tend to define information according to self-referential aspects. Information is something that comes into play with self-organization. It has no deterministic aspect because the relation between cause and effect is broken. A self-referential definition of information means that a system's own activity is interposed, and the cause becomes merely the trigger for processes in the system that produce an effect, where the system makes a choice when it turns the possible into the real. It is a choice that is irreducible. In this moment, information is in the making. The informational event leaves traces in the system, in its structure, in its state, in its behavior. These traces can become the starting point for a further informational event that relates to another system in which it interacts with the self-organization of that system.

Chapter 2: ENTROPY

Initially, entropy was introduced by Rudolf Clausius as a measure of a thermodynamic system's change of state when energy was added to it by a reversible process. Later, Ludwig Boltzmann reformulated this in a probabilistic way, using entropy to describe a system's internal disorder. In thermodynamic entropy, this is the probabilities of microstates, or more precisely: the probability distribution of the energy states of a material system. For physical systems, maximum entropy is associated with their equilibrium state, towards which a natural system will spontaneously shift according to the second law of thermodynamics.

Boltzmann's physical theory does not look at the specific behavior of individual atoms or molecules but takes a statistical viewpoint and examines the probabilities of different states. By linking the entropy S of the state of a macroscopic system with the number of all possible microstates, Boltzmann built a bridge between the microscopic structure of atoms and our macroscopic world. Boltzmann recognized that the entropy of a macroscopic state can be interpreted statistically and calculated from the probabilities of the microstates, which are

described by their structure as the locations and velocities of all atoms. The fact that not only atoms but also other elements can sit in the structure and also show the same structural effects makes it transferable to other systems. Structures therefore have an immaterial attribute. By now, the concept of complex structures and their entropy has grown beyond the scope of thermodynamics. With its method of statistics, it has developed into one of the basic concepts of science. The concept of entropy is an adequate measure of chaos and order that has gained new dimensions in the course of modern developments. Thermodynamic entropy was reinterpreted by Claude E. Shannon to found the field of information theory, in which it served to measure the expected information contained in a message and the minimum length of a lossless encoding. In information entropy as defined by Shannon, these are the probabilities of occurrence of arbitrary, unspecified events. If these events do not obey the basic mechanical laws, information entropy does not need to satisfy the second law of thermodynamics. Information entropy is therefore more general than thermodynamic entropy. This means that an information theory interpretation of thermodynamic entropy is now possible: entropy measures potential information. It measures how much the person who knows the macrostate could still know if they also knew the microstate. As entropy increases, so does the amount of knowledge not possessed by the person who knows the relevant macrostate, but which they could (in principle) gain by measuring the respective microstate. Shannon's definition of information is correct if information and entropy are understood as potential knowledge. According to Weizsäcker, this is shown by the example of evolution. Evolution means entropy growth, i.e., an increase in the number of forms, as potential information. According to Weizsäcker, knowledge (*Erkenntnis*) can be interpreted as an increase in information. Greek philosophy speaks about *eidos* as form. According to Weizsäcker, information can be defined as a quantity of form. In physics, the concept of structure is of great importance in the description of matter. We recognize here the idea of the ancient *eidos* in a material sense, i.e., putting matter in form. The atoms are brought into a form in the structure. A good example is the structure of a crystal,

such as a diamond consisting of carbon atoms. A schematic representation of the diamond structure can be seen below:

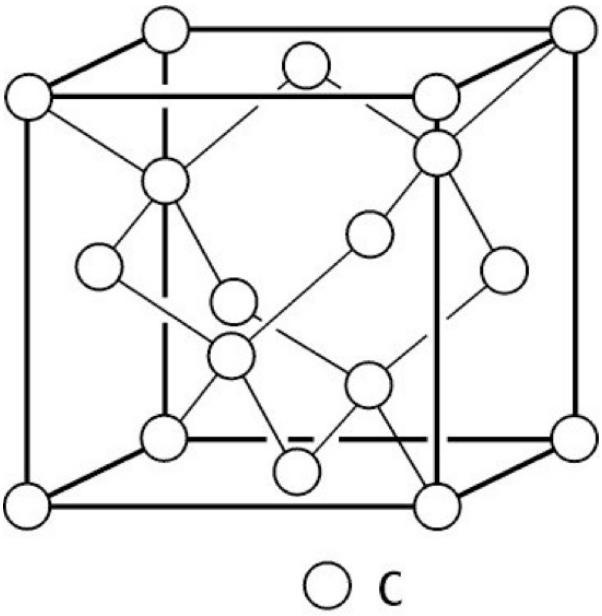

Figure 5. Schematic representation of the diamond structure, from https://www.spektrum.de/lexikon/physik/diamantgitter/2988, accessed May 26th, 2023.

It is also a diamond structure if it is an industrial diamond, even if it is a material whose lattice nodes are not carbon atoms but atoms of other elements. The structure therefore has immaterial properties. A structure as we see in the figure consists of a collection of nodes joined together in pairs by lines.

The concept of structure therefore captures relatively abstract properties of a system. However, its strength lies in the fact that it is transferable to other systems and thus allows analogies to be drawn.

If the structure describes an order, then information is the increase of knowledge (the certainty) in this state. Entropy is the measure of indeterminacy, or the potential knowledge of what we can conclude about a state. The term “structure” is closely related to the polar concepts of order and disorder. According to Boltzmann, the probability or improbability of the occurrence of states of order and disorder can be used to characterize these two terms, whereby

this probability is expressed by entropy. Structure formation is therefore the formation of a state of order, and, in this sense, is associated with a reduction in entropy.

The scientific method is the method of describing objects by analyzing or dissecting them. In a large system, you can draw conclusions about the macrostate from the disorder in the microstate. This is only possible using the statistical method of probability calculation. In the context of statistical physics, it was shown for the first time that a composite large system can exhibit qualitatively new properties compared to the subsystem, which are referred to as emergent properties.[9] For example, entropy and irreversibility are typical properties of large systems, whereas they are properties that are not defined at all for small systems. The concept of emergence is central to the philosophy of knowledge. The emergence of emergent properties should be included in the conceptualization of complex structures. Although material things consist of elementary particles and fields, this aspect is often irrelevant. We do not regard the car as a system of elementary particles, but as an entity, as an object of use. Since we want to understand the world as a unity, the fundamental question arises as to the relationship between the laws for the elementary and for the complex.

Several basic assumptions can be inferred. Two of them are important. Firstly: complex structures have emergent properties; the whole is more than the sum of its parts. This aspect that is true for physics has been transferred to society and the economy, where there are different points of view. The second assumption for the relationship between the laws for the elementary and for the complex is: Complex structures and the laws to which they are subject have emerged in the process of evolution. Their historicity is their central characteristic. This point highlighted a crucial aspect of complex structures, namely, their historical character. It is crucial for the study of complex systems. Almost all complex structures have an "ontogeny" (an individual history of their origin) and a "phylogeny" (a tribal history of the class to which the

[9] See ibid., 19.

structure belongs). This applies not only to biological beings, but also to complex technical structures, such as railroads, automobiles, airplanes and computers. As a rule, complex structures can only be understood in the context of their individual and phylogenetic history.

The aspect of historicity also plays a decisive role in psychology and the humanities. It therefore also includes an immaterial aspect. Wilhelm Dilthey assumed a structure of the soul that possesses driving forces. In his book *Ideen über eine beschreibende und zergliedernde Psychologie* (1894) he took knowledge of individuality as his starting point. In order to understand a person's individual history, you have to find out how they came to be. It is the developmental history of his soul's structure that is reflected in his biography. The historical aspect and historicity play a decisive role in Dilthey's description of the life of the soul. In order to gain insight into this developmental history, one must take account of the bonds and factors of the individual's development, and then, from the knowledge of these earlier stages, brighter light is shed on the individual "soul life" developed.

Regarding the soul's structure, "Dilthey did not use the term information" but used the Greek words *hylē* and *eidos* as a foundation for individuality and identity. Here, we recognize the use of the term eidos in an immaterial sense. However, the crucial point for Dilthey's argument is that the structure of individuality follows no logic but represents the world itself as a whole.[10]

This is what makes Dilthey's use of structure, with the description of *eidos* relating to individual history, so exciting, because it does not follow a rational method. This contradicts other approaches in the humanities or social sciences that analyze structures rationally. We will discuss individual history and its structures in connection with information from Dilthey's irrational perspective in more detail in the next chapter.

[10] See ibid., 84.

Chapter 3: INFORMATION PROCESSING

The rise of computer-processed information offers a new form of knowledge acquisition. We even have a communicative relationship with the computer, for instance, when corresponding with an AI-driven application. On top of that, we can use maps, can find ancient literature very quickly, and can produce letters, scientific texts, or poems and novels in a style of our choosing. Can a computer produce meaning though, or is it just calculating and processing logical sequences? We can say computers produce information in a rational way.

The relation between computing and *ratio* was already recognized by Thomas Hobbes. By equating reason with mathematical operations, Hobbes understands thinking and cognition as analogous to arithmetic and calculation. Hobbes already formulated an idea on which computers and artificial intelligence are based. Furthermore, he speculates that machines could not only perform calculations but could also think and act independently. He thus anticipates the ideas of cybernetics by drawing analogies between machines and organisms. If we consider a brain that processes information, the next problem is to establish a source of information for the human brain. Francis Bacon already recognized the problems concerning the amount of data that needs to be processed and analyzed. When calculating and computing with large numbers, the computing power of the brain quickly reaches its limits. It needs tools to help structure its research. As the brain's ability to perform arithmetic tasks is limited, humans are dependent on aids that guarantee precision and accuracy. Such aids help to avoid incorrect conclusions being drawn. The development of the rational method of acquiring knowledge is a relief for the brain. Its origins reveal the path to the calculating machine and, thus, also the foundations of the computer. The motivation here was to create knowledge with order and security—security in the sense of constancy and predictability.

Descartes had the idea that the mind already knew fundamental truths independently of its perception of the environment. This makes it possible to derive the elementary truths of

mathematics. Descartes was aware of sensory illusions. In order to generate knowledge, one would first have to reflect mathematically in order to arrive at insights. In his writings, Descartes made the individual the absolute authority of truth and called on him to elevate doubt to a methodological principle. In doing so, he placed critical reason in the highest position, and thus the question of the thinking subject was in the foreground. In his *Discours de la méthode* (1637), Descartes uses words such as "perfect," "certainty," and "correct" to describe attributes of the rational method. At the same time, Descartes is aware that his reason does not always work perfectly correctly. To get closer to exact measures or calculation, the invention of a calculator was unavoidable. Pascal posed a question that is still relevant today: Can machines have an ability to think comparable to that of humans? What distinguishes living humans from machines? One passage states: "The arithmetical machine produces effects which approach nearer to thought than all the actions of animals. But it does nothing which would enable us to attribute will to it, as to the animals."[11] This quote highlights the information processing or calculating aspect of the machine, which it has in common with humans. Of course, the difference is that the machine is more precise and faster. What is remarkable here is that he concedes that both animals and humans have will, which is a mental phenomenon.

Coming back to Pascal's Pascaline, Gottfried Wilhelm Leibniz surpassed him in building a calculating machine that could not only add but also multiply and perform root calculations, whereas the Pascaline was only able to add and subtract. Leibniz's calculating machine, which he saw as one of the most important tools of the human mind, was based on the binary system. In his book *Explication de l'arithmetique binaire* from 1703, he describes

[11] "La machine arithmétique fait des effets qui approchent plus de la pensée que tout ce que font les animaux; mais elle ne fait rien qui puisse faire dire qu'elle a de la volonté comme les animaux" (Blaise Pascal, *Les Pensées de Pascal,* ed. Aloïse Guthlin (Paris: P. Lethielleux, 1896), 425. Translation by W. F. Trotter (*Blaise Pascal: Thoughts, Letters and Minor Works*, Harvard Classics, vol. 4 [New York: P. F. Collier & Son Company, 1910], 117).

arithmetic using only the digits zero and one. His studies on the binary system have had a lasting impact on modern information theory.

The advantage of binary numbers is obvious. All numbers being expressible by 0 and 1 provides the fundamental system for science and leads to new discoveries. Leibniz's way of thinking had a profound influence on the logic of cybernetics: in reducing thought to the simplest of terms, the problem of selection appears here as a yes–no decision between two sides of an alternative. In computer science, the simple representation of these yes–no decisions is based on voltage being either on or off, which corresponds to a binary digit (bit) as a unit of information. According to Leibniz, arithmetic and logical thinking are the basic characteristics of human beings because they are subject to reason. He says that although humans and animals living "without reason" show similar reactions, the difference is that humans "have reason and science," and he describes the "mind" as a "reasonable soul." With this expression, he affords *ratio* the position of man's highest principle. What is decisive here is the act of reflection and abstract thinking, which is necessary in order to be able to refer to oneself. According to Leibniz, the act of reflection is based on reasoning, which, in turn, is founded on two "great principles." One is the principle of contradiction (*principium contradictionis*). This principle is based on a binary logic that a statement, event, etc., can either be true or false. The second principle is the principle of sufficient reason (*principium rationis sufficientis*). This principle states that no event is true unless there is sufficient reason. The analysis consists of breaking down ideas and truths until the final fundamental truth is reached. These two main theorems have had a lasting impact on the history of science right up to the present day. The *principium rationis sufficientis* method can be linked to various information theories that were introduced in the first chapter. As we know from information theory, information is measured in binary digits. However, these only have a syntactic function. "The measures as defined, for instance, by Shannon, have nothing to do with what these symbols symbolise, but only with the frequency of their occurrence." In order to attribute meaningfulness or significance to the transmitted

signals, Bar-Hillel and Carnap made use of probability theory, among other things. Without an interpreting subject, meaning was to be created through endless combinations of zeros and ones. If one wishes to obtain processable elements, technical signals with meaning and significance, one has to then address the question of interpretational dominance. If information has meaning in itself, it does not need a subject. It no longer needs an interpreting individual to anticipate meaning. The information itself is already in the items in question, waiting to be discovered. What began in the early fifties, making information quantitatively measurable as a bit and providing it with a semantic theory, can be traced back to the ideas of Leibniz and his *Satz vom Grund*. The rational method starts from pure objects and seeks and finds the "truth" within its realm of reason.

Friedrich Nietzsche approaches the problem from a human perspective. For Nietzsche, a word cannot be firmly defined, but must always be thought of as a metaphor. However, metaphors are not fixed but changeable and, therefore, not mathematically tangible. According to Nietzsche, the formation of metaphors is a fundamental human drive that is subordinate to all concepts. Nietzsche refers to two fundamental ways of thinking, intuitive and rational, reasonable thinking. The latter as a method has produced findings in the natural sciences, particularly in thermodynamics and quantum physics, which have replaced the old paradigms of the 17th and 18th centuries.

Martin Heidegger defines the rational method as a basic feature of modern science. Heidegger explicitly refers to Leibniz and his *principium rationis sufficientis*. In order to quantitively measure and organize facts, the presence of computers and their technology is needed. The computer organizes and provides facts, but offers a mathematical interpretation: the equation. Following Leibniz, facts must always be justified. There is a causal connection between facts and justification. Heidegger formulates this as a causality of "reason."

Heidegger asks what reason is and answers that it is a word. However, a word always has a meaning. A meaning of a word refers to a thing. With respect to the essence of language,

Heidegger doubts the latter is only an instrument of information. To speak a language is not a mechanism that runs uniformly. However, information is the basic attitude of the new *Dasein*. Accordingly, the idea of human language as an instrument of information is increasingly gaining ground, or the definition of language as information provides sufficient reason for the construction of "thinking machines" and for the construction of large computer systems. However, in that information informs, i.e., notifies, it also forms, i.e., directs and aligns. As notification, information is also the device that puts man, all objects, and conditions into a form that is sufficient to ensure man's dominion over the whole of the earth. Human ideas are limited by the *principium rationis*. They allow no other thought. The *principium rationis* becomes the principle of all imagination. This means that imagination is dominated by the *principium rationis*. It is now rational and managed by reason. According to Heidegger, this broadly conceived arithmetic is the way in which man perceives, assumes, and accepts things. The reasonable, rational imagination follows the *principium rationis.* Following the *principium reddendae rationis sufficientis*, Neuroscientists and AI researchers try to objectively record mental states. With ever-increasing, ever-cheaper computer power and the immense amount of data available, the latest research results are astonishing. We communicate with voice assistants like Google Assistant, use translation software like DeepL, and integrate intelligent systems into our homes and vehicles. Technological change clearly has an impact on our society and our social fabric. We have shaped computing machines and artificial intelligence; now they are shaping people and society. The increased computing power combined with falling costs and the seemingly unlimited possibilities for data storage and data analysis should once again be mentioned. The digitalization of our society has been driven by technological achievements in the past and then accelerated once again by the coronavirus pandemic. AI developments are leading to a new view of the world and of our image of humanity. In order to understand these changes, we need to address the question of what the term AI expresses, and what lies behind it. If you look at the developments in AI, we see that they are able to predict the best possible

probability through statistical calculations. They are linked to the methods of natural sciences, and their successes have led to the humanities also making increasing use of their methods. This is because scientific exactitude raises the claim of being a universal and fundamental science of the mind. Edmund Husserl's criticism is justified when he says that objective methods do not involve the observer. The humanist and life philosopher Wilhelm Dilthey dedicated his life to clarifying the nature and spirit. In his text *Der Aufbau der geschichtlichen Welt in den Geisteswissenschaften* (1910), Dilthey tries to grasp the mental world systematically. He describes it as a context of effects that is based on the structure of the life of the soul. The humanities explore this context of the mental world through understanding, in contrast to the natural sciences, which address the causal connections of nature.

According to Dilthey, the natural sciences explain phenomena, i.e., trace them back to their causes. They stand at an objective and theoretical distance from their object of investigation. The objects of the humanities, on the other hand, do not allow this, as the scientist himself is part of the investigation. The object of investigation of the humanities is not a reality based on facts but the human historical course of life itself. However, for Dilthey, this can be understood in the sense that the object of the humanities is linked to the experience of human states. The expression of these states can be understood in the form of expressions of life. This dual relationship between experience and understanding arises empirically through retrospection.

Dilthey highlights the contrast between material and mental substances. He then replaces this antithesis with the dichotomy of the external world and the internal world—the external world as it is captured in perception through the senses, and the internal world as it is originally represented by internal perception (insight/understanding) based on mental activity (reflection). If we follow Dilthey's argument further, we see the difficulty that the humanities are not completely independent of the natural sciences. Rather, it is crucial for Dilthey to emphasize how "relative the distinction between these two classes of sciences is."

For Dilthey, intellectual concepts can never be removed from the context of nature. In order to maintain the natural coherence of the sciences, Dilthey demands that the methods of the natural sciences be regarded as the foundation, and that such fundamental methods must also be identified for the humanities. Accordingly, the experimental methods (empiricism) form the basis of the methods of the humanities, which, for Dilthey, are hermeneutics and descriptive psychology.[12] He explains that the natural sciences form the basis of human psychology. He refers to the change in the nervous system that goes hand in hand with the mental state. For Dilthey, abstract mental concepts can never be deduced inductively or understood as a causal sequence of events. Dilthey thus rejects classical empiricism and behaves as a Kantian in this respect. In this sense, mental content is by no means empirical. What is empirical, however, is the thought process in which the mental content is experienced and produced. For Dilthey, mental contents are therefore experiences of thought and can only be understood from a historical context. In his philosophy, and consequently in the humanities, Dilthey is concerned with understanding and discussing intellectual content on the basis of the context from which it emerges.

Dilthey attempts to systematically understand the world of the mind in his work *The Construction of the Historical World in the Human Studies* (1910). He describes it as a structure that is grasped by spirit. Dilthey sees the inner spiritual dimension as a method, because the spiritual world emerges from the life of the individual. In order to understand the whole, the spiritual world requires a context that links individuals together. In order to express the structure of consciousness in an intelligible form, categories must be formed that describe systematic connections. The unity of consciousness is represented by all individual experiences. Understanding their structure and context gives life its own meaning. Individual units of experience must be taken out of the flowing stream of life and merged into the unity of meaning

[12] See Christian Damböck, "Wilhelm Diltheys empirische Philosophie und der rezente Methodenstreit in der analytischen Philosophie," *Grazer Philosophische Studien* 85, no. 1 (January 2012): 94.

of life lived. An experienced event informs the mind by changing its structure. A change in state of mind results. In this sense, information can be gathered from individual experience. In the moment of contact with the environment, our mind gets informed. Yet, the moment becomes the past and starts to exist as a memory. Every time we reflect or remember an event, our state of mind changes again, and, therefore, our memories change, and vice versa. However, the coherence of experienced events represents consciousness. It differs from a computer, which recalls the information as it was stored. The memories of the mind change every time we reflect or remember. That is the reason that our memories are unreliable. They do not present the objective factual reality based on rational analysis of the single parts and their causal explanations.

In his *Drafts for the Critique of Historical Reason*, Dilthey outlines his autobiography with regard to the hermeneutical category of "meaning" in relation to historical thinking. If we reflect on memories, the individual experiences in the course of life take on meaning. Dilthey's hermeneutic approach is based on a model of experiencing subjectivity that captures the history of human consciousness. According to Dilthey, the spiritual world arises in the understanding of a subject, as the mind is in search of objective knowledge. The paradoxical problem can only be solved if the meaning of the individual elements that form the whole context are considered separately. Understanding meaning is perceived in the context of the individual-historical perspective of self-understanding. "Understanding is a rediscovery of the 'I' in the 'you.'" The subject becomes one with its object. This requires aesthetic design. The terms "context," "spirit," "subject," and "meaning" can be understood as core concepts of hermeneutics, whereby the "context" as a whole establishes the "meaning" of the individual. The "spirit" establishes this context and rests in the understanding "subject." The "understanding" of past "life" produces "meaning" in the "experience" of the context. Understanding in the humanities presupposes a connection between subject and object. Commonality is considered to be an essential prerequisite for a process of understanding: The connection between subject and

object can be fathomed by the humanities scholar with the help of empathy. The expressions of this experience, which are preserved in art and especially in the works of poetry, provide access to this. The representation of a poem or a representation in art constitutes a significant kind of order that exists elsewhere. For the poem or the artwork, the structural theme derives much of its evocative value from the human condition, whose particular form of order it makes visible or audible. A structural theme deserves to be ordered, to become a message, because it says something about man and the world.

Conclusion

Wilhelm Dilthey's understanding of science and his hermeneutic method form an alternative model of thought to rational methods. Two aspects of his philosophy were elaborated: Dilthey's theory of the humanities, which is characterized by a specific complementary relationship to the natural sciences, and his view of philosophy and, by extension, the humanities as a science of experience. Dilthey's hermeneutic concept emphasizes the empirical process of perception, since both the process of experiencing and the meaning of events depend on experience. Dilthey's hermeneutic approach can be linked to the theory of self-referential systems. The human being stands in relation to his environment, which he perceives with his sensory organs. According to the theory of self-referential systems, a perceived event is referred to as information. Information here has a communicative character. This is because the event informs the mind about the facts in the outside world. An event is an experience that is experienced subjectively. Strictly speaking, it is therefore not objective. Information as an event is perceived in different mental states. Depending on the state, information is perceived differently, which is why it cannot be considered purely objective. The selection of information therefore depends on the emotional or mental state the person is in.

This is only possible on the basis of a structure that limits and selects the possibilities of events. Information therefore requires structure. For Dilthey, this is expressed in a mental context. According to Niklas Luhmann, information is not a structure but an event that actualizes the use of structure. Following his train of thought, this means that when we take in information, our mental structure is formed anew. For Dilthey, as for Luhmann, temporality plays a decisive role in the description of information. Events as information are time-fixed elements. They only occur once in a period of time (moment). This means that they are determined by their temporal occurrence and are unrepeatable. This allows us to understand information as an elementary unit of processes, and this is precisely what information illustrates well. Information that is repeated is not information. It retains its meaning in the repetition, but loses its informational value.

For example: You read about the outcome of a presidential election in the newspaper. If you then read the same thing again in another newspaper, it no longer has any informational value. It no longer changes your own mental state, even though, structurally, it presents the same selection. Furthermore, information does not get lost even if the event disappears. According to Luhmann, it has changed the system's state and thus left behind a structural effect. The system, in turn, then reacts to these changed structures. If we consider the memories in the context of the informational event and its structural effect, this connection only appears to an observer. By observing oneself, one can gain surprising new information about one's own mental state. However, this mental connection only exists for an observer and is expressed most clearly in Dilthey's analysis of autobiography. In a person's autobiography, the essential memories are preserved in the memory and brought together to form a unit of meaning. The threefold identity between author, narrator, and protagonist is its constitutive feature. However, if subject and object are identical, it cannot be concluded that objectivity prevails. In this sense, an experienced event is not an object, as it always undergoes a transformation or recoding of

the pure event. These experienced events remain reflections or descriptions of memories that are only accessible to an observer.

By reflecting on memories, the individual events in the course of life are given meaning. In the process of reflection, memories are constantly edited or changed. As a result, remembered events and their meaning are exposed to structural effects, and, as a consequence, are constantly reconstituted. For this reason, memories are distorted and can experience shifts in meaning, as shown by the example of Joseph von Eichendorff's autobiographical writings. In Dilthey's hermeneutic method, the unity of consciousness is represented by individual events; the events are given a meaning, and these are connected in a context. This process is never complete. In this sense, the linguistic expression of an autobiography represents a fixed moment of the mental context of meaning. This makes it possible to give other observers informative access to one's individuality. From a hermeneutic perspective, the autobiography is an expression of the concrete reality experienced. By uniting individuality and form, it is possible to objectify the author's personality in his or her work. Accordingly, Dilthey's hermeneutic method is based on inner experience, which is expressed linguistically. Dilthey's process is never inductive or a logical, causal sequence of events. In Dilthey's hermeneutic concept, information is taken in from the outside world. However, the informational events are not simply mapped onto the cognitive structure but are subjectively mentally constructed and brought into a context of meaning. On the basis of consciousness, a mental entity is articulated through an emergent process and made accessible to the outside world again. Dilthey's hermeneutic method does not treat the objective and subjective sides of the information process as separate but as opposites that belong together, that point to and depend on each other.

This dialectic of subject and object means that information only ever exists in a relationship between the subject and the object. Thus, the generation of information in the subject and the process of objectification of the subject are mutually related to each other in the intellectual context. Dilthey's hermeneutic method thus stands as an alternative model of

thought to the rational method, the historical development of which was outlined in the third chapter.

We will now consider the other concepts of information presented and their characteristics. The concept of information, as we use it in everyday language, in the sense of news or conveyed knowledge, plays a central role in today's society. Although knowledge and its communication are fundamental phenomena of every human society, it is the rise of information technology and its global impact that characterizes our society as an information society. The understanding of information underwent a fundamental change as a result of Claude E. Shannon's definition of information. The word information became detached from its Latin origins and tradition and was associated with the concept of entropy.

The development and widespread use of computer networks since the end of the Second World War and the emergence of information science as a discipline in the 1950s are evidence of this orientation. Shannon's concept of information is a reductionist one, which defines information purely syntactically in terms of messages. The reduction consists in the fact that information can be broken down into the smallest particles (individual bits), and that a message is made up of the sum of these parts. Shannon defines information on the basis of probability theory. Entropy is the potential information, and negative entropy is the actual information. This view of information has the same meaning in all contexts. It guarantees an objective analysis in processes of human cognition or communication. It is also used to describe processes in scientific disciplines or AI research. The foundation of knowledge acquisition is based on the basic concepts of information, entropy, and complex structures.

In information theory, order is described as the carrier of information, because information is defined as the opposite of entropy, and entropy is a measure of disorder. Transferring information means creating order, and since entropy increases as the probability of a state increases, information behaves in the opposite way: it increases with improbability. The less likely an event is to occur, the more information its occurrence represents. The question

then is: What type of event sequence is the least predictable and therefore contains the maximum amount of information? Obviously a completely disordered one. When we are confronted with chaos, we can never predict what will happen next. The conclusion is that total disorder provides a maximum of information, and, since information is measured by order, maximum order becomes maximum disorder. The source of the problem lies in the fact that if we speak about order we mean an order in a structure. In this sense, the attribution of order or disorder is a hermeneutic decision. In a purely statistical sense, however, the term order can be used to describe a sequence or arrangement of objects that does not come about by chance. In information theory, structure means nothing more than the occurrence of certain sequences of elements that are to be expected.

For Shannon, information is something that takes place in the outside world, independent of an observer or of a recognizing or observing human subject. His sender–receiver model expresses that information is something that is transported from a sender to a receiver. At the same time, Shannon speaks of messages that have to be selected from a repertoire. This makes the physical notion of observer-independent information questionable, because a selection can only be made by an observer. Although Shannon limited the concept of information to technical systems, his theory spread to natural and social science disciplines. This led to discrepancies, as Shannon had ignored semantic and pragmatic aspects. In the linguistic theory of signs, Charles Peirce introduced the distinction between syntax, semantics, and pragmatics. On the basis of the latter's three-dimensional semiotics, Charles Morris formulated the thesis of the informative effect of signs. In everyday language, a distinction is made between information and misinformation. Information is thus related to the factual accuracy of a message. In contrast, Morris focuses on the effect of the sign on the recipient. The informative use of signs has nothing to do with truth or falsity; rather, the effect is the decisive aspect. We inform even when we disinform. It is not the semantics but the interpretation of the signs by the recipient that is decisive for the informative use of signs. In

our digital society, we are confronted with misinformation on a daily basis, as the US presidential elections or the vaccine debate during the coronavirus pandemic show. The definition of misinformation is based on a classic dichotomy of truth and falsehood. In this view, misinformation is seen as fundamentally false, so it is recognized, fought against, and deleted. This narrow view often overlooks the deeper connections that misinformation can reveal. In my opinion, the question of distinguishing between false or true information is not fundamental. Linguistic statements are context-dependent and can be interpreted metaphorically, whereby the decisive factor is their subjective effect. In contrast, the rational method states that scientific knowledge is based on facts and can be explained objectively and rationally. However, objective knowledge cannot mean the elimination of the cognizing subject. This is because meaning and the understanding of information are always tied to humans. If scientific knowledge is produced by artificial intelligence and cannot be understood by humans due to its complexity, it remains meaningless.

While Shannon's understanding of information refers to an objectivist concept of information, constructivist theories, such as the autopoietic theory of biologists Humberto Maturana and Francisco Varela, the cybernetic concept of Heinz von Foerster, and the self-referential concept of Niklas Luhmann, form a contrast. In all three concepts, information is understood as communication that triggers a structural change in the system. Communication is based on an input–output system. Maturana and Varela developed the concept of living systems as autopoietic and thus provided a basis for radical constructivism. The cyberneticist Heinz von Foerster places information entirely on the side of the mental and assumes that the environment contains no information. For him, information is an utterance or description that only has meaning if it is associated with the cognitive structure of the observer. Foerster therefore represents a radical constructivist view, as knowledge only exists for an observer on the basis of the observation of his own structure. For Luhmann, too, the environment contains no information. For Luhmann, information is not something that is waiting to be grasped. In

his theory of self-referential systems, Niklas Luhmann sees information as part of the communication process: information involves a difference from what is already known, and this difference triggers a cognitive structural change. Luhmann also draws on Shannon by understanding information as a selection from a repertoire of possibilities. Yet, here, his concept of information differs from the intelligence concept of information in that he relates information to meaning-constituting systems. Information is thus subjectivized. Weizsäcker discusses the concept of information from two sides. On the one hand, information only exists for humans. On the other hand, the modern concept of information tends to detach itself from the human subject. Communication and understanding in the sense of creating new structures are carried out by organisms and, ultimately, also by machines. As we saw, Weizsäcker formulates the relationship between form and consciousness by saying that matter has form while consciousness knows form. This statement summarizes the objective and subjective aspects at play. On the one hand, information means the quantity of form of a material body. This quantity of form can also be described using the intelligence concept of information. If entropy in thermodynamics means the loss of order and thus of form, then current information means something like the negation of entropy. On the side of subjective cognition, information has syntactic, semantic, and pragmatic dimensions. The different concepts of information within information science reflect the tensions between a subjective and an objective approach; however, the hermeneutic concept can be seen as a bridge between these two poles.

Dilthey's hermeneutic method is suitable for providing an interpretation, as it takes into account both the inner world and the outer world and links them together. Aspects from the theory of self-referential systems can be transferred to Dilthey's concept. It not only offers explanatory approaches to human information processing but also to our unreliable memory. Our memory does not function like a computer that stores information and retrieves it precisely. Memories are subject to constant change. Every process of reflection and information intake is accompanied by a change in mental structure. As a result, memories are formed anew each

time. The reference to the outside world is given by the fact that the reflecting subject always includes the social and historical conditions he is living in.

Principal Contributions

1. This dissertation offers a historical survey on the status of information. In examining different approaches to the status of information, it highlights the discrepancy between information as something taking place in the outside world (physics) and information as something that arises in the internal world of human beings (psychology, etc.). A self-referential approach could serve as a bridge between these two worlds.

2. This dissertation contributes to the contemporary discussion of information in relation to entropy. It also highlights the analogous use of the terms information and entropy, the latter of which originated in the field of thermodynamics and was transferred to several other disciplines, such as information theory and the social sciences, through insights into cybernetics.

3. This dissertation makes the case that the concept of structure is a fundamental aspect of knowledge acquisition in the disciplines of the natural sciences and social sciences. The investigation of the concept of structure is characterized by information and entropy.

4. This dissertation explores the term entropy as a measure of disorder. The judgment about order or disorder is about meaning. The attribution of order or disorder is a hermeneutic decision

5. This dissertation contributes to the contemporary discussion of information processing by discussing Wilhelm Dilthey's hermeneutic approach. His holistic approach is opposed to the mathematical rationalism in that it understands subject and object as a unit. Moreover, Dilthey's hermeneutic concept of consciousness is linked to the self-referential concept of Nicolas Luhmann.

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