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Systematic Unfoldment of Differential Ontology from Qualitative Concept of Information

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Abstract

A certain philosophical ontology is presented as developed from a qualitative concept of information, leading to conclusive points of possible far-reaching relevance for philosophy and science.

Keywords: informational differential ontology, differential epistemology, philosophical informatics, causality theory, projective causality, Fibonacci algorithm, concept of border, Erasmus syllogism

1. Introduction

In relation to information science, we can basically distinguish between two different meanings of "ontology": (i) in the classical and purest philosophical sense as the discipline researching "being; that which is" in the most universal, abstract and fundamental regards; (ii) in the modern, specified and instrumental sense inside computer science as defining suitable sets of "representational primitives" (classes, attributes, relations) with which to model a domain of knowledge/ discourse for computation. We denote the first meaning as *philosophical ontology* and the second meaning as *computational ontology*. When we write "ontology" without further specification, the first meaning is implicated. In the present text, we focus and exhibit intimate relations between the science of information in its very foundations and a certain *philosophical* ontology.

When discussing the relation between philosophical ontology and informatics, usual approaches will depart from an ontology presented by a sophisticated philosopher, say Leibniz, Kant, Hegel or Quine. Next, the field of informatics will be placed inside this ontology, and the chosen philosophical ontology will be applied to approach the field of informatics in order to achieve some new results, e.g., for construction of a more suitable computational ontology in

specified respects. Instead of departing from more pure philosophers, similar approaches may be undertaken as departing from modern generalizations of quantum mechanics into some quantum ontology, or from some second-order cybernetics including aspects of philosophical phenomenology. In any case, such approaches start out with establishing philosophical ontology basically independent of, prior to and external to the foundations of information science.

In radical distinction to such approaches, our approach is to depart from the very *concept* of information, and systematically *develop* a novel philosophical ontology by strict, successive and more organic *unfoldment* of what is already *implicated* in the concept of *information as such*. The basic idea was to establish an adequate and *qualitative* concept of information, i.e., of *something* existing (for someone), and to explore and exhibit what *had* to follow from this by philosophical rigor and consistency. The resulting ontology was presented in the treatise *Outline of Differential Epistemology* (Johansen [1]; yet to become finalized into English translation for publication). Here, (differential) epistemology was not understood as opposed to (differential) ontology, as often the case in philosophical treatments, but rather as the epistemological "head" growing out of the ontological "body" from unfoldment into the more sophisticated among causality operators. Knowing of something being implies that being itself becomes extended by this knowing. The present text will present some key points from said treatise, supplemented with various novel remarks.

In the discipline of informatics, different *quantitative*—and highly fruitful—concepts of information became established, as the classic concept by Shannon (and Weaver) [2] and later concepts by Kolmogoroff and by Chaitin (*Algorithmic Information Content*). Zurek [3] clarified how these two apparently opposing kinds of concepts, with respect to indicating algorithmic complexity, could be understood as complementary, depending on choice of fundamental perspective and reference frame, and thus possible to synthesize.

Zenon from Elea pointed out that "if being did not have a quantity, it could not be" [4] (p. 115). Quine presented his famous criterion of ontological commitment: "To be is to be a *value* of a bound variable" (our italics). These statements are consistent with the general philosophical point that anything being only can exist as *bestimmt* in the sense of Hegel, i.e., *as definite*, and as such also must possess exact quantitative aspects. Quite another issue is how easy or fruitful it is to *measure* these quantities. If we take the existence of *love* as example, this ontological phenomenon or entity obviously has its quantitative aspects, while it is also obvious that these aspects due to the complexity of the phenomenon are far from easy to measure and due to the more sacred intimacy of the phenomenon probably not that fruitful to attempt to measure.

A deeper philosophical point is that *any* quantification, with logical necessity, is a quantification of *something*, i.e., of a *quality* (as also the case for Quine's "variable"). Thus, the category of quality is ontologically prior to the category of the quantified quality. This must also be the case for the concept of *information*. It is not possible to establish any quantitative concept of information without *de facto*—tacitly or explicated—presupposing a qualitative concept of information. When *avoiding* explication of the conceptually and ontologically underlying and prior *qualitative* concept of information in favor of merely operational quantifications of the concept, there is some danger of *fetishizing* quantification as such. Sometimes such elements of fetishism, at least to some extent, may be rather innocent and even fruitful for certain purposes (say establishment of sufficiently adequate IQ tests), while they may be basically shortcoming with respect to more

profound scientific reflections and possibly crucial scientific progressions. Avoidance of quantitative fetishism with respect to the concept of information is crucial in order to establish a universal philosophical ontology with multidisciplinary potency, including the discipline of informatics. Hence, there is a need to explicitly establish an adequate *qualitative* concept of information.

2. Qualitative concept of "information"

The most influential qualitative definition of information has been Gregory Bateson's definition of information (in his shortest version) as *the difference which makes the difference* [5, 6]. We take this famous definition as a point of departure for some further adequate qualification and modification.

Sometimes Bateson qualifies his definition of information as a difference which makes a difference for *something*, or for *someone*. In general, a phenomenon *cannot* appear as a difference unless it appears in relation to something *for which* it makes a difference. This something we denote a *subject*. This may be the *emphatic* subject of a human being or it may be the *projected* subject from a human being into more or less *imagined* subjects in a spectrum spanning from an ape or a whale to a billiard ball or a photon. Thus, we can make Bateson more consistent by reinterpreting Bateson's "something" as a projection from a human, or other sufficiently intelligent being "someone," say from the human biologist or physicist.

Generally speaking, there must be a *relational triad* involved in the very constitution of information as such: (i) an input-difference, which makes (ii) an output-difference into the reception (including into higher perceptions, not excluding more unconscious mental ones) by (iii) a subject, either an *emphatic* human subject or a *virtual* subject constituted by projection from and interpretation by an emphatic subject. A necessary condition to constitute an emphatic subject is the subject having *emotion*. Thus, there cannot exist information in the cosmos without the existence of emphatic subjects having emotion.

As a thought experiment: Imagine AI advanced and self-replicating nanobots becoming able to exterminate emotional subjects including humans, as e.g., the nanotechnological construction of $Ba_xSr_{(1-x)}TO_3$, i.e., barium strontium titanate claimed by some sober biologists to qualify as a novel *living* species. It seems hard to imagine that such nanobots would qualify as *emotional* beings. In order to understand how these nanobots would rule our world, it would still be by anticipatory *projection* from emphatic human (or ET) subjects, not by the nanobots *themselves*, whatever the sophistication of their AI algorithms. In such a nanobot-ruled world, one might say that there still would be a lot of *potentially* discovered information creation and transfer going on, while such potentiality would not be *actualized* without the presence of human (or other) subjects possessing the *emotion* to constitute emphatic subjects and from that *perform* the projection.

Man is a subject that necessarily operates with a concept of difference, and it is only through *our* reflection that the bringing forth of information in ourselves or other subjects that we observe, necessarily must be comprehended as a difference making a difference. A subject, then, *can de facto* register information without this *appearing* as a difference for the same subject; and *all* subjects *must* receive information without it *immediately* appearing as difference *for them*. Therefore, when we

speak of a subject's reception and operation of differences, we do not refer to *subjective* differences, i.e., differences that appear as such for the subject itself, but to *objective* differences, i.e., differences that are implicit in any information as it appears for an external, *reflecting* subject.

Accordingly, we also find it inaccurate to *define* information as difference (that makes a difference). In the first place, information should be defined as any *something* which is something for a *subject*. Difference can be defined as the *relation* prevailing between two somethings qua separated. Then difference is a specific *kind* of information which presupposes that a subject juxtaposes two somethings and has a concept of difference. However, a subject can very well receive and operate *other* information without this precondition being satisfied. A different matter is the fact that the existence of all information presupposes and includes *objective* differences, so that information *as such* is characterized by the fact that it can potentially be described as (objective) difference that makes (objective) difference, and consequently, for the difference-reflecting subject also makes a subjective difference and constitutes a difference-information. The difference between information and difference can be illustrated by the fact that while an information necessarily is *one*, the objective differences it presupposes can very well be *two*, provided that the subject receives analog input-differences where the information is delimited by both an overlying and an underlying threshold. Information should accordingly not be *defined* as objective difference, but objective difference is a necessary *determined characteristic* (*Bestimmung* in the sense of Hegel) by all information and consequently something that *all* information can be conceived as and by. Difference-information, in its turn, is a kind of information where a subject *reflects* in a specified way upon objective difference included in (other) information.

3. Decomposition of that which is onto two differentiated ontological dimensions: processual-physical (3 + 1D) vs. algorithmic

Any description of a dynamic system can only become meaningful through de facto being both discontinuous and continuous. (For a fundamental exposition of the relation between statics and dynamics in systems theory, see Feibleman and Friend [7].) Since it describes a course occurring in time and time is regarded as a continuous quantity, the description must, on the one hand, preserve this continuity. On the other hand, it would not be possible to describe anything at all without stating discontinuous transformations during the course. The only way to unite these two considerations is to let the description represent continuity and discontinuity in *different dimensions*, i.e., the description that unfolds a *two dimensional figure of logic*. We can imagine this as a description proceeding continuously along one dimension, but discontinuously along another dimension.

Hence, we will have a trajectory of only continuity, projected on a horizontal axis, and a trajectory of discontinuity projected on a vertical axis. This means that the two projections are respectively continuously continuous and continuously discontinuous. Then, the description must move in stepwise *alternation* between movements in horizontal and vertical direction.

The very concept of discontinuity presupposes a discontinuation upon (the qualitative entity) *time* considered as inherently continuous. Hence, the trajectory on the horizontal axis must basically be regarded as continuous movement of *time* and in time. For something to happen in

the system, this must happen as related to specified and discontinued *points* along the time line. When *nothing new* happens on the vertical axis of discontinuation, as considered by the description of the system, this implies that not only time is considered as moving continuously inside the according time interval, but also that *space* coordinates of what is(are) object(s) of dynamic description keep on moving in a continuous manner. Thus, the movement along the horizontal dimension of continuity is continuous movement in (3 + 1D) *spacetime*, where this horizontal dimension is most easily conceived by giving priority to the (sub) dimension of time in order to represent continuous movement in spacetime compressed at merely *one* ontological "dimension" inside a higher and broader ontological architecture. We denote movement along the horizontal dimension as *process*, and the according ontological domain as *physical being*. Here, the term "physical" does not refer to any *absolute* domain, say elementary particles in quantum mechanics, macrophysical objects in Newtonian mechanics, neurons in neuroscience, genes in molecular biology, or human mind-bodies in social science, but to a *relative* domain conceived in *relation* to the vertical dimension of discontinuity in a dynamic system description.

The discontinuous movement along the vertical axis *induces* the something new that happens along the continuous movement along the horizontal axis. Thus, in description of any system, the movement along the vertical axis holds de facto ontological *priority* when explaining what happens along the horizontal axis, and therefore, also for the system as a whole. Discontinuous movement happens at *points* in time, as regarded at the horizontal axis, i.e., momentarily and *without* any extension in time. (This does not imply—of course—that said discontinuous movement has no extension in time when regarded from *another* reference frame involved in another (higher) system description.) The movement along the vertical axis is regarded as discontinuous from the horizontal dimension involving continuous time. However, there is still a *movement*, i.e., a specified *succession*, along the vertical axis when regarded at this axis *itself*. We denote this vertical axis as the *algorithmic* dimension which therefore is implied in any dynamic system description as radically different from the dimension of time and physical process.

The movement along the vertical dimension cannot happen in isolation from the movement along the horizontal dimension, but only by algorithms transforming a certain input (set of variable values), delivered from *physical process*, into a certain output. We denote this concrete performance of an algorithmic operation as *informative transfiguration*. The change in physical process as induced by an output from an algorithmic operation, we denote as *differential movement*.

Any algorithm, de facto operative in any dynamic system description, must contain, whether implicit or explicit, semantics as well as syntax. The *semantics* of the algorithm indicates the *types* of input elements it can operate (e.g., numbers), the *operational rules* between elements (e.g., the four elementary operators of arithmetic), the *relational rules* between operated elements (e.g., <, > and =), and the *transformation rules* (e.g., implication) resulting in qualification (and quantification) of types of output elements (e.g., numbers). The *syntax* of the algorithm indicates the specified *succession* among its semantically possible types and rules.

This minimalistic definition of "algorithm," illustrated by arithmetic, may seem too abstract and insufficiently specified. The very meanings of "algorithm" and "computation" were primarily established by Turing's theoretical construction of the Universal Turing Machine (UTM), which was a great mathematical as well as—in our view even more—philosophical achievement that

established the foundation of informatics and computer technology. However, we do not find it adequate to apply the definition of "algorithm" that is too specified, in order to cover (at a general level) *all* discontinuations in the vertical dimension implied in human system description and underpinning cognition (whether conscious or unconscious). A general definition of "algorithm" that is less specified than Turing's may allow progresses in informatics based on broader and deeper philosophical ontology than the one underlying UTM (cf. later in this text).

4. Qualitative concept of "border"

We have defined difference as a relation between two somethings that are *separated*. The subject can only imagine its division of a something into two by imagining that two somethings are separated by a *dividing line*, or more generally and accurately, by a *border*, where the dividing border can be understood in all dimensions—as border point, border line, border surface or border space. A border seems to have a curious double nature of being and not being at the same time.

The concept of border is itself, partly self-referentially, one case of a *borderconcept*, since it is imagined (if we take the case of a line) as a continuous assembly of points of *infinitesimal* extent. A border is something being that approaches something non-being as its limit, i.e., something being that *tendentiously* is something *not* being. It is therefore contrary to the concept to imagine a border as having a particular spatial extension since any extension always can be made smaller by a more microscopic contemplation. On the other hand, border is imagined as something *being*, and how can we imagine something as being without imagining it as extended in space? But, as soon as we try to specify this extension, we fall short. To specify the spatial extent of a phenomenon implies stating a lower *and* upper threshold (thus, *borders*) within which the phenomenon is located. But for border as such, it is only possible to give the *lower* threshold, namely that the border has an extension (infinitesimally) larger than no extension, i.e., that the border has *nothing* as its limit. That a phenomenon is imagined as spatially extended without this extension being possible to specify, seems highly paradoxical, but, nevertheless, we are able to operate with such a conception.

A border, then, can only be conceived as determined tendentiously by *nothing* being its limit. By conceptual logic, however, the concept of nothing seems to presuppose the concept of border rather than the other way around. The concept of nothing can be thought as constituted as the concept about the ultimate border that always will delimit a border that is continuously diminished.

The concept of border seems positioned *in-between* which is and which is not, between the concepts of being and nothing. A border is something, but because it is infinitesimally narrow, the concept points toward something *not* being.

However, just as little as nothing can be said to *be* (exist) in any immediate sense, can a border be said to be *between* something not being and something being.

Further, if the approach is sufficiently microscopic, *any specific* border imagined will also dissolve (by the way through the constitution of *other* borders). Therefore, any drawing of a border line is *relative*; it is the *subject* that brings its inherent boundaries upon the object.

If, however, the border is dissolved through *reflection*, it appears not as relative at all in its *immediateness*. Here, it is interesting to note that not only is it possible for a subject to perceive *differences*; in addition, any organism's perception necessarily *overestimates* these differences due to an intrinsic *contrast enhancer*:

In every studied organism it has been found that sensory neurons typically send collaterals (axon branches) to interneurons that have an inhibitory effect on the neighboring sensory neurons. (…)The effect of a lateral inhibition circuit is to enhance the contrast between highly stimulated neurons and their nonstimulated neighbors, since the stimulated cells fire at a lower rate than their base rate. Some such arrangement in the retina is believed to figure in the perceptual effect known as 'Mach bands' (Churchland [8], p. 72f).

It is not possible in the strict sense to *perceive* a border. Therefore, when we speak of the border *between* two somethings, this cannot be meaningfully understood as any physical or perceptual noticeable border. After all, there is nothing spatially or temporally extended which separates the two somethings. In between the two somethings, nothing else is located than mere discontinuity, a border which has no physical dimension. The border is not a nothing, because the two somethings could not be separated by the subject, but at the same time, the border can have no physical dimension, and as such it seems to be nothing after all. The only resolution to this paradox is to assume that the border exists in a different *sense* than the physical sense.

In *what* sense can a border be said to exist? It cannot be perceived, and thus it has no physical dimension. On the other hand, it can and must be *thought*. Therefore, if we think of the border as physical, this can only be permissible if we conceive it *as if* it were physical, i.e., we think of two somethings that we perceive *as if* they were separated by a physical border. In general, we imagine a border rendered concrete as very narrow, e.g., as a dividing line, despite such a concrete representation going against the conceptual content of border as being of *infinitesimal* extension. Thus, such representation constitutes an ontological negation. However, such a negation is the only way we can think about the relation between two somethings *as if* their separation was outer, subject-external and not inherent and hidden in the subject itself.

We can think a something without immediately reflecting upon its borders. The border between two perceived somethings can only be said to be in a *double* simile sense, namely (i) by something unthinkable being thought as if it was thinkable; and (ii) by the thinkable, a subject-internal being, being thought as if it was a subject-external being. Hence, the border cannot have any immediate perceptual existence. In this regard, the border is a *nothing*; border is only a something qua subject-internal being.

In order to acknowledge two somethings as different, the subject must necessarily have a concept of difference which in turn presupposes a concept of border. Only by applying such a concept, can the subject itself acknowledge that there really are different somethings it has classified, *de facto* and objectively, as different prior to and independently from having any concept of border. Only then the *objective* difference can be reflected by the subject as a *subjective* difference as well.

This reflection necessarily happens by *applying* a concept of border which has a non-physical character of being. But this application can only occur by *projecting* the non-physical concept onto the *same* physical being that the subject projects the two somethings onto.

The dividing third something, which separates the two somethings, are actually the *thresholds* that *inherent* in the subject's own algorithm, and which accordingly never can appear visible for the subject *when* it applies them. Accordingly, paradoxes implied in characterizing determination of a physical border are products of *distorted epistemology*, i.e., of the subject's erroneous self-understanding of the character of being of its perceptions. This epistemology can only be corrected from a more advanced reflection, which still unavoidably has to make use of the concept of border, but which abstains from transferring it onto perceived being in any other way than in the form of simile.

Thus, it is an epistemological error to claim border to be subject-external being. This is a projection of the subject-internal being of the concept. Nevertheless, the subject indeed makes use of precisely this projection in all other than its most advanced reflections. Projection is without reflection about its origin, and this epistemological mistake is thus to be understood as a form of *traceless classification*.

5. Traceless vs. reflexive classification

When the subject processes information, it will depend upon the algorithm of the subject whether the information added by means of an internal classification is simultaneously accompanied by deletion of information from the lower logical type level. If this is the case, we denote the classification as *traceless*; if—in the opposite case—the lower, preceding information is maintained, we denote the classification as *reflexive*.

If we look at algorithms of *perception*, far most classifications are traceless, not reflexive. The most striking and radically instructing case here is *reception*, i.e., the initial informative transfiguration among the steps constituting perception as a whole. Typically, reception follows the *Weber-Fechner relation* where (potential) differences from the outside of the subject's border surface (as the skin) are received by the subject in a *logarithmic* manner when constituting its internal inputs (cf. Bateson [9]). If we, by measuring devices, are able to quantify the (pre)inputs before they cross the border surface, (pre)inputs with, e.g., measurement values **2, 4, 8, 16**, and **32**, indicated by boldfaces, will become differentiated at the receiving side of the border surface with the respective values 1, 2, 3, 4, and 5. This means that constitution of any quantitative (subtractive) difference in the reception requires *larger* (subtractive) differences on the outer incoming side of the border surface, as specified by the logarithm, and that uniform reception of the minimal (subtractive) difference requires uniform in-sending of *ratio* differences on the preceding side. Further, when comparing differences on the two sides, most differences detectable on the preceding side will *not* be detected on the side of reception. For example, **5**, **6**, and **7** will all be received as 2, due to not reaching the threshold of **8** received as 3. Hence, such differences on the preceding side become received through *traceless* classification and are eliminated in the further information processing involved in perception. In our conscious reflection over this, we easily distinguish between the involved ordered pairs, say (**5**, 2) and (**6**, 2) and thus perform a *reflexive* classification upon the traceless classification.

When investigating reception more carefully, it becomes revealed a rather intricate dialectics between the qualitative and quantitative aspects of information. Regarded from the horizon

of the subject in the act of reception, what is going on at the preceding side, if anything, is an inaccessible *Ding an sich* and does not represent any actual information. It is the act of reception which basically *constitutes* information, both in its quality (as given by the implied semantics of the receiving algorithm) and in the specific quantification of the quality. The reception *constitutes* information by discontinuation of *something* on the preceding side, so that this something can only qualify as *potential* information from an act of reflection *after* the information became actualized and constituted by the reception itself. Thus, it is not accurate to regard the quality with, e.g., a value **8** as the *same* quality which becomes constituted in reception with an input value 3. Ontologically, it is rather a *pre-quality*.

By reflection, traceless classification can be formulated into a certain implied syllogism, namely of the form "*a* is *c*; and *b* is *c*; ergo: *b* is *a*". For example: **5** is 2; **7** is 2; ergo: **7** is **5**. We name this form as *Erasmus syllogism*, after the notorious argument flung out by the character Erasmus in Ludvig Holberg's comedy *Erasmus Montanus* [10]: "A rock cannot fly; Mother Nille cannot fly; ergo, Mother Nille is a rock," where after Mother Nille bursts into crying. Trivially, the Erasmus syllogism is invalid by criteria of formal logic, contrary to a valid syllogism as "*a* is *c*; *b* is *a*; ergo: *b* is *c*."

A phenomenon *a* can be denoted *metaphor* for another phenomenon *b*, if phenomenon *a* stands in the same relation to a phenomenon *d* as phenomenon *b* stands to a phenomenon *e*. If we apply *c* to denote location at the left side of such a relation, the metaphor then rests upon the following inference: "*a* is *c*; *b* is *c*; ergo: *b* is a." Thus, we see that application of *a* as valid metaphor for *b* depends upon an inference having the form of Erasmus syllogism.

Gregory Bateson [9] used the term "syllogisms of grass" for Erasmus syllogisms and argued that such syllogisms and metaphors, despite their invalidity by formal logic, play a crucial role in nature, spanning from perception to more elaborate phenomena as poetry, humor, and religion. "[T]hese syllogisms are the very stuff of which natural history is made (…) all preverbal and non-verbal communication depends upon metaphor and/or syllogisms in grass (…) all verbal communication necessarily contains metaphor (…) metaphor is in fact the logic upon which the biological world has been built" (pp. 27–30). Bateson pointed out that even the syllogisms of formal logic presupposed *linguistic* classifications of entities as well as the categories of grammar themselves. Insofar such classifications are performed in traceless manners, cybernetics and epistemology ought to give much more emphasis to Erasmus syllogisms and metaphors. Interestingly, simple experiments in cognitive science by d'Andrade [11] and others have delivered support to this view by showing that many university students are not able to perform even simple syllogisms of *modus ponens* and *modus tollens* when the syllogisms are dressed in natural language, especially when the use of language appears confusing or emotionally loaded. Thus, human thinking also involves algorithms that are *not* valid by criteria of pure logic, operating at rather deep and opaque levels, and which should be accounted for in the very foundation of a broadened information science.

6. Manifolded differentiality of that which is

From the exploration of ontological characteristics of the border concept and some reflection on constitution of information in the act of reception, it should appear as a necessity to contemplate

that which is at different *levels* of being, depending upon which level of logical type it is classified at within the operations of the subject.

What we usually apprehend as being in the physical sense is that which in one way or another can be registered as immediately being from our *perception*.

It is embedded in the very nature of perception that regardless of its distinctions residing in the subject itself, the subject has to apprehend the somethings that it perceives as subject-external being. Since the classifying criterion is always hidden (but expressed) *in* the classification itself, it is generally so that the subject in its reflection must consider the level of being in which it operates (at least) *one step lower* than it really is. This has a dramatic consequence for the lowest level of classification since the subject necessarily must perform its classification as traceless and thus to project it as subject-external. It is only for an advanced reflection to discover this projection as a simile. Projection involves a *fundamental ontological distortion* since subject-internal differentiations are conceived as subject-external.

Thus, the distinction between physical and ideal being is really a distinction *within* subject-internal being. However, since the subject necessarily reflects its classification imperfectly, this must appear as a distinction between subject-external and subject-internal being. Hence, the truly fundamental ontological distinction between subject-external and subject-internal being *appears* for the subject itself *twisted* into a distinction between physical and ideal being, while objectively it is merely an internal distinction between classification levels of the subject.

Any understanding is structured hierarchically in the sense that it reflects forms of being at a certain level of classification and abstraction by means of thought forms that only exist at a *higher* level. Thus, different forms of understanding may be distinguished by: (i) the ontological level of their thought forms; and (ii) the ontological level of the forms of being that the thought forms are to understand.

We can define *illusion* as a subject's placement of a phenomenon at a *mistaken level of being*. Such an ontological mistake can only be demonstrated by means of *reflection* (by a different subject, or by the same subject) upon this placement. After such reflection, though the phenomenon is not *eliminated*, it is replaced at a *different* level. The subject's apprehension of the level of reception as subject-external, or of the separating third as a physical border are examples of such *necessary* illusions or distortions. Illusions are always due to traceless classification.

A reasonable definition of *substance* is *that and only that which is being at the perceptual level*. Thus, substance is perception as it immediately appears for the observing subject, i.e., as a projection onto the subject-external. From an advanced reflection, however, it was not possible to let the concept of border refer to such a low ontological level, and this is tantamount to the fact that neither (subjective) difference nor discontinuity be placed at such a low level. Thus, we can conclude that difference is not a substance despite that difference also is a being.

In contrast to substance, *quality* can be imagined at all levels of being. Also at the lowermost level of being, quality will distinguish itself from substance. A quality at this level is a substance beheld in the light of the difference reflection, i.e., being at the first level seen from something being at a higher level—whereby being at the first level by virtue of this elevated view no longer can be understood as (only) substance, despite the formal identity of extension.

Thus, the concept of quality at the lowest level of being is a concept-logical combination of the concepts of substance and difference.

The levels of being have a hierarchical order which means that something can only be at one level in the continuation of other preceding somethings having appeared at all underlying levels. Something can only become being through a stepwise transformation of something pre-existing which is only to be found at a lower level of being. We can define an *idea* (in contrast to substance) as any something which is to be found at a higher level of being than the physical level. Then, any instance of being is either an idea or a substance. Since all ideational being *ultimately* starts out from physical being, we can say that all ideas are based upon substance. For instance, the idea of a particular number is based upon a concrete, perceptual number notation, and any idea is *immediately* based upon one or plural ideas at lower levels of being. Thus, it is also *possible* that an idea is immediately based upon a substance. However, the idea of a particular number, for instance, is based upon ideas that separate Arabic numerals from other patterns, and this basis is not a substance according to our terminology.

Many ideas are also tied to substance in another way than the one given by retrospective connection. This occurs when a new idea arises by an earlier idea being *combined* with a substance, e.g., by an idea at level 100 arising through a combination of an idea at level 99 with a substance at level 1. This is the case for instance with the idea of a particular quality. We will therefore name such ideas *substantial ideas*.

It seems to be a characteristic of our *conscious* ideas that they have precisely such a substantial character. Even the most abstract thought seems to necessarily have a perceptual binding, i.e., that it imagines other ideas by tying them to, and letting them be *represented* by, something perceptual. In fact, it does not seem possible for us to consciously think anything at all without imagining it *as if* it was perceptual and extended in time and space. This involves that the subject in its thinking reaches back to the lowest level of being (feedback), i.e., that *the subject all the time takes the longest imaginable step backwards in order to be able to take yet another step forwards* in level of abstraction.

A suitable definition of *consciousness* can be the overall relations between the substantial ideas in the system of ideas. Thus, any idea within the system that is not substantial will escape consciousness, including necessarily the idea *of* a substantial idea and the idea that *makes* an idea substantial. Such ideas are unconscious because they are present at a meta-level until they are possibly made substantial themselves. In order for the subject to become aware ("conscious") of its own activity, a significant logical distance between that which thinks and that which is thought seems precisely to be what is required, and the substantialization of the ideas is precisely a mechanism which produces such a distance.

With necessity, elementary reflections on that which is has to be dualistic, dividing being into physical vs. mental, objective vs. subjective, object of thought vs. thought itself. However, from more advanced reflection, dualistic thinking implies two fundamental mistakes concerning the nature of being: It is *twisted* because it apprehends the differentiation of subject-internal being as a differentiation between subject-external and subject-internal being, which is due to its outward projection that is perceived; and it is *amputated* because it apprehends the differentiation of being as dual instead of enormous manifolds.

7. Extrapolated decomposition of that which is onto *three* differentiated ontological dimensions: processual-physical, algorithmic, and *transalgorithmic*

We define the *structure* of a system as the total set of relations *between* the algorithms of the system, i.e., the set that *orders* the algorithms by indicating their succession and reciprocal positioning. Structure must be understood as an *algorithm*, i.e., as the *structuring algorithm* which operates as a *meta-algorithm* in relation to the other algorithms of the system. Correspondingly, this meta-algorithm must be imagined and performed by a *meta-subject* internal in the system. Then, we can also imagine a system-internal input process from a firstly activated algorithm's position onto the structuring meta-algorithm, and an output process from this meta-algorithm onto the positioning of the other algorithms. This output process is to be understood as *differential movement* down to a lower level of being. Thus, it does not function as input for the first-order algorithms, just as the latter algorithms do not function as inputs for their output-processes.

Just like structure can be regarded as a meta-algorithm, the other algorithms can be regarded as substructures. It is common to consider a system as consisting of components and of the network of relations between the components. The structuring meta-algorithm, then, is an algorithmic formulation of this component external network of relations, while the other algorithms are component internal.

The structuring meta-algorithm, just like first-order algorithms, operates in an ideal universe. But, with the presence of meta-algorithms, the ideal universe is no longer only differentiated in different levels of being internally in each algorithm, but also *between* algorithms of different order. We can consider this as an ontological differentiation in *depth*, by which the ontological total universe manifests from a *ternary* differentiating complex. While that which was previously differentiated horizontally by a vertical differentiation, this vertical differentiation must now be seen in relation to a differentiation in depth. We will separate this depth universe from the algorithmic universe by denoting it *transalgorithmic*. A structuring meta-algorithm can only be described at a meta-level where the subordinate algorithms do not appear as algorithmic.

Meta-description is necessary in order to understand relations between algorithms of the same order (i.e., first-order description) insofar as these relations are themselves algorithmic, that is, determined by second- and higher order algorithms lying above or behind them. In order to understand relations between algorithms of the same order, then, these must be described from relations between algorithms of *different* order. In this respect, the algorithmic universe can only be understood from the transalgorithmic. Transalgorithmic differentiations are always present in dynamic system descriptions, because algorithms and processes can only be described as occurring in *particular* orders which are structurally determined. For this reason, such descriptions also include a transalgorithmic dimension.

Even though the relations between same-order algorithms immediately can only be understood from *one* structuring meta-algorithm, relations between plural structures must themselves be structured. Insofar as such relations occur, there must also exist meta-meta-algorithms, and so on. Thus, the transalgorithmic universe encompasses algorithms of different orders up to the highest thinkable order, i.e., up to the transalgorithmic (depth) level above the topmost structures that we can think of as interdependent.

We can distinguish between the following types of meta-algorithms: (i) *structuring* algorithms (effecting relations *between* algorithms); (ii) *ingoing* algorithms (effecting relations *internal* in an algorithm); and (iii) *outgoing* algorithms (effecting neither algorithms themselves nor relations between them).

Meta-algorithms that effect backward on algorithms that the meta-algorithm receives its input from, immediately or mediately, we will denote *re-acting meta-algorithms*. These constitute a subgroup of ingoing meta-algorithms, in contrast to the other ingoing meta-algorithms which we will denote *pre-acting meta-algorithms*. Process, algorithm, and structure are to be comprehended as *relative* concepts. In a *combined* system description, this relativity manifests by first-order algorithms acquiring a double nature as algorithmic vs. processual, depending on, respectively, whether they are regarded in relation to processes at the lowest level of being in the description or in relation to second-order algorithms.

8. Ontological unfoldment into the complete nexus of causality types

We have clarified how information can be understood as a (objective) difference that makes a difference, i.e., as that difference which brings about another difference. More precisely, the relation between the two differences consists of the fact that if the first difference takes place, then the other difference *must* also take place. We *define causal relation* as this relation between the two differences. Further, we define the *first* difference as *cause* and the *second* difference as *effect*. Consequently, *information* is tantamount with the relatum in a causal relation that is termed "*cause*." Accordingly, information exists if and only if (at least) one causal relation exists.

This does not imply that "information" with respect to the *intension* of the term (as semantically opposed to the *extension* of the term) is identical with "cause." The *extensionally* same (first) relatum in a causal relation appears *immediately* as "information," while it appears also as "cause" only *after* a subject's *reflection* upon the relation. The subject cannot *immediately* perceive the (second) difference which the (first) relatum has brought upon the subject, notwithstanding that this difference must be *implicitly* present (by having *made* the relatum into information).

Thus, different from, e.g., the contention of Bateson [9] (p. 51), there cannot be cause and effect without existence of information. Even plain descriptions of a system by means of physical mechanics must *de facto* operate with distinctions which with necessity issue from informative transfigurations, and algorithmic causality must thus be implicitly or tacitly present also in such descriptions.

This means that an adequate concept of causality must be sufficiently abstract, universal, and elementary to reside inherently and basically *enfolded* in the *qualitative concept* of information as such, to become *unfolded* and *established* by a deep and rigorous philosophical *back-reflection*, hitting the mark of the enfolded quality of causality. This is far from any trivial statement or any straight-forward achievement.

Standard logics operates with a concept of *material implication*, from Frege and Russell onward, as a certain *truth function* of a first variable p and a second variable q, where this function per

definition is untrue if the (binary) truth value of p is true and the truth value of q is untrue, while the function is true for the three other pairs of truth values of p and q. This concept of material implication, whatever its usefulness in mathematics and informatics, leads to plural propositions becoming judged as true, despite *contradicting* intuitive notions of causality. As examples, consider, e.g., (i) p => (q =>p); (ii) –p => (p =>q); (iii) (p =>q) v (q =>p). Rather obviously, the definition of material implication has severe shortcomings as: (i) the definition is *too broad* to hit the mark of causality as enfolded in information as such; (ii) the definition presupposes that the truth functions of p and q can be established in mutual *independency before* they become related and compared, in *contradiction* to the informational concept of causality which *unfolds* the relata of cause vs. effect; (iii) the definition presupposes *preceding* establishments of truth functions of p and q while *ignoring* any role of causality in the very *establishment* of these truth functions.

The limitations of material implication have been sought surmounted in various developments of modal logic which introduced a concept of *strict implication* where q *must* be true if p is true, and also introduced related possible-world semantics with necessity and possibility operators. These attempts imply somewhat ontological *differentiations* within the universe of imagined truth values, and between those constellations where p and q *necessarily* must coincide as true vs. where they coincide as true *without* this being due to strict implication.

We regard these attempts as still restricted, while fruitfully pointing in two adequate *directions*, namely with respect to (i) seeking toward hitting the mark of causality as it is *de facto* enfolded in information as such, and operating at an intuitive, subconscious level with a *deeper* ontological foundation than the assumed free-standing toy universe of formal logic; and (ii) anchoring and relating causality of different types in a strictly and exhaustively differentiated *ontology*.

Our treatise [1], pp. 113–194, sought to reestablish causality theory as a whole from basic fulfillment of aspects (i) and (ii). With respect to aspect (i), the most basic challenge was to theoretically adequately back-reflect the category of "causality," universally *already* existing as tacitly operative inside all information in and of nature, including a subconscious category acting as crucial constituent in informative reflection by human thinking inside an *imagined* free-standing thought universe (as a certain subsystem, not *only* imagined, of being).

The next basic challenge was to theoretically grasp and exhibit how this de facto *universal* category of "causality" became unfolded into the two most basic *types* of causality, namely *projective causality*, with necessity implied in *any* constitution and processing of information, as already indicated, and *formal logical causality*, with necessity indicating the most universal and basic de facto *formalization* of causality. We exhibited the make-up of formal logical causality from a *deeper* formal relation than material implication or strict implication, more specifically as implied, in a specified formal manner, in *any* relation between classification and elements involved in constitution of information.

With respect to aspect (ii), we presented a rigorous unfoldment of the whole *nexus* of possible causality types as *anchored* in the universal concept of causality, while at the same time, successively and logically *unfolding* inside the framework of a concisely differentiated *universal ontology* by the three dimensions: transalgorithmic, algorithmic, and processual-physical (3 + 1D). Inside the page limitations of the present text, we must restrict ourselves to a somewhat cryptic short-hand description of the systematic differential unfoldment into key features of the different fundamental causality types (complementary connected as illustrated by **Figure 1**):

Formal logical causality: this category is universal for all thinkable information, i.e., for *any* information flow in *any* described information matrix, i.e., in the imagination of a pure and free-standing logical universe. Formal logical causality is deduced in its precise form from specified classification logic between the thinkable classes and elements from ontology differentiated vertically. All other causality types are subtypes and "clothes" of this abstract one, which is what qualify them as causality types. They unfold from specified additions of different *similes*, *necessary* in any dynamic system description, explicitly stated or not.

Algorithmic causality: this is the causal relation from an input-value to an output-value inside the algorithm.
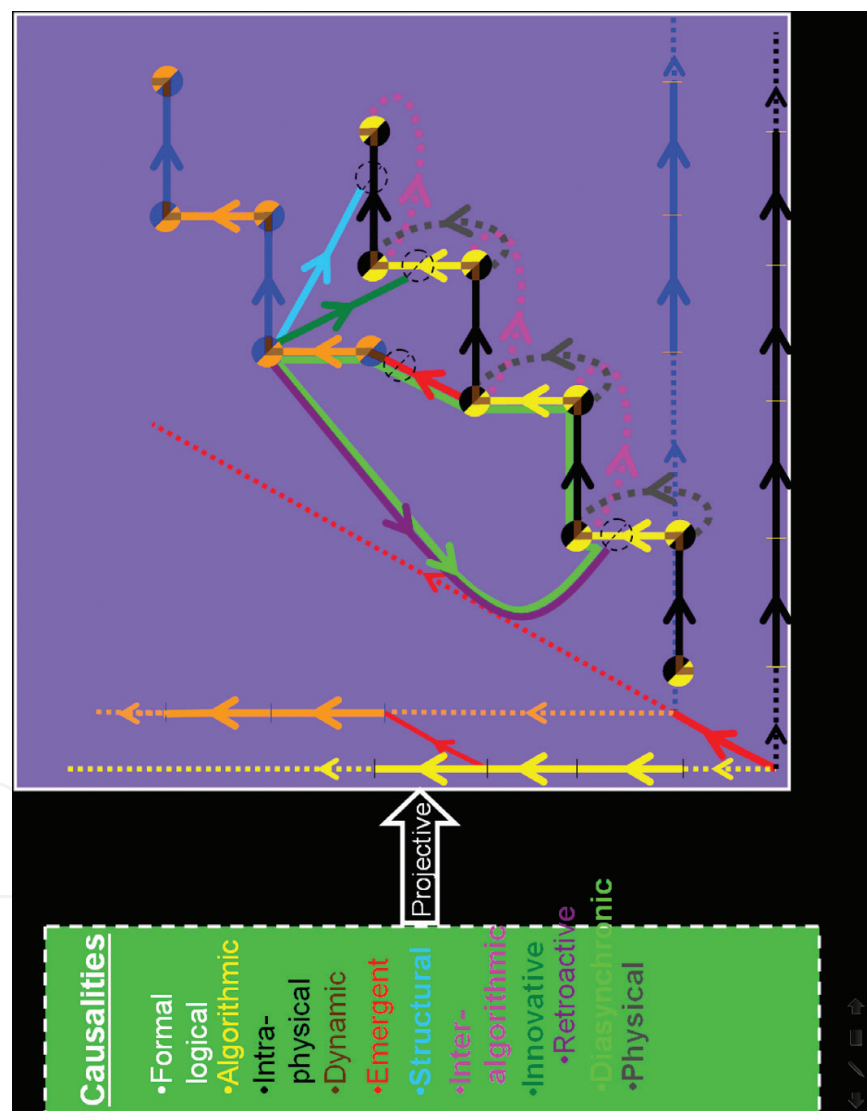

Figure 1. Illustration of the causality nexus anchored in the three dimensions physical (horizontal in black; 3 + 1D compressed as 1D time), algorithmic (vertical in yellow), and transalgorithmic (depth in red). Description of first-order alternates between process (black) and transfiguration (yellow), second-order between blue and orange. Higher orders activate from emergence (red) and unfold as structural change in process (light blue) or innovative change in transfiguration (dark green), with the possibility of the last being retroactive (purple). Whatever degree of order and systemic complexity, the illustrated conglomerate of causality types and arrows constitutes a completed nexus of information flows.

Intra-physical causality: this is the causal relation from start point to end point of a process.

Dynamic causality: this is the causal relation with the two subclasses: a) from end point of a process to start point in an algorithm; b) from end point of an algorithm to start point in a process.

Projective causality: this is the causal relation from the meta-subject to the thought object as a whole, the potential inner classifications and causal relations being actualized in this projection (including formal logical causality). In **Figure 1**, the arrow of projective causality originates from the field (in green) of an enfolded nexus of causality types, denoting a segment *inside* the thinking meta-subject that makes the description, and manifests as the field (in indigo) of an unfolded nexus of causality types. The frame of the originating field is marked with broken white lines in order to distinguish its ontological status from the nexus projected into the derived field.

Structural causality: this is the meta-algorithmic causality relation directing the process-output from an algorithm to the process-input for another algorithm and hence positioning all algorithms in a structure.

Inter-algorithmic causality: this is the causal relation from an algorithmic output to the algorithmic input for another algorithm, hence ignoring the intermediary physical process by a projection to the vertical algorithmic axis.

Emergent causality: this is the causal relation from an algorithm to a meta-algorithm.

Innovative causality: this is the causal relation from a meta-algorithm to a first-order algorithm. An important subtype of innovative causality is the *retroactive* causal relation from a meta-algorithm to a first-order algorithm earlier connected to the meta-algorithm by emergent causality.

Diasynchronic causality: this is the causal relation made up by a *circuit* of algorithmic, physical, intraphysical, dynamic, projective, emergent, structural, and retroactive innovative causality.

Physical causality: this is the physical relation from a process output to the process input of the next process; hence, ignoring all intermediary algorithmic and transalgorithmic transfigurations by a projection from the vertical axis or the depth axis to the horizontal axis.

It follows from the illustration of the causality nexus in **Figure 1**, that, e.g., the conventional notion of *physical* causality is far from constituting the *most* fundamental causality type. It is also far from any *trivial* causality types, due to its condensation of many involved causality paths through plural shortcuts and similes. Thus, it follows from strict and consistent philosophical-ontological reflection on the nexus of causality types which *make up* the reality of cosmic wide information, that ideas about cosmos as *fundamentally* physical or—even worse—*only* physical, are basically *radically amputated and illusionary* as judged by strict standards of scientifically informed and informing philosophy/meta-science.

From these fundamental causality types, various *elaborated* causality types constituted by combinations of fundamental causality types were exhibited by Johansen [1] (ch. 3.2); among these are: chance causality, probability causality, stochastic causality, intentional causality, selective causality, and imagined causality. Thus, more elaborated and epistemologically refined causality types, crucial in human and social systems, were understood *inside* the causality nexus

anchored in the three ontological dimensions (see Johansen [12, 13] for specified applications of this causality theory).

9. The role of semantics and subject with respect to some recent developments of "computation"

The concept of algorithm should be understood at a sufficiently high level of abstraction to be consistent with the most abstract and deepest concept of causality, in order to provide differential philosophy with some robustness against progresses in information science. Thus, the concept of algorithm should not be restricted to the ontology underlying the conventional binary informatics of UTM. Later on, informatics has experienced significant extensions of Turing informatics, in form of David Deutsch's triadic qubit informatics (quantum computation), and the further development to Rowlands' (with Diaz) quantum holographic informatics entailed in his highly ambitious opus magnum *Zero to Infinity. Foundations of Physics* [14] which presented a universal theory of philosophy into science named *Nilpotent Universal Computational Rewrite System* (NUCRS). Rowlands' theory significantly upgrades the *semantic*—and thus *qualitative*—aspect of informatics by providing "a semantic model of computation" as "Nature's Rules" (ibid.: 557). The same was the case for David Bohm's sketch of a second-order informatics based on an elementary unit consisting of a 2x2 matrix with inherent feedback. Accordingly, Bohm often *defined* "meaning" as information about information (e.g., in [15]).

Mikhail Ignatyev, referred to as "the father of robotics" in Russia, pioneered the field of robotics from 1963 on [16] and i.a. constructed the first submarine robots. Later on, Ignatyev [17–19] developed a universal *linguo-combinatorial* cybernetics which placed and recognized semantics in the very heart and foundation of cybernetic theory (cf. [18], p. 18f). Further, this departing role was given to semantics in a quite elaborated sense, namely to natural language understood as the universal language operating in the human mind/brain, more abstract than its monoplural manifestations into the specific languages of the different mother-tongues (cf. [17], comment to his Figure 1). In its mathematical core, Ignatyev's universal theory consists of a certain set of differential equations, qualitatively based on a binary distinction between signifier and signified, and anchored in quantitative description of systems by means of *Pascal's triangle* which manifests the formula for "the basic law of cybernetics, informatics and synergetics for complex systems" [17]. Ignatyev's application of this theory to nanorobotics (cf. [19], p. 674) led to the discovery of an important *connection* between Pascal complexity (understood as the values of the involved "arbitrary coefficients" in a row of Pascal's triangle) in the *algorithmic* composition of a nanorobot vs. the Pascal complexity inherent in the *material* substances making up the nanorobot. Interpreted in the framework of differential ontology, this connection, argued by Ignatyev, indicates that certain *quantitative information laws*, not previously discovered, are enfolded in system description characteristics when two (or more) systems of different levels (such as of the two dimensional-pairs (meta-algorithmic, algorithmic) and (algorithmic, time-physical)) are adequately combined in a unified description. This may have far-reaching implications with respect to understanding of ontological architecture

in general, especially with respect to quantitative laws constraining or directing information flows between different levels in highly complex systems involving *intelligence* of different degree of complexity and operating at different systemic levels. It is significant that the cybernetic theory of Ignatyev operates at (and from) a level of abstraction where *mind* and intelligence are not excluded from the system, or regarded as more or less secondary epistructures derived or emerging from material underpinnings.

According to Ignatyev, linguo-combinatorial cybernetics has proved capable of developing exhaustive "models of all the known chemical elements, their isotopes, and molecular structures" (cf. [19], p. 673). Thus, Ignatyev refers to the establishing of "cybernetic physics" ([18], p. 20) and states such cybernetic physics/chemistry as *superior* to the conventional method of linear combination of atomic orbitals, because "the linguo-combinatorial method considers all the combinations of interaction" ([19], p. 673).

UTM considers the string/tape as only carrying binary information. Here, the substantial representation of the distinction does not matter as such (say 0 vs. 1, black vs. white, electron present vs. absent), nor the substance of the tape carrying the distinction. Some substances are more adequate than others in order for UTM to function fast and reliably, while they are irrelevant for the concept of UTM which implies a radical split between the operating machine and the substance it operates on. Contrary to this, in Ignatyev's robotics, the substance of the robot *does* matter, namely with respect to its internal informational characteristic as specifically described by its Pascal complexity by means of Ignatyev's cybernetic physics. The "control unit" (analogous to the operating machine part in UTM) of Ignatyev's robot *employs* the Pascal complexity of the material substance by *extracting* information from the substance into *itself*, as well as into establishment of feedback loops of tuning and calibration *between* the control unit and the substance. Other things equal, the higher the Pascal complexity of the material substance, the more advanced nanorobots can be constructed. Hence, nanotechnological development of novel substances as, e.g., certain carbon isotopes, characterized by higher inherent Pascal complexity, becomes crucial for development of more advanced nanorobots. Ignatyev's robotics indicates rather paradigmatic implications for information science, implying more intimate and interactive relations between the operating and the operated part than in UTM. In some aspects, this relation may seem ontologically more similar to human claims of possession phenomena than to UTM. Walk-in from an external entity takes advantage of the complexity of the human mind/brain in order to expand its field of operation by implementing itself as a control unit for the human mind/brain system. In analogy to Ignatyev's material substance, higher degree of freedom in the targeted system, as indicated by the "arbitrary coefficients" of its row in Pascal's triangle, does not restrict, but amplify the range of control performed by the targeting control unit.

It was stated in our qualitative concept of information that there is no such thing as information without the implied presence of a *subject*. The cybernetic foundation by Ignatyev points in the same direction. This is also in agreement with Rowlands who establishes his theory with a basic universality not at all *excluding* subjects or the field of psychology (cf. [14], p. 598).

The mathematician-physicist Diego L. Rapoport has provided crucial contributions to several disciplines (as physics, genetics, informatics, and cybernetics) by means of a universal *Klein-bottle* paradigm (cf. i.a. [20–22]) which ontologically surmounts the Cartesian cut by basic inclusion

of the subject (see Rosen [23] for many basic philosophical contemplations of the significance of the Klein-bottle). Rapoport [22] analyzes how already the *photon* has to be treated from the subjective-objective *dynamics* constituted by the ontological figure of the Klein-bottle. Consistent with this, the treatment in Rapoport [20] starts out from second-order cybernetics, *involving* the subject, and from ontological recognition of perceptual *depth* in the sense of Merleau-Ponty, by Rapoport interpreted as the dimension of the Klein-bottle reentering itself and related to the *transalgorithmic* dimension in differential ontology. Rapoport developed Klein-bottle logics, anchored in the paradoxical logic initiated by A. Stern [24], where Boolean logic manifests as an intermediary subcase. Rapoport's development of Klein-bottle logics and informatics is intimately linked not only to quantum mechanics and torsion physics, but also to cognition. Such linkage is indicated by his discovery of a *logical time operator* at second quantization coinciding with a classical difference yielding non-null torsion in cognitive space. Rapoport introduces the *denktor* to connect cognitive space to superposition and vector space with bras and kets, and the *logical potential* carrying *logical energy* to connect basic cognitive dynamics and the quantization rule of Bohr-Sommerfeld. This indicates how concepts related to the *subject* are given basic recognition in the theory of Rapoport. In Rapoport's theory of time, statements of quantum physics become converted into logical statements, especially by means of the Hadamard gate in quantum computation. His time operator "*is a primeval distinction between cognitive states in (-) Matrix Logic as its action amounts to compute the difference between these states. As a geometric action, Time is a ninety degrees rotation in the 2-plane of all cognitive states*" [22]. This indicates the general relevance of Rapoport's theory of time for cybernetics of complex systems, and even more so since Rapoport "*relates Time to intention, control, will and the appearance of life*" (ibid.). More specifically, in Rapoport's highly elaborated analysis, *logophysical* time is a projection of a vortex structure to the cognitive plane that is further associated to will and intention.

In order to fully integrate the concept of subject into information science, an adequate concept of *emotion* must also be introduced and integrated, or at least related, as with necessity tied to the concept of (an emphatic) subject. We stated, in connection to the qualitative concept of information, that there is no such thing as information without tacitly implied emotion. As a simple illustration: a prototypic case of something considered "rock-hard" and undeniable real, is a heavy stone falling down on one's toe, inducing strong emotional pain. Hence, the quality of emotion is tacitly *implied* in the notion of information as really real, and at the most basic level not *opposed* to such a notion. When Turing established an abstract, universal, and elementary concept of "information" and "computation," this required, among other skills, an extraordinary act of *abstraction* and *detrivialization* of the ordinary notions of "somethings" experienced in daily as well as scientific life. Contrary to common opinion, we regard the establishment of an abstract, universal, and elementary concept of "emotion" as requiring an *even more* difficult act of abstraction and detrivialization, and bordering to the very *limits* of meta-scientific inquiry. It leads too far to explore this demanding topic in the present text, but we will state as a postulate that the *exodos* of emotion *as such* from theories of informatics and computer science represents a theoretical shortcoming of rather basic nature, having possibly fatal implications for AI developments consistent with a human interest. As example, if one considers a transhumanist goal of transporting "consciousness" into a substantial carrier external to the human body, how is one to scientifically decide whether this "copy" *feels* the same—or anything at all—if the scientific theory does not include an adequate *concept* of emotion?

10. Unfoldment into number theory

With respect to the concept of border, we clarified that the border itself cannot have any physical extension, but is *virtual* in relation to the environment, and is an inherent category of the subject *projected* into the environment. This projection is the only way to constitute the input as a real input for the subject to process, because it is the only way borders can be made and processed, and the only way for information to exist. Hence, it has to be universally true *both* that the subject projects differences downward the ontological hierarchy *and* that this projection is a necessary operator to constitute information. This is a universal basic paradox enfolded in the very quality of information, and hence in the general make-up of the universe. However, this is not an unresolved paradox, but the way the universe works and walks. With necessity, the basic unit of information processing must have this double nature, both projecting an algorithm to one step below its real existence, and *using* this projection to reach the next higher step in its successive processing. We can imagine this double nature of the walking thought as having to step one step back in the ontological staircase with one "thought foot," the other foot still standing on its original step and regarding the first foot as not being its own, in order to in the next run discontinuously jumping to the step above, the first foot leaping two steps, the second only one. Thereafter, this procedure has to be repeated for every further walk by thought.

The *Fibonacci algorithm*, constituting the Fibonacci series inside the set of natural numbers, proceeds from a number B in the series to the next number C, by moving back from B to the preceding number A and then moving forward by adding A and B into the proceeding number C. This is equivalent to stepping one step back with one foot, and then jumping with both foots to the step above. Hence, the form of this algorithm is *exactly the same* as the pattern described above as the abstract, universal, and elementary form of border constitution and information processing. This must mean that the Fibonacci algorithm expresses the *quantitative* aspect with necessity involved in *all* information processing of nature, because it is implied in the universal *quality* of the very category of information. Whether and how this fact *appears* at a manifest level for human observation is quite another question.

The Fibonacci algorithm constitutes the most abstract, universal, and elementary ontological *bridge* between the qualitative and quantitative aspects of information. When we express the Fibonacci algorithm into the Fibonacci series, the formulation takes place *inside* an *already* established ontological domain, namely the number landscape made up of the set of natural numbers. This set is *not* constituted by the Fibonacci algorithm itself in conventional number theory. However, the claimed result from our consistent reflection upon the quality of *border* as implied in the very quality of the information concept, was that the Fibonacci algorithm, contemplated at *the deepest* and *most abstract* ontological level, is implied as the constitutional *tie* between the qualitative and quantitative aspect of information *as such*. If true, this implicates that even the ontological domain of *numbers*, presented primarily as the set of *natural* numbers, should be theoretically possible to establish by consistent unfoldment of the Fibonacci algorithm as contemplated in the ontological "primordial" sense.

Our treatise *Fibonacci generation of natural numbers and of prime numbers* [25] established the complete and unique set of natural numbers as a *generative result* from strict, systematic unfoldment of the primordial Fibonacci algorithm through successive alternation between

Fibonacci constitution of ordinal numbers vs. cardinal numbers, in our terminology specified as *perplex numbers* (in some relatedness to Chandler [26]) vs. *size numbers*. The set of natural numbers became generated in strict and unique succession between so-called *Fibonacci atoms* and *Fibonacci molecules*, exposing the hidden generator *resulting* in formal coincidence with the theorem of Zeckendorf [27, 28]. Also, the treatise presented some novel mathematical results more "technically" (e.g., [25], Figure 2; cf. also Johansen [29]), and some deeper considerations with respect to ontological placement and refinement of the four basic operators of arithmetic, as well as with respect to reestablishment of the connection between number theory and geometry at a more intimate level in the very foundations of mathematics. The significance of this last deep-connection had earlier been recognized in our deduction of a complete and unique pattern of prime numbers, with the treatise of Johansen [30] representing the main publication; see also Johansen [31–33]. See Strand [34] for mathematical reformulation of our deduction by means of *group theory*, as well as further reformulation by means of *genonumbers*. See appendix in Johansen [33] for the publication of a software program confirming the correctness of the mathematical deduction, copyrighted by JM Strand and SE Johansen, initially demonstrated at the end of our lecture Nov. 24, 2010 at the *International Conference on Mathematical Sciences* at University of Bolu, Turkey.

Conventionally, the significance of the Fibonacci algorithm in number theory had been basically restricted to exposing the Fibonacci series as a *subset* of natural numbers, with various interesting mathematical properties, while at the same time, the significance of the Fibonacci series in the make-up of a plethora of *natural systems* had been (and still is) steadily growing. Our treatise [25] intended a *Copernican turn* for number theory in its very foundation, because the set of natural numbers was *not* taken as established *before* the definition of the Fibonacci series, but strictly and systematically generated from the most *abstract, primordial,* and *pre-numbering* formulation of the Fibonacci algorithm, due to the deep-significance of this algorithm as implied in the very *concept* of information as such. (The fact that the Fibonacci series of natural numbers also *after* this refoundation still remains as a subset of natural numbers is a trivial statement, without any relevance to the deeper and crucial issue of whether the *set* of natural numbers should be adequately understood as an *epistructure* generated from successive unfoldment of the Fibonacci algorithm in the deeper, *pre-numbered* sense.) This *radical inversion* of the conventional relation between the set of natural numbers vs. the Fibonacci algorithm, pretends a *paradigmatic* revolution in the sense of Kuhn [35]. This Copernican turn in the establishment of number theory may also suggest a deeper and rather direct scientific approach to explain why and how Fibonacci series are that fundamental in characteristics of *natural* systems.

The treatise also exhibits how Pascal's triangle becomes *generated* by (further) unfoldment of the Fibonacci algorithm inside number theory, including the slightly amputated version of Pascal's triangle which constitutes the foundation for Ignatyev's linguo-combinatorial informatics, cybernetics, and robotics (cf. [25], Tables 5–9; and also Johansen [36]). Thus, it is possible to scientifically address linguo-combinatorial informatics from a *deeper* foundation of qualitative informatics represented by differential ontology and epistemology.

Without beforehand having established our qualitative concept of information, involving the qualitative concept of border, with sufficient rigor, inside our differential ontology (including differential epistemology), it would have appeared as hubris, as well as rather strange, to

attempt to reconstitute the foundations of number theory (as well as its basic interrelatedness to geometry) from a philosophical ontology, or to anticipate any novel results inside "pure" mathematics becoming possible to achieve from consistent unfoldment of such ontology. Thus, our mathematical achievements were *crucially inspired* and *catalyzed* by certain key results established as enfolding from our *qualitative* informatics inside our differential ontology and epistemology. Next, regarded in basic retrospect, these mathematical achievements, especially the systematic refoundation of number theory from strict unfoldment of the deeper Fibonacci algorithm, provide crucial *support* to the foundations of our philosophical informatics and differential ontology as being able to deeply *hit the mark* of key issues in philosophical ontology and related qualitative informatics. When it proves able to even catalyze number theory, the so-called *queen* of mathematics, in key aspects by paradigmatic inversion, lifting, and extension, this provides a strong indication that it may show able, through later applications and developments, to also catalyze *other* formal disciplines, including informatics, as well as disciplines of natural as well as social science.

With respect to influences from our qualitative informatics and differential ontology into substantial achievements inside *formal* disciplines of logics and informatics, we refer primarily to works and references by Rapoport [20–22], and more generally to the references by Rowlands [14] (p. 530, p. 550). With respect to consistency with achievements into *informational geometry* and *particle physics*, we also refer to works and references by Erik Trell [37–39]. With respect to achievements into *anthropology*, we refer primarily to works and references by Fyhn [40], Follo [41], and E. Røyrvik [42].

R.M. Santilli initiated the discipline of *hadronic mechanics* which claims to have accomplished a radical lifting and broadening of conventional quantum mechanics and relativity theory [43], as well of related mathematics [44], and stretching into related liftings of chemistry leading to "new clean energies" [45], as well as into expansions of theoretical biology [46]. We refer to Gandzha et al. [47] for an introductory overview of these achievements, and to Santilli [48] for the most extensive presentation of these theoretical developments. Johansen [49] argued basic consistency between differential ontology and the ontology underlying hadronic mechanics and mathematics. Quartieri [50] presented some contemplations concerning implications of this consistency for system theory. Johansen [51] presented some discussion of achievements in hadronic geometry and biology as interpreted from differential ontology, as well as some sketch of further extension into hadronic psychology. The number theorist L. Schadeck [52] has referred to our consideration of the Fibonacci algorithm as the universal-elementary "reality atom," as the "Johansen-Fibonacci paradigm," and has also suggested the radical possibility of extending UTM into "Hadronic Turing Machines" by incorporation of isoduality into the basic unit of informatics.

11. Related works in philosophy of science

In quite profound respects, Rapoport's achievements were originally inspired by, as well as applying, paradigmatic and theoretic elements from *Spencer-Brown's* remarkable *Laws of Form* [53] which departed from the mark of "*distinction*" as its primeval key concept. There occur significant resemblances between Spencer-Brown's work and our *Outline of Differential Epistemology* [1] (with its first edition published in 1991, authored without knowing *Laws of*

Form), not at least with respect to the concept of *difference* playing much the same role in our work as *distinction* did in the work of Spencer-Brown. Interestingly, Spencer-Brown was hinting toward mathematical results from our own qualitative informatics when he, somewhat cryptically, wrote about the "beautiful manifestation of the form, whereby you break up the distinction and it turns into a Fibonacci sequence" and "You break up truth and you get Fibonacci."

Also the works of the late *David Bohm* exhibit some striking resemblances to our own differential ontology, among which, in this context, we will briefly mention a few. Bohm [54] represented his most extensive work presenting and explaining theoretical and mathematical details of quantum mechanics from a deeper ontological interpretation. The work *Science, Order, and Creativity* [55] presented an extensive ontological architecture with *three dimensions of order*: the *successive* one (change, change of change, change of change of change, etc.), the *generative* one (change of successive degree of order, change of change of successive degree of order, etc.) and the *superenfolded* one (change of degree of generative order, change of change of degree of generative order, etc.). Bohm's concept of *soma-significance* indicated a general conception of dual unity of algorithmic vs. physical being, and he analyzed, related to his critique of the Copenhagen interpretation, the categories of randomness and probability as operators *inside* a framework of causality. Bohm was highly influenced by Hegel's *Wissenschaft der Logik* [56], with related emphasis on analyses of relations of *conceptual logic*, and with the twin concept of *enfoldment/unfoldment* of implicated orders playing a general key role in his scientific approaches.

In our treatise Johansen [57], we presented the foundation of a novel economic theory having some basic similarities, as well as some basic differences, to the complex theory of capital created by the late Karl Marx [58]. Marx' economic theory was highly influenced by Hegel's conceptual logic, and attempted to systematically unfold concepts and relations, qualitative as well as quantitative ones, considered already enfolded, *in nuce*, in the economic category of (the capitalistically produced) *commodity*. In contrast to Marx, our own economic theory was developed inside a certain *differentiated* economic ontology. Our development of the concept of *labor time content* (*Wertgrösse/Wert*), the key concept in second-order economics, would have been theoretically impossible (in a plethora of qualitative and quantitative aspects) to achieve from a simplistic *binary* ontology which would consider this concept to either exist or not exist in the real economy.

Our later development of a *universal* differential ontology was inspired by the fruitfulness of differential ontology in order to reach novel and significant results inside the specialized discipline of (second-order) economic theory.

As further suggested by our later results into the field of mathematics, it seems likely that aspects of differential ontology hold the potential to create novel and significant results also when unfolded into other fields. With respect to informatics, our prediction is that *Fibonacci informatics*, anchored deeply in differential ontology, will have the potential to blossom.

12. Some main conclusive points

From the rather compact presentation and reasoning above, we may extract some main theoretical points:

i. Starting out with an adequate *qualitative concept of information*, it is possible to systematically develop a certain universal *philosophical ontology* by successively unfolding categories that already reside as tacitly enfolded inside this qualitative concept.

ii. This philosophical ontology implies *differentiation into two complementary dimensions*: one *processual-physical* (compression of conventional 3 + 1D) and one *algorithmic*, where the last one holds the upper hand. All systemic descriptions and explanations involve de facto *alternation* between these two dimensions.

iii. Further, this philosophical ontology implies differentiation into a *third complementary dimension*, the *transalgorithmic* one, in the overall composition of its architecture. The relation between the transalgorithmic and the algorithmic dimension is quite analogous to the relation between the algorithmic and the processual-physical dimension. *Combined* systemic descriptions and explanations involve de facto short-cut synthesis (conflation) of these two relations.

iv. This philosophical ontology is highly *differentiated* into said dimensions as well as into intradimensional *ontological levels*. Due to this circumstance, as well as due to the key role of the category "difference" in the constitution of the qualitative concept of information, we can denote this philosophical ontology as *informational differential ontology* (not to be confused with the term "differential ontology" in some French and not that rigorous philosophy). The architecture of this differential ontology surmounts dualistic (and monistic) ontologies by being more richly (and strictly) differentiated, while at the same time exposing elements of dualistic/binary conflation as necessary intermediaries inside its architecture.

v. *Anchored* in this differentiated ontological architecture, it is possible to establish a novel and basically complete theory of the *nexus of causality types*. This involves differentiation into specified *basic causality types*, where *physical causality* manifests as the least basic among these. From the basic causality types, various *elaborated causality types* can be exhibited as composed from various combinations of the basic ones. The more elaborated ones will constitute the "head" of *differential epistemology* from the universal "body" of differential ontology constituted already by the basic ones. From this, the cosmic web of informational relations appears, theoretically, as a manifestation of the deeper nexus of causality operators, and in this sense as categorically *closed* with respect to philosophical imagination.

vi. The very *concept of "causality"* in its most elementary, abstract, and universal sense is sought established as already implied in the *qualitative concept of information*. This intends to give the concept of causality a deeper and more adequate ontological foundation than in notions of "material implication," as well as "strict implication," implying special emphasis to and refoundation of the two deepest causality types, namely "projective causality" and "formal causality."

vii. The qualitative concept of information, with special emphasis on strict reflection upon the implied key category of "border," is argued to involve a constitutional logic that with necessity involves *projective causality* and shows to be analogous to the *Fibonacci*

algorithm, which thus becomes regarded as the universal *constitutional bridge* between the qualitative and quantitative aspects of nature. This view has become supported by a reconstitution of number theory, presented by the author, were the field of natural numbers manifests from systematic unfoldment of the Fibonacci algorithm as regarded in a deeper and basically qualitative sense.

viii. The possible adequacy and fruitfulness of the presented informational differential ontology, are also shortly argued to be supported by some more recent developments in philosophy, logics, cybernetics, and physics, suggesting possible positive applications of said ontology also into the field of information science. It is also suggested that stronger theoretical focus into aspects of *semantics* and even more into addressing the very category of *emotion*, might show fruitful for further progress in information science as aligned with a human interest.

Conflict of interest

The author declares no conflict of interest connected to the publication.

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