Thinking, future and ‘non’-causality. On life and consciousness in the complex plane

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Abstract: This paper challenges the perspective of modern homo oeconomicus towards self-interest and egoism. This old perspective relays upon basic causal and deterministic assumptions derived from (neuro)biological and philosophical approaches which are incompatible with the non-linear nature of and the self-organising capability of living systems. We therefore propose a new concept, which explores the two dimensions of information: a causal and a ‘non’-causal dimension. It is shown in this contribution, how the ‘non’-causal dimension deals with the future, by following a mathematically imaginary dimension, and thereby covering rich phenomenal experiences. We propose a novel system model, which recognises both, the real world and the imagined future world. This model explains the appearance of the stream of human consciousness, enabling our development by enfolding of our potentialities. This paper provides the fundament for a new interpretation of neurobiological concepts about our self-understanding by covering valued real and imaginary dimensions.

Keywords: anthropology; biophysics; causal and ‘non’-causal information; computational and systems biology; consciousness; dogmatism in quantum physics; evolutionary biology; future; ‘imaginary’ truth value; informational growth of living systems; neuroscience; thinking.

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Biographical notes: Gerhard Luhn earned his PhD in introducing physical and anthropological concepts to engineering design (analysis of the implicit dimension of acting and knowing). His current research centres on a new concept of information in the context of computer science and neurobiology. Beyond this, he works with Gerald Hüther since a couple of years towards a renewed understanding of humankind.

Gerald Hüther is one of Germany’s most known neuro scientists. He studied biology in Leipzig, and leads now the ‘Akademie für Potentialentfaltung’ in Göttingen. http://www.gerald-huether.de/. Gerald intends to explain in straightforward terms how the brain works, how our environment and behaviour affect its development, and how we can influence and encourage the usage of our brains in a new and unseen manner.
Introduction

This text is structured as follows. In Section 1, we will introduce the at-first-glance-unfamiliar usage of the term ‘non-causal’. This term is used because it underlines the one thing that is interesting to us about any information: its newness. Engineers explicitly use the term non-causal to describe events which ‘come from the future’. These events are designated and created in technical systems such that an event may appear to come before its actual stimulus. This is done in systems where the sequences of events and their time dependency are somehow known. Of course in reality and physics, including quantum mechanics, the ‘future’ does not yet exist. However, we found that based on a system model which conceptualises specific characteristics of living species, the notion of the future can be applied in a strict system theoretic model. In order to be consistent with quantum mechanics, we speak in this study about ‘non’-causal events. We conceptualise ‘information’ as the continuous interplay between causal and ‘non’-causal events, thereby developing structural couplings between systems. Life in particular has developed this ‘future’-embracing, ‘non’-causal dimension. The key concept to be introduced, which helps to build the bridge between micro- and macro-physical structures, applicable to causal and ‘non’-causal events, is the imaginary dimension of reality.

Section 2 is based on an idea by George Spencer-Brown, and on the concept of recursiveness in quantum physics. We both introduce and ground imaginary valued, future-oriented forces as ‘non’-causal events in a physical framework. Spencer-Brown introduced the concept that any living system is characterised by its basic capability of re-entering into its own structure and configuration. A system model will explain the main characteristics of this approach: a structural coupling of the system with itself. The mathematical characteristic of this re-entry is a theoretically never-ending oscillation of a system, which thereby modifies the structural set-up of the system. While the classical logical understanding is restricted to viewing a system either in state ‘0’, or in state ‘1’, we show that the capability of oscillating between system states gives us the perspective to see the universe as a system which continuously ‘completes’ itself. The ability to oscillate thereby appears as a solution to Kurt Gödel’s incompleteness theorem. We show that this structure delivers a key concept of living species: the development of ‘memory’ as sequences of oscillations. Moreover, we show how such recursiveness and re-entry deliver the ability to self-replicate.

Section 3 brings this system model into the context of how information gets continuously created, and how the core component of such information (the newness) is our future, or the future of any living system. We introduce an optimisation parameter, which motivates any further development: the shape and size of its/a given system’s phase space. Living systems continuously strive to enrich and extend their own phase space - in interaction with other systems. Given this, we can recognise structures of reasons for human existence, and the origin of all forms of ‘morality’.

Section 4 brings the two dimensions of information together: the first dimension deals with the self-awareness of systems (and the self-measurement of their own phase spaces and structure). The second dimension deals with the meaning of such structure within our world: we call this phenomenon ‘potentiality’, or ‘potential for interaction’. We show that we can overcome the dilemma of von Neumann, who already saw this double aspect of information: any program can be a ‘design’ (a structure) or a ‘program’ (an activity, or potentiality), but the system has no intrinsic information when it needs to switch from one mode to the other. We will see that a third dimension - the reality of paradoxes -
enables us to understand and develop the imaginary, ‘non’-causal dimension of life. In fact, we are always processing both aspects together: being a structure, in a dynamic process sense of structure (structuring) and being active. In consequence, we are encouraged to reciprocally enrich our phase spaces, because then we will by evidence enter into a state of enriched meaning and spirit. And further, once we arrive in such a new state, new ideas will emerge. We know from biology, that cooperatively organised systems create a higher energy gain for all the involved individuals (through the transition in new phase ranges), and/or much less waste.

The concluding section encourages to develop universes of potentialities within all living species, each creating new physical realities and chains of causes. Living species hold primary activity, and there is no homunculus or other super-world-formula acting somewhere in the unknown background and keeping us as marionettes.

We encourage the reader to envision the possibility of structure-enfolding oscillations, so that we might feel the spirit of the physical and mental reality of imaginary dimensions. We encourage all of us to develop the human spirituality, which is a natural spirituality.

1 The notion of information and the search for new regularities

Almost everything is equal at the beginning - germs, snowflakes, living beings, humans. Then, magic happens: the nuclei interact in a fascinating way with the environment and thereby enable the formation of countless different snowflakes, living beings, humans. Snowflakes are exposed to a variety of environments, temperatures, pressures, levels of humidity, and undergo a transformation - which is the magical moment - to more complex, stylish and aesthetically different patterns and figures. “Friends are like snowflakes: more different and more beautiful each time you cross their paths in our common descent. For the final truth about snowflakes is that they become more individual as they fall - that, buffeted by wind and time, they are translated, as if by magic, into ever more strange and complex patterns, until, at last, like us, they touch earth. Then, like us, they melt” (Gopnik, 2011).

Which and how much information is contained in such structures? Shannon, one of the founding fathers of information theory, considered the number of answerable questions with yes/no as a fundamental measure of the information content of a structure. Hence, many questions are necessary to ‘scrutinise’ a complex, unknown structure. In simpler systems such as a dice, if we want to inquire about one of the numbers on the rolled dice (given a 2 was thrown), the following strategy can, for example, be followed: first question: “is the number of points between/inclusive of 4 and 6?” Answer: no. Second question: “is the number of points between/inclusive of 1 and 2?” Answer: yes. Third question: ‘is it 1?’ Answer: no. Now it is clear that it must have been a 2. Usually the logarithm of base 2 (with yes/no as so-called binary questions to be answered) is needed for questions about a system with \( n \) possible outcomes (for the die, \( n = 6 \)): \( \log_2(6) = 2.58 \) bit.

Objects or physical systems always strive for a state that minimises the energy required for their conservation. The minimum energy for a soap bubble is a spherical surface. For crystals, the surface energy density depends on the orientation of the crystal in the room, which leads in contrast to the isotropic sphere, to anisotropic surface shapes. For a snow crystal, the sixfold symmetry of the crystal grid is decisive. Additional
feedback mechanisms arise during crystal growth: the corners of a hexagon extend further into the environment than the rest of the object. Consequently, more molecules tend to accumulate there, which leads to the manifestations shown in Figure 1. Based on this, snow crystals develop an astonishingly large number of complex shapes. The mathematician Garcke attributes this to a process of self-organisation whereby complex patterns form out of ‘nothing’ due to ‘ramification instabilities’ (Garcke, 2012). Here, we refer to the interaction of feedback mechanisms with further, random distributions in the close environment of the growing crystals. Scientists differentiate between random (statistical) and non-random information. The structural design of the seed contains the regular, non-random information and the wonderful shapes that emerged during - random - interactions with the environment, which depict the coincidental fluctuations of the environment.

Information and causality:

- In a broader sense, ‘information’ is conceptualised as a state of structural coupling between two (or more) systems, so that the multiplication of the number of each system’s microstates with each other is less than the possible number of microstates of the coupled system. Shannon’s idea is included in this proposal. Information deals with the structure or the shape of systems with regard to structural couplings. This explanation covers the causal dimension of information.

Figure 1  Comparison of a dividing ovum and a growing snow crystal. (a) Cell division of an ovum (diameter approx. 0.2 mm). (b) Growth of a snowflake seed; duration: approx. 5 minutes. Diameter of the left seed: approx. 0.2 mm (© courtesy of Kenneth Libbrecht) (see online version for colours)

How, then, does newness and novelty come into the world at all? The physicist Erwin Schrödinger argued that the only task of consciousness is to deal with novelty. The conscious process may create new knowledge, but also artful objects. For this reason, scientists and philosophers (nota bene the logician Friedrich Ludwig Gottlob Frege, 1858–1932 (Frege, 1993)) have argued for a compositional aspect of our being - whether in nature, language, knowledge or thought. Frege explained that the meaning of a complex expression is given by the meanings of its elements and the rules used to combine them (Szabó, 2013). Such rules may not only cover syntactic elements, but also aesthetical or even more complex cultural information. We have to deal with those informational dimensions as well. Additionally, biology is struggling with an explanation of the appearance of life, and with the question of whether there is ‘progress’ at all. Darwin’s famous law of the survival of the fittest is nowadays seen as the rippling on the surface of some deeper movements (Reichholf, 2008). The biologist Reichholf confirms Darwin’s law of natural selection. Organisms change over time as a result of changes in
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heritable physical or behavioural traits. However, shortage of nurture may stimulate new phenotypes of a species, but do not cause the emergence and development of new species, and do not even trigger cultural development.

However, which idea can help us to look into this deepness?

In this paper, we will give a first outlook on a new proposal, which identifies - in conjunction with the causality thesis of information - ‘non’-causality as the deeper root of the appearance of newness, especially through and in living systems.

Information and ‘non’-causality:

- In a deeper sense, ‘information’ is conceptualised as a process of systems entering into their own configuration space and structure [based on Spencer-Brown’s (1994) proposal, brought into biology by Varela (1979)]. On the micro-physical level, this deals with the recursiveness of quantum-mechanical interactions. On the macro-physical level, this recursiveness conceptualises as the introduction of the complex plane to any system parameter. Given this, new structural couplings become ‘simulatable’ in the complex plane, that is, as points with one real and one imaginary value. The interesting point is that this recursiveness in the complex plane creates on the macro-physical level the influence of potential future system shaping (and corresponding forces) on the present system activation and interactional structure.

- In brief, we propose that information is a future-based composition and corresponding actualisation of the current system state (information deals with the actualisation of the state/phase space of the system), and interlinks with two dimensions of our world:
  a. the dimension of causal structure and current capabilities
  b. the dimension of ‘non’-causal envisioning of potentialities (including the capability of ‘re-programming’ the entire system).

Causality identifies the effects of past (up to present) events on current happenings in systems. ‘non’-causality identifies the effect of future events on current happenings. Consciousness or the conscious state denotes (signals) potential modifications of the current organisational level of the system with regard to a further enrichment of the current phase space of the system (see Sections 3 and 4). As such, consciousness is the medium of exploiting and aggregating body-centric and mental states to an overall mood and intention. The neuroscientist Tschacher summarises, that mental states cover the dimension of being about something, whereas no physical phenomenon seems to have such a distinctive feature of the mind (Tschacher, 2014).

Some structures are capable of self-replication - one of the most important characteristics of living systems. Beings created by means of self-replication and/or cell division are even capable of writing touching poems, starting wars and searching for the meaning of life. Hence, there still seems to be an enormous gap in the understanding between the coincidental external effects on a system and its potential for development.

In 1943, Erwin Schrödinger first examined this gap (he called this ‘a hiatus’) from a physicist’s perspective in his lecture ‘What is Life?’ initially held in Dublin (Schrödinger, 1944). He concludes that cells are ‘aperiodic crystals’, denominated by him as such, wherein individual molecules of these crystals save the information necessary for replication. Molecules are recognised as carriers of the genetic information - a fact that later stimulated the discovery of DNA by Watson and Crick. Through the replication
process, life evades the drop into the - dead - state of equilibrium. Order arises from order and is maintained. Also: living beings conserve this order by increasing the disorder in their environment, and/or by ‘siphoning off’ order. In physics, the term ‘entropy’ denominates the number of possible states of a system. Normally, systems strive for the state of maximum disorder (and/or the state of minimum energy). Beings, in contrast, do not, and this is why Schrödinger calls the order taken from the environment as ‘negative entropy’, and/or negentropy (Léon Brillouin) - which was also called ‘information’ in the broader sense.

A further point, already presented by Schrödinger, is also relevant: the condition that takes the ‘coincidental external effects’ on the system to a new level simultaneously due to the fact that these external effects become structurally known to the system. This, in turn, corresponds to the above-mentioned hiatus through which the system can not only detect its environment, but also structurally integrate it. However, the overall structure has to form an entity to be re-evaluated so that it remains logically structured in the exact way that is still to be outlined. Schrödinger talks about “physical laws of a completely new type” (pp.114). These regularities comprise such as self-replicating system in a new manner.

Systems interact with the outside world and with themselves at the same time. This enables the creation of new causal chains in the universe. Such newly arising structural orders only exist in singular and that is inherent to the individual conscious perception of each human being.

So far, we have discussed the causal dimension of information processing. ‘Causal’ means in a physical sense that the actual configuration of a system or a process is somehow determined (including stochastically described relationships) through his or her historical records. On the other side, Schrödinger suggested that consciousness is a matter of the experience of Novelty. However, Novelty deals with the future, whereas the physical concept of causality does not. How can this be brought together?

At this point, we want to sketch a new proposal, which we will lay down in more detail in a forthcoming article (Luhn et al., 2017). One of the most successful modern sciences shapes our present world: physics. Causal thinking dominates physical and economic thought; it applies a specific pressure on our interdependence and our way of organising relationships. The economical, measurable part is dominant. In ‘non’-causal thinking, we are however not influenced by the past, but by our vision and anticipation of the future.

The dominance of causal thinking seems to be burned into our minds. For example, we mostly think in terms of ‘problems’, which indicates kinds of conflicts regarding our past actions and experiences. But modern psychologists such as Martin Seligman have shown that it is not the reflection on such problems that informs our decisions, but the vision and imagination of our future life (which contains many other perspectives as well; Seligman, 2011). The deterministic perspective has influenced many philosophers as well. The philosopher Metzinger argues that our understanding of the self as a mental entity results from a faulty inference from our experience (Metzinger, 2003, 2009). He argues that no one has ever experienced the outcomes (or the being) of our neuronal processes.

If this were true, then of course it is not only psychotherapy that could not be practiced any more. Any self-healing practice, meditation, yoga, up to the placebo effect would itself be just an illusion.
Another example comes from modern wars and terrorism. The problem of finding solutions to the flow of refugees from the Middle East into, primarily, Europe is now often simply stated as unsolvable. It involves bringing into the decision process a different perspective that, again, allows for the causal efficiency of factors that are ‘non’-causal in the standard sense. Simply spoken, we are not interacting with refugees as humans, but as things. This of course blocks any reasoning and creativity about our common human future, which is made by humans, and not by things.

This scenario implies two goals of this text to be illustrated:

1. The regularities that comprise the formation of structure in the universe up to the creation of life and consciousness, need to be outlined. They will be referred to as ‘structural laws’ or ‘structural couplings’ in the subsequent parts of this text.

2. The second aspect that depicts the above-mentioned hiatus needs to be identified. These are the categorically new ‘processes’ applicable by the foundation of these structural laws. The two different and seemingly incompatible interpretations of the notion of information are based on the not-yet-performed overview of these two perspectives up to the present: on one hand the perspective (a), that attributes ‘information’ to the objective system, and on the other hand the perspective (b) (developed inter alia by Brillouin, and nowadays a standard perspective of computer science: “Entropy is usually described as measuring the amount of disorder in a physical system. A more precise statement is that entropy measures the lack of information about the actual structure of the system.” Brillouin, 1962, pp.160), that attributes ‘information’ to the observer. These perspectives, which have coexisted without any relationship so far, enable us on one hand to understand ‘information’ as an objectifiable quantity that manifests itself in the structure of the systems (and which led scientists such as Moravec (1998) to the assumption that robots would become our legitimate successors one day: objectivist world view), and on the other hand to understand ‘information’ as a mere variable of state that can only be generated by subjects (whereby the notion of information is then understood in the context of the semiotic tripartism as: syntax (individual units of information/characters), semantics (meaning of the characters for the recipient), pragmatism (further effect of the characters); the most important reason for this subjectivist approach is the different meanings of identical characters for different recipients: subjectivist world view). However, it is no coincidence that the notion of information has always accounted for these two aspects (a) (the objective dimension; see above) and (b) (the subjective dimension: the observer; see above) from an etymological perspective. Shannon’s concept explores important aspects of the objective dimension of ‘information’ which have not yet been merged with the subjective dimension so far (Kahry and Mahner, 2004).

Our approach is simple: ‘structural laws’ in the classical physical perspective rely on causal information, as outlined above. In conjunction with this, ‘structural laws’ in terms of knowledge and feelings (and especially their processes of appearance) rely on ‘non’-causal, future-oriented information. Such feelings are integrated towards the mood and atmosphere which are exploited by any living species. These structural laws appear and develop in a holistic background, and also - from a semantic perspective - include new ideas and imagination. Let us think about the young female macaque monkeys, who invented to wash potatoes. The older ones only brush off the sand with their hands.
Scientists then observed over the next few years a dramatic change in potato-consuming behaviour throughout the island, where the tribe lived (De Waal, 1999).

But how do ‘structural laws’ play together with ‘thoughts’ and, finally, with ‘information’? The entropy of a system is usually defined as the number of microstates of a system. Thus, entropy might change, if we knew more about the system. This is where Brillouin’s subjective dimension enters into the game. The physicist Rovelli proposes a way out of this dilemma: he explains that entropy is a property of certain (macro-physical) variables, which furthermore requires at least two systems to interact (Rovelli, 2013). Two gases, which are separated in two volumes, might interact on a separation foil. The interaction takes place under macro-physical variables, such as temperature and pressure. The physical interactions between the gas and this system are then objectively described by thermodynamics. Generally, physicists do not bother with all the possible different microstates which a system might occupy, and which are identical to Shannon’s concept of information. “Therefore the information relevant in physics is always the relative information between two systems. There is no subjective element in it: it is fully determined by the state and the Hamiltonian interaction that dictates which variables are the relevant ones in the interaction” (Rovelli, 2015, p.79). Rovelli then shows that, from the perspective of quantum mechanics, systems can always acquire new information. Given the boundary conditions of the universe, living systems incorporate finality and intentionality from the beginning. Rovelli (2015, p.81) finally concludes that this kind of interactionalism seems to underlie the physical and biological world, which leads to following structure or task: “To maximise the management of information”.

Rovelli’s interpretation is conclusive, and this text will develop a system model also covering and concentrating on the interplay between the micro-physical and macro-physical levels of such a model. Therefore in Section 2, we will develop a simple system model. It may sound somewhat complicated, but the idea of imaginary information helps to overcome this problem for the following two reasons: \textit{First}, this is a physically evident proposal. Leonhard Euler gave an initial example. Within his theory of mechanical buckling, he showed that columns may show a sudden lateral failure. But for low forces this effect does not appear, so Euler named the corresponding, mathematically described deformation an ‘imaginary deformation’ (Stüssi, 1944). \textit{Second}, we attribute our mental imagination an imaginary dimension in the same sense: the appearance of new ideas as new structural laws which deal with our future. ‘Structural laws’ are the physical counterparts of ‘mental ideas/mental concepts’, which are all together governed by this double dimension of complex valued, real and imaginary information.

The word ‘forma’ contained in the notion of information is the translation of terms from Greek philosophy, especially from Plato (idea/typos) and Aristotle (eidos/morphe). ‘Information’ hence comprises two poles that are very fundamental to us: on one hand the physically describable shape of something, and on the other hand the effect of a shape or message on a recipient. It is a very old notion, and is analysed by Capurro (1978). Capurro, together with Seiffert, shows that those two poles tend naturally to the concept of education as well:

‘Information’ is, to remain up-to-date, the mother or at least the aunt of ‘education’ because ‘education’ itself is only a translation of older, more significant Latin terms including, among others, ‘informatio’ (Seiffert, 1968, p.27).
How could the perspective of future, which is an intrinsic part of any ‘education’, be supported by a new understanding of ‘information’?

Today the two major theories of mind are blocking themselves within a classical deadlock. Roughly speaking, determinism deals only with descriptions of past-oriented, causal relationships - and is based on a ‘closed’ physical metaphysics. Contrary to this, libertarianism (‘libertarianism’ is meant here in the sense of the moral view that people fully own themselves, and have certain power - including morality - beyond determinism) demands a ‘wider context’ to be included into the scientific context - and is not capable of providing a physically plausible, but ‘non-physical’ (in terms of classical physical theories in which the ‘future’ can never act on an actual system state), that is: ‘non’-causal approach. Now we are arguing that any serious theory needs both perspectives. As a consequence, we argue that an acceptable theory of mind does not only have to explain the past-oriented descriptions of what is currently happening. On the contrary, such an approach also has to give direction (in terms of developing dispositions and capabilities) in order to decipher and unmask the bad things going on today.

This may be seen as similar to the invention of science as practiced by Galileo Galilei. He found a way which negated dogmatism as practiced by the church. Such dogmatic and somehow unconscious rules are nowadays incorporated into our primary, causally (economic) oriented organisation of life and business. Last but not least, it becomes clear that any theory of mind can never rely on purely descriptional elements (a classical objectivistic theory), but has to have a balanced dispositional element as well (subjectivistic perspective). That is to say, the so called hard problem of consciousness cannot be solved within the classical set-up of what a theory is. This indeed goes along with the spirit of Galilei. Our goal is to show the causal power of any ‘feeling’ (mood, spirit, morale, humour, socially perceived cultural atmosphere). Whereas such ‘feeling’ comes out of ‘non’-causal activities: we follow our feelings.

2 Development of new physical structures through utilisation of the interaction potential of the involved components (immanence and transcendence of the interactions)

In this section, we will introduce a simple system model, which introduces the one missing thing in our chain of arguments: the structural coupling of any system with itself. So, let us develop how mental ideas might emerge out of structural laws, both covering the same imaginary dimension. A core attribute of things that emerge is related to the concept of potentiality. Here we will find an additional bridge between the physical and the mental. The system model will ground our argumentation within a strict logical framework, so that the conclusions are committal.

In physics, relatively well-known concepts that are applied in different fields are associated with the terms ‘potential’ and/or potentiality. For example, a moving pendulum changes between moments of kinetic and potential energy. This sinus-shaped movement is part of the class of so-called quadratic potentials. In principle, ‘potential fields’ are used to describe fields that have the possibility of performing work, for example in masses or in charges. This is also known from the perspective of quantum physics. In his book ‘Was ist Leben?’ (‘What is Life?’), published in 1944, Schrödinger illustrated the effect of potential differences in molecules. Molecules can take on different excited states and hence develop different characteristics. In chemistry, the
concept of reduction/oxidation potential is used to describe the different states of electric charge of the coreactant.

The physicist Bender proposes a concept where he takes the uncertainty principle to mean that there is intrinsic uncertainty in the energy of a particle, and considers that this uncertainty has an imaginary as well as a real part (Bender et al., 2008). Then he shows that a deterministic classical particle whose energy has a small imaginary component can exhibit phenomena that are associated exclusively with quantum mechanics: such particles may tunnel into forbidden areas, and other phenomena. In other words, new thoughts in physics unveil formerly unseen potentialities of matter.

Also in biology, the notion of potential plays a decisive role in understanding the interactions and dynamics of living systems. In the case of early differentiation processes, embryologists describe the transformation of the prospective omnipotence of embryonic cells into cells with a different structural importance. Neurophysiology uses the notion of activation potentials. In daily life, the word 'potential' describes an apparent spectrum of possibilities - be they for a favourable opportunity, a product or a business, or also directly for people ('she has great potential'). However, no continuous concept framework seems to exist to describe or even explain the different but interrelated effects of 'potentiality' on the different levels of reality. Nevertheless, we still perceive them as continuous throughout the levels. The switch within a potential or a potential field always comes with the supply or removal of energy and/or work. This is why we generally distinguish between the status quo and the potentially possible states in systems. If everything was in an energetic equilibrium, there would be no changes and the world would be purely static. Potential/potentiality is the expression of the interaction possibilities and hence of the development possibilities of structure-creating systems.

The second law of thermodynamics says that physical systems approach a state of equilibrium. This will then be the state of the highest probability. Sometimes, however, things reach an order by themselves, e.g. based on a regularity that counteracts the second law of thermodynamics: the exclusion principle according to Pauli says that all electrons must move around the atomic nuclei on different orbits. And there are only very few of such possible orbits. A transition from one orbit to another is equivalent to a change in energy level. The orbits with the lowest energy levels are the inner orbits. This principle applies accordingly also for molecules and larger compounds. Without the effect of this principle, the circulating electrons would crash directly into the atomic nucleus. Moreover, all matter would unopposedly collapse during the release of extreme amounts of energy.

The physicist Bonchev argues that the Pauli principle causes an overall trend in the universe: it causes the continuous creation of new structures (Bonchev, 1981). Though it does not act as a causal force (from the past), it acts instead as a logical fulfilment condition and embraces possible future configurations. This needs to be considered together with a new proposal by the physicist and mathematician Grössing (*1957 Vienna). He developed an interpretation of quantum mechanics, which gives foundation to the primary recursive structuration of any quantum mechanical process (Grössing, 2000).

These explanations lead to the following hypothesis:

1  The hypothesis of Compositionality and Continuity: Processes of physical structure formation take place through the interplay and/or the interaction of opposite principles (as the second law and the Pauli principle), which interact between causal
and ‘non’-causal processes and lead to the development of systems of greater possibilities of state and/or state spaces. Hidden potentialities are developed in an overall structure of physical continuity (In accordance with the logicians Gottlob Frege and/or Stéphane Lupasco, this is called the physical compositionality principle.)

When we go back to the singular point of the formation of the universe, we ask ourselves the following question: what information existed at that time and point. According to Shannon’s notion of information, information content is equivalent to the logarithm of possible states (Shannon, 1948). There is, however, only one state in the singularity, i.e. the information content of the universe would in this case be equal to zero. Nothing, though, can arise or develop out of a state with zero information. Physicists try to avoid such non-continuities, and for this reason Hawking introduced the concept of time, which covers real and imaginary values (Hawking, 1988). He used the imaginary dimension to represent all different kind of possibilities which do exist, in addition to the actual configuration of the universe. With this concept he avoids the point of singularity of the so called big bang, because besides the one ‘real’ state of the universe all other possible states are represented as a potentiality in an imaginary dimension. Already the next state of the universe has led to an uneven distribution of the energy density, and the ‘meaning’ (or the ‘content’) of the new shape consists of the activities that are induced by this emerging uneven distribution of the energy.

The notion of the ‘imaginary’ needs an extra sentence. Our main argument is that any knowledge or conscious activity points to a not-yet-actualised future. Otherwise, we would not need any disposition, or ability. All would be stupidly mechanical. Now, we take dispositions as mathematically imaginary-valued structures. Physical systems usually expose real-valued properties. A metal block may fall on earth - the corresponding equations have real-valued roots. However, this same metal block may somehow lose its magnetic properties, when the temperature falls below a certain value (the so-called Curie temperature). Spontaneous magnetism only occurs below the Curie temperature. Now, this ability to show spontaneous magnetism is an example of newly appearing properties of a system. Those properties cannot be prognosticated a priori. We show in the remaining part of this section, that such a potentiality of new properties is holding from a mathematical perspective an imaginary state: corresponding equation has imaginary roots.

However, physically measurable activities cover only real-valued phenomena (we conceptualise those as projections from the more meaningful imaginary parts). Consequently, this theory will also cover parts which will never be evaluated in a real-valued sense: the mathematical world of imaginary-valued spaces. Later we argue that it is our ‘task’ to transform the entire world towards new dispositions and structures.

The preceding thoughts provoke to challenge the notion of materialism, reductionism, libertarianism and theistic intelligent design. It seems that all those perspectives are true within their domains. Looked at atomistically, evolution is a purely random physical process. However, looked at as an emergent whole, it is an undeniably teleological process.

Is there a deeper level of meaning? The answer seems to be ‘yes’, but with an unexpected challenge, or chance. If we follow the above-mentioned task and encompass the future, which is the ‘real’ imaginary, then of course this will not make the imaginary dimension disappear, or become smaller.
Consequently, this notion of science tells us that the goal is not to eliminate or ‘solve’ seemingly contradictory aspects of our notion of the world. The quantum is a wave and a particle at the same time. While those properties interact, new phenomena (up to the many-world-thesis; see Section 4) are becoming possible. This means: the goal is to create more ‘secrets’ or ‘mysteries’ (or ‘phenomena’, in physical terms). As we have seen in the introduction, science should always unleash our bondages. This was maybe the goal of Galilei as well, when he developed his scientific methodology. One could think on the one side, that this methodology enables to decipher the world, and to eliminate human causality. However, this is not what we want to intend. First, we argue that any system in this universe contains abilities to create new causal chains. Second - even more important - science should be usable to understand and unleash our bondages. Just in the sense as Galilei wanted to interpret the Bible in a new, undogmatic manner.

Since the first change of state, the universe has been on a path on which
1 new shapes or systems emerge continuously with correspondingly enlarged state spaces through phase transitions
2 newly emerged shapes steadily remove the degree of inconsistency (uneven distribution of the energy) resulting from each new development.

In each newly developed shape, there is the potential to create a variety of further shapes/structures/figures. To put it another way: in-phase transitions, free energy and/or one of its derivations have a singularity in the classical real-valued physical model. This is characterised by a sudden change in the properties of the substance and/or the system (and/or the field, the structure ...). Nevertheless, there are critical points in higher state ranges (temperature, pressure ...) at which the discontinuous phase transition passes to a continuous one. Above the critical point, there is no phase transition. This shows the meaning of the concept of continuity. On the other hand, we argue that new phase spaces, new structuration are already present in an imaginary dimension. This means: if critical points are exceeded, each system has the potential to differentiate further, nomologically distinguishable state spaces that lead to a further diversification of the system behaviour during interaction with the environment. This so-called discontinuity can be understood as a continuity, if we add the imaginary dimension. Furthermore: we first look at physical regularities as a structural determination of real phenomena. The term ‘phenomenon’ originates from the Greek ‘phanetai’: what appears, what manifests itself; for us: what appears as a description.

Information is or conceptualises the structural coupling between systems (real component), and their further development (imaginary component). However, how can this imaginary dimension evolve within a consistent logical perspective?

Let us recall the first change of the state of the universe. In the beginning, there seems to be only one state: a somehow homogenous aggregation of energy. The universe now needs to operate on this single state - on itself - in order to establish the next state of the entire system. What does it mean that a system operates on itself? We assume that natural laws as structural couplings chain the two system states together in an informative manner. Then, information about the form of the system has to be present in state zero and state one. Within the classical understanding, a system is defined by a set of input parameters, which causally influences/enters into a system (von Bertalanffy, 1969). Any system shows a border, which separates itself from the environment and from other systems. Each system covers certain abilities to transform input values to output
parameters and corresponding values. von Bertalanffy (Austrian biologist, 1901–1972) already includes physical, engineering, biological and sociocultural systems into the scope of his theory. In physical systems, the idea of continuity is a base concept (Leonhard Euler used this idea in his mechanical theories). A main element for showing such a continuity is the structure, the form of a system (including its borders as well). However, new structures may appear when a system interacts with its environment and/or with itself. In general, the entire universe - and any subsystem of it - must be chainable within a theoretically countable sequence of changes (including structural changes). Due to its quantum nature, all the different states are countable.

Here comes the point of interest. The physicists Laughlin (*1950 in California) has studied the appearance of newness in nature (Laughlin, 2005). He calls this effect emergence, and explains for example that the low-energy properties of a crystalline state are caused by a higher, emergent organisation principle. These emergent states are called phase spaces because they may cover a variety of possible different states, and are all bound to a new structural law. Within our interpretation, such an emergent phase space holds an imaginary state when it has not yet come into existence. How can such an imaginary dimension be conceptualised? Could consciousness fulfil this criterion?

Here we need to look at the fundamental recursiveness of the universe. A future state \((y + 1)\) depends on the current state \((y)\). Within Newtonian mechanics, many equations are directly solvable (that is, the ‘\(y\)’ in ‘\((y + 1)\)’ can be eliminated, so that a future state does not depend on the current state; example: Newton’s law about the fallen distance of a free-falling object: \(y = \frac{1}{2} gt^2\) [\(y\): fallen distance; \(g\): gravitational constant; \(t\): time]). A counter example is exponential growth. The number of species might increase exponentially. For example, a one-celled specie might divide into two organisms per day. On day_1 there is only one organism, on day_2 there are two, on day_3 there are four, on day_4 there are eight etc. Such exponential growth might bring species into situations where structural changes are required. Is there a most primitive process which guides any transformation of structure and form?

We might think of a simple electric buzzer, such as the bell in old ringing telephones. The basic design involves a circuit that includes an electromagnet which, when supplied with current, attracts a metal bar which pulls it away from an electric contact. This thereby breaks the circuit by cutting off the electricity to the electromagnet, which allows the metal bar to spring back into position where the electric contact re-closes the circuit re-energising the electromagnet, and so on. The resulting on-off-on-off… activity is what produces a buzzing sound. The corresponding logical formula looks like:

\[
\text{ON} = \text{OFF}.
\]

We see that the corresponding ‘program’ never halts. This indeed looks similar to the liar’s paradox: this equation declares that when a system is ON, it is OFF. This cannot be a true statement, because it cannot be ON and OFF at the same time - at least in the framework of classical logic. The mathematician Kurt Gödel sees the liar’s paradox as semantically analogous to his incompleteness theorem. This states that there are true statements which are not provable in a given system. Truth is something more comprehensive than mere provability (Küppers, 2013).

Any system can always be ‘completed’ with new statements, which are not provable in the current system. We interpret ‘new statements’ as emerging physical laws, or emerging structural coupling, based on the capability of continuous oscillation between possible (and not causally provable) system states. Bistable figures are an example of non-halting pattern recognition algorithms.
However, how does the imaginary come into the game? Obviously, we have to accept such contradictory states as part of the reality. However, what does that mean? It is seemingly no restriction or impairment of our framework, because just in this moment we are enriching our system model in an unsuspected manner: such ‘contradictory’ states seemingly add the capability of infinite oscillation into our framework. This offers a kaleidoscope of possibilities for every system to incorporate so-called unprovable statements or structures into the system. We just saw that Laughlin explained this phenomenon as the effect of emergence in physical systems. Consequently, Spencer-Brown proposed that besides the logical states true and false, there exists a third, ‘imaginary’ truth value. From a mathematical standpoint, this is true for equations of the form \((y + 1) = f(y)\), in which the roots hold imaginary numeric values (example: \(y = -1/y\); the roots of this equation are \(\pm i\); \(i: \sqrt{-1}\)). In Spencer-Brown’s interpretation, the solution oscillates infinitely. Now, for a more complex recursive system the roots might oscillate in infinite depth. Our simple electric buzzer does not yet show a structure, which would enable infinite depth. This becomes possible, when a stimulus is not immediately transformed into an output, but into a further modification of the system. Simple reflection is an example for this. The following section and system model (next Figure) will bring this to the foreground.

How can this be interpreted within our approach? The answer seems to be quite simple, because an oscillation between two states can be seen as the oscillation of a current physical, but ‘incomplete’ described system. It fits into this approach that a solution for the Euler buckling is an infinitely long oscillation (there exists only one oscillation cycle which advances in infinitely small intervals). Any oscillation deals with two physical parameters: frequency and amplitude; these are represented in a complex plane, covering real and imaginary values. If we now include neurological activation patterns into our argumentation, we find a conclusion, which interrelates those seemingly different domains. Neuroscientists have understood for a long time that neural activities are coordinated through patterns of neural oscillation (Pöppel, 1989). Non-oscillative, non-complex neural mechanisms have been widely analysed, like in pattern recognition. However, nowadays complex-valued conceptualisations of neural activities are gaining ground (Reichert and Serre, 2014). Additionally, task-unrelated activities are seen as sources of creative cognition (Jung et al., 2013). Jung et al. are analysing the need of an organism as whole to start thought processes without directly coupling to primitive stimuli of sensation. Pocket is arguing for a basic oscillative characteristic of our mind, including a non-deterministic perspective of our free will (Pockett, 2015). Oscillations are those activities, which modulate from a mid- and long-term perspective the further structuration and development of species. Those activities enforce the creation of new phase spaces, and neuroscience conceptualises such phase transitions as a fundament for the conscious process: “[...] critical dynamics in the framework of Critical Theory of Statistical Physics stipulates that the brain is poised to undergo sudden second-order phase transitions to new macroscopic configurations with distinctly novel properties” (Werner, 2010, p.10).

However, consciousness does not appear as an epiphenomenon of the physical processes of a collection of organic chemicals in the human brain. Conscious experiences express the ability to mediate future fulfilment conditions as new, yet ‘imaginary’ truth-values. There is a structural ability of any physical and biological process, which fulfils the former raised topic to interrelated real-valued and imaginary-valued processes, which we call ‘consciousness’.
Besides the ideas of Pöppel and Werner there is another interesting object: mirror neurons. Those neurons fire not only when their owners perform certain actions but also when they watch someone else performing the same activity (Rizzolatti and Laila, 2004). This opens the way to learn by imitation, as the example of the macaque monkeys is showing. Interestingly, Rizzolatti argues that the mirror system represents the neurophysiological mechanism from which language evolved. The main idea is that language starts from gestural communication. Those communications include already semantics, which are inherent to gestures. Rizzolatti’s inspiring work is still widely discussed. His work supports substantially the process to understand neural activities in animal and human brains.

However, when Rizzolatti is arguing that “[t]he meaning of words is based first on the old nonverbal semantic system” (Rizzolatti and Laila, 2004, p.187), he misses the point. Those non-verbal semantic systems are close to perception and motor activity, and do not at all address what the Philosopher Sartre called ‘the imaginary’ (Sartre, 1940). When we imagine, we are free in a sense to invent such a phenomenal sensation system as language. Language seems the system, which is - based on its recursive, fractal structure - capable to continuously negate the so far existing world, and create ‘undecidable’ statement. Such recursiveness goes along with oscillation, and for these reasons imaginary-valued oscillative systems seem to be the precursor for the appearance of consciousness experiences, and subjectivity.

Last but not least, the oscillative nature of all biological systems is seen as one of the main pillars of life, including capability of movement. To sum up, we see this complex-valued, oscillative nature of living species as a main entry-point for conceptualising imaginary-valued descriptions of physical and biological systems, whereas the imaginary dimensions are a precondition for development and learning. How can information fill the gap between complex-valued descriptions of living species, and the third, ‘imaginary’ truth value?

Given the boundary condition of the universe, systems will continuously create their own phase spaces, and even create their own future and time. Our basic idea is that the universe is fundamentally incomplete (in Gödel’s sense) and that biological systems create dispositions, or capabilities, which point to the future in order to ‘complete’ the universe. The following picture illustrates the three different kinds of system models which we need to discuss:

1 Case (a) Figure 2 shows the classical approach in system modelling, such as is mostly used in engineering science. It also shows the system concept as is used in classical, Newtonian physics.

2 Case (b) shows feedback systems, including non-linear systems and the concept of fractals. A main application of this structuration is the growth of populations. The recursive structuration of quantum mechanical processes is also a case of this category (Grössing, 2000).

3 Cases (c) and (d) are based on the self-referential circle, which has been proposed initially by Spencer-Brown and brought into biology by Varela.
Spencer-Brown mentioned that this re-entry is a precursor of memory, because sequences of re-entry and oscillation are used as ‘programs’ in other contexts. Varela has maybe not seen the physical foundation of this concept, and did not think about a natural force...
towards continuous enrichment of biologically deployed phase spaces. It is important to see that this process, which covers further representations of the self, does not reduce the structure and capabilities of the self, but on the contrary enriches it.

This is what we wish to add to this scenario, and what makes any information valuable. Based on such processes of re-entry, the system creates its own time (in terms of the creation of macro-physical fulfilment conditions). We may understand that our future disappears, if the process of re-entry gets restricted to deterministic, real-valued activities, without any imaginary component.

The process of self-replication itself is also covered. There, a molecule can be seen in a situation in which the next state would cover the molecule in a state, where it is combined with some more components, which all together show the seed for a replication cycle. Therefore we conclude:

2 The hypothesis of the logical foundation of consciousness. Consciousness is in the first place not a physical or biological function, but instead is a logical capability (based on Gödel’s incompleteness theorem, and related to Spencer-Brown’s proposal of the existence of a third ‘imaginary’ truth value), which underlies and enables the continuous creation of information in terms of structural couplings (physical view), and - correspondingly - new ideas and dispositions. Those new structures and ideas represent future fulfilment situations and conditions. There, the process of ‘continuous creation’ is based on the mathematically endless recursive process of self-reference.

Readers might think that this seems to be rather an intellectual excurse, with little pragmatic consequence. Instead, we posit the contrary: we wish to show that the imaginary dimension of thinking - including all our wishes, feelings, emotions etc. - are part of a ‘real’ physical framework. They rely on human interaction, and as such, we want to add new value and responsibility to the value of ‘real’ human interaction, and try to withdraw our modern-day blindness to our future. The key topic for overcoming this blindness is to understand that our modern-day deterministic, mechano-economical thinking blocks from itself any further oscillation, because it does not stimulate any process of the re-entry of human ideas into real behaviour. It remains in the classical system model 2 (a).

The next two paragraphs argue that the concept of an imaginary truth-value also gets discussed in physics nowadays. This adds more evidence to our approach. Additionally, in Section 4 we aggregate those remarks into a more general form with regard to current physics.

Ananikian and Kenna explain in their article “Imaginary Magnetic Fields in the Real World” (Ananikian and Kenna, 2015) that there is proof of the existence of such imaginary information. This proof has been provided by the Chinese physicists Peng et al. (2015): “Long thought to be merely mathematical constructs, a realisation of these imaginary fields has now been observed in magnetic resonance experiments performed on the spins of a molecule”, is the conclusion of Ananikian and Kenna. But physical parameters which are holding an imaginary component are still seen as ‘unphysical’; that is, only the real-valued component of such a parameter is seen as physically existent.

Nevertheless, this is the first time that physicists conceptualised the influence of imaginary components on a real physical system. In the words of Wei: “Since a complex parameter is unphysical, at a high temperature no phase transition is expected with the varying of the physical parameter. Here we show that the quantum evolution, driven by a
designed interaction, of a system initialised in thermal equilibrium is equivalent to the partition function of a complex parameter. Therefore we can access the complex singularity points of thermodynamic functions and observe phase transitions even at high temperatures. This discovery makes it possible to study thermodynamics in the complex plane of physical parameters” (Wei et al., 2014).

We propose that the informational content of this imaginary structure is to be seen as the process of a system newly entering into its own configuration. Given this, the informational structure holds a ‘non’-causal disposition. On this basis, a third core hypothesis can be derived:

3 The Completion hypothesis: Formation processes of new, physically effective structures (new phenomenon and/or phase ranges) take place in areas of critical phase transitions and generate new fundamental information as new physical regularities. Such phase transitions are firstly ‘signalled’ in the complex-valued configuration space of any system, and come into existence via a process of re-entry of a system into its own configuration space (holistic organisation). Then, those primarily imaginary-valued parameters (still ‘non’-causal) approach the real axis, and appear themselves descriptively as structure-creating phenomena and therefore complete the description of the universe (causal). This interplay creates the immanence of the formation and information process.

This clarifies the double dimension of ‘information’:

a the structure of the ‘shape’ of each system (based on the structure of the system described in terms of causal regularities)

b the meaning of the ‘shape’ of each system (this is the effect of the system in its environment in terms of $f$, i.e. the compensation of energy gradients: hence, the meaning of the system is its further potential transformations).

The key issue is consequently the interplay of this double aspect, which creates the immanent structure of this overall process, and expresses itself in our experienced mood, spirit, morale, and sociocultural atmosphere.

‘Information’ therefore manifests itself in the connection and in the development of the descriptive levels - and this captures exactly what has to be neglected in the objective, functionalist and/or algorithmic-computerised conception of the brain structure by definition. In that context, the non-causal potential of a structure is not relevant - although this is what matters in life, what characterises the process of life marked by apparently intrinsic events, because a phase transition immediately and instantly depicts a new regularity of the structure of the system. This information does not have to be communicated in the traditional sense but is available immediately and instantly to all involved organs, cell structures, molecules and atoms (also to the complete living being on all organisational levels).

This is also identical to what we subjectively appreciate with regard to the imaginary dimension of information: that it grants us access to new and interesting aspects. Such a capability of information creation, however, cannot be generated with today’s computing systems (more precisely, not in the sense that computers would restructure their own hardware or redevelop it in a structure-intrinsic way). These relationships can however be ascertained with the two sides of the notion of information. On one hand, the objectified ‘shape’ of something and on the other hand the received message, and/or the subjectified
'non'-causal process of something that is based on it; - what can be fathomed only by the system itself, i.e. the subjectively experienced and perceptible potential of a state within recursively developing state spaces. The ‘objective’ contemplation, in contrast, does not take this imaginary potential into account. A further remark in order to process philosophy and systems theory is required. Joseph Brenner has brought the concepts of von Bertalanffy and Whitehead into a relationship with a concept of Lupasco (Brenner, 2008). This is of great interest, because Lupasco made a proposal to overcome the classical dualistic logic. Similar to our proposal he insisted in the necessity of a third truth value, which he called the included middle, or included ‘third’ element. Our proposal is highly inspired from this background.

Each physical regularity expresses its own algorithmic description as a phenomenon. When two systems interact (for example two solid systems; one of which might be ‘weaker’ than the other), then the shape of their interacting boundaries will express the stability and further internal structure of each system as a phenomenon. As a next example, systems might interact in transition areas when developed energy gradients are being compensated: this occurs in accordance with the shapes (phenomena) that manifest themselves descriptively, induced by the equations.

Through conceptualisation of this retroactivity of the system, interaction with the environment, and its own system description of itself, our proposed interpretation of information becomes a fundamental part of the development of systems. However, this double aspect of information, i.e. on one hand the objectifying (real-valued ‘structure’) and, on the other hand, the subjectifying (individual, highly imaginary-valued ‘process’) perspective can be consistently conceived as one because they form a unity, the unity of the universally interpreted ‘self’.

Of course we need to add that each self finds itself in the recursive process with the non-self, which gets activated by ‘non’-causal events. This automatically draws our attention to the characteristic that becomes increasingly visible at this point and that needs to be developed in this process: the principle of the potential of development that is continuously applied in the evolution of the universe.

In other words: there is a transcendence effect - as a counterpart to immanence.

3 The transition from the creation of structure in physical systems to the formation of self-replicating structures: on the interrelation of causal and 'non'-causal physical processes

Out of the initially simple, stable particles, increasingly complex atoms and molecules such as carbon, nitrogen, hydrogen, oxygen, phosphorus, sulphur, etc. will form. In contrast to simple, stable inorganic compounds, covalent bonds become possible in organic compounds in which the electrons do not accumulate in a way as to form completed shells. Corresponding to the energy level of individual atoms, diverse energy levels emerge in the regions between the atoms of a molecule. Due to their structure, partial regions of such molecules that can have an attracting, repelling or neutral effect in relation to the remaining configuration of the molecule are important for the structural design. These unsaturated molecules based on covalent bonds have themselves the potential to release or absorb electrons. This comes with the possibility of forming even more complex structures that in turn develop three-dimensional structures. In crystals as well as in metal systems, all involved atoms interact wherein the information of the
The respective configuration is available to all components (electrons, neutrons, protons). The growth processes of such configurations are mainly determined by accumulations or also by phase transitions (e.g., the development of crystals during cooling of the liquid phase). The biophysicist Tverdislov characterises the dialectics of this biochemical development “as a tendency to standardisation, for simultaneous, self-contradictory and opposing counter-forces” (Tverdislov, 2012). The most suitable objects for this process would be chiral systems with similar dimensions, which, however, cannot be reduced to each other.

A big problem in the search for an explanation for the development of living systems is the nearly unlimited number of possible conjunctions of different molecules that makes the formation of self-replicating systems totally unlikely. This is why Abbott et al. (2008) suggested a highly parallel ‘trial process’ that can be explained on the basis of quantum mechanics. According to this, the environment works as a causal meter to assess the potential of a molecule compound. This would mean that new information is created through an interaction process of the environment and a new molecule that joins the compound of the new large molecule and the environment (roughly simplified, it is comparable to the new bond of two metal blocks in such a way that the valence electrons can freely populate the volume of both blocks). The accumulation process of molecules occurred very frequently and, with the strategy proposed by Davies, a very fast identification of the configurations that enable a development towards a sustainable enlargement of available state spaces could be possible. Davies assumes that a phase transition with the further differentiation and enlargement of the state spaces (comparable to a new seed development and/or ‘bubble nucleation’) actually takes place due to the eventual occurrence of replication processes. Now we could imagine an excitation pattern, and/or an alignment pattern for the electrons in a molecule (regulated again according to the Pauli principle), which subsequently induces pertinent (phase) transitions in accumulating systems. This would ensure transmission of the ‘information’ of this pattern, and the information of the achievable state spaces can actually be used as a basis for the formation of the new molecule. Consequently, systems could replicate for the first time because a replication pattern, which leads to larger and more complex molecule systems, contains precisely this information. From that point, such ‘aperiodic crystals’, as such structures were denominated by Schrödinger, would steadily multiply due to their inherent codified information.

In the next part of this section, we will provide a rough overview covering the main chain of argument to introduce causal vs. ‘non’-causal information processing. More details will be laid down in the forthcoming book.

Figure 3a, b shows in a rough overview the set-up of causal and ‘non’-causal events on a current system. While causal events are well-established knowledge in physics, ‘non’-causal events need some further explanation. The British physicist Hiley (*1935) discusses in more detail the quantum-mechanical aspects of how the past, the future and the now interrelate (Hiley, 2013). “Thus not only does the future form contain a trace of the past, but it is also constrained by what is ‘immediately’ possible. So any development is governed by the tension between the persistence of the past, and an anticipation of the future” (Hiley, 2013, pp.9). This is still a work in progress, but Hiley is relating his work to Spencer-Brown in a similar manner as are we. We built our argument on the model of self-reference, as introduced in Section 2, and based on Spencer-Brown and Varela: systems might be capable of entering into their own configuration space. If such a recursion holds, then the system might approach of course an endless process of
Thinking, future and ‘non-causality’

re-entering. Now, this process may happen in a ‘simulated manner’. That means that this process happens with measurements of its own shape. Systems are capable of measuring their own shape, for example in ‘counting’ critical, self-manufactured and resonating waves, which encompass the entire body and shape of the organism (Laughlin, 2015; we assume that such measures can also be memorised).

Figure 3   (a) System state in the context of causal and ‘non’-causal events: balance of causal and ‘non’-causal (possible configuration during the emergence of life). (b) System state in the context of causal and ‘non’-causal events (see online version for colours)

Therefore, this process will enable the capability of creating simulated convergences of modifications of a system’s own shape, with regard to some optimisation parameter. We assume a single optimisation parameter: the value of its own phase space, which aggregates into our experienced mood and sociocultural atmosphere. To understand the concept of ‘value’ we need to have a concept of biological and - built on this - mental memory. In Section 2, we developed the embeddedness and recursiveness of any interaction of systems. The concept of counting comes into existence when a similar activity is remembered as such, and if a system of ordering can be applied between such different activities. Spencer-Brown introduced the idea that there is a fundamental, primary activity: making a distinction. This may be applied to the development of the
universe, because in the beginning there was only one state, which then developed into subsequent states. Additionally we see that all states depend on each other and no information gets lost (Hawking just recently mentioned that black holes do not exist; those black holes have been the only candidates in which information could have been lost; Hawking, 2014). A ‘similar activity’ is one which is controlled by an identical physical regularity. Systems of order appear when different numbers of chained activities are remembered. That is, if a representation of the complexity of a system is given. We argue that this assumption can be concluded out of our arguments.

The same is assumed for our next conclusion:

4 Hypothesis of the informational growth of the universe, including all its subsystems:

Any system tends (as caused by the high entropy at the beginning of the universe), to enrich its own phase space, because it is guided by ‘consciousness’: by a logic which enables the development of contradictory, oscillating chains of system states.

This is a direct conclusion out of thesis one (compositionality hypothesis), two (logical foundation of consciousness), and thesis three (completion hypothesis), in conjunction with the boundary conditions of the universe. In the beginning entropy was very low, which indicates the existence of a very high number of possibilities for further system developments.

This proposal is not in conflict with the overall concept of causality in physics. One might find similarities to this approach in other concepts like agent causality (Chisholm, 1996), or libertarianism (the philosophical counterpart of determinism) in general. However, the attempt is to propose a solution which nevertheless holds a consistent physical structure - what Schrödinger would have also claimed. We argue that ‘non’-causal relationships only appear on a macro-physical level, whereas on the level of quantum mechanics the Schrödinger equation holds. The solution is a cyclic interpretation and functioning of quantum mechanical interaction.

New (material, energetic) shapes steadily form in the dynamic interplay. The double aspect of this process is described by the notion of information: on one hand, a new shape develops which is to be characterised by the physical structural law (e.g. the structural law of snow crystals) of this shape (and/or this structure). On the other hand, a new meaning and/or a new content (in our example: the world of the snow crystals) arises. The meaning now consists of and/or is the potential of the state spaces. Living systems have access to and/or produce, by means of their reproduction cycles, a new category of such state spaces, i.e. spaces that are fed by a low entropy and therefore steadily create structures of order and therefore finally also the arrow of time. The source of this low entropy (or high order) is the sun. The Earth is constantly exposed to radiation of a relatively high frequency by the sun. This radiation is transformed into low-frequency radiation especially by beings that are placed at the bottom of the food chain (plants), and the order of the high-frequency radiation is converted to cellular transportation mechanisms. As we know, the energy balance of the Earth is even, i.e. exactly the same amount of energy that arrives at the Earth is radiated back into space. However, the emerging ‘order’ is steadily absorbed by all beings and transformed into further structures of order. This is how living systems create state spaces that are not yet directly materialised but that increasingly contribute to creating the preconditions of the replication process (and hence the arrow of time). In such systems, the interaction potential of the involved components manifests itself in a new way because from a biological perspective, this creates exactly the quality of novelty that we nowadays
attribute to all genuine and/or interesting information: new aspects are those that enable us - and/or the systems that slowly perform a replication process - to further develop our thoughts and actions.

4 The production of information is the immanent principle of the development of living systems

The development of first living creatures is obviously an emergent phenomenon. Also Abbott and Davies understand life as a process of information processing, complemented however by the condition that these processes also take on the structure of the quantum-physical transformations (concurrency and at the same time overlap of several processes; here, Davies makes reference to the concepts of quantum computing). Davies further points out that the overlapping, superposing processes of information processing eventually 'project out' life. This information processing action not only creates a very large number of possible alternatives, but it also creates at the same time information about the candidate to be selected. Moreover, this is the candidate who has the largest state space based on our hypotheses (Davies only uses the following paraphrase in this context: *branches of the wave function containing life* Abbott et.al., pp11).

We propose, instead, the following chain of argumentation. These forthcoming 10 points are based on the presented concept. We need to include one further perspective: a brief discussion of the role of quantum mechanics. The physicist Zeh analyses in a recent book the ongoing dogmatism in quantum mechanics (Zeh, 2012). On the one side, the followers of quantum probabilism can be found. Based on this concept, reality does not exist in any fundamental manner, but only statistical measures and corresponding statements. The main drawback of this approach is that capabilities and dispositions as described in this text cannot be derived out of this statistical approach, because there is no fundament to rely on. On the other side Zeh places quantum determinism. This concept is based on so-called hidden variables, but cannot explain the emergence of new ideas. The relational concept of information as developed in this text cannot be derived. Zeh instead proposes a many-worlds concept. In simple words, this idea attributes a fundamental activity to any system. Classical determinism attributes only one root of all causes, and allows only one fundamental source of any activity: the so-called big bang.

Here we can - with regard to Section 2 - conclude that the idea of a many-worlds concept in physics may not only overcome the current dogmatic blocking in physics; it might also lead to a many-people concept, where we can add physical evidence to our imagination. Our proposal goes with Zeh’s idea of the many-worlds interpretation of quantum mechanics. This system model and underlying logic explains how new structures as new ideas might appear which are capable of establishing new causal chains (in a Kantian sense). We think that the ongoing dogmatism in quantum mechanics is an expression of the increasing economic pressure worldwide, especially in science. Students become less and less encouraged to express and develop new ideas or concepts. The next 10 points are offered as a narrative aid to envision the prospect and range of this paper:

1 Whereas causal relationships mark physical relationships between past and current activities, ‘non’-causal relationships mark relationships between future and current activities.
Causal activities emerge out of traditional determinism: forces are exchanged between bodies and bodies transfer energy without adding new chains of causal relationships.

‘Non’-causal activities emerge out of future configurations of systems and their relationships. Systems are seen to be capable of entering into their own configuration space, and thereby setting up multiple new possibilities and potentials for further interaction.

The process which is capable to enter into its own configuration space is conceptualised as physically describable process (using Spencer-Brown’s theory as backbone: The Laws of Form).

The application of Spencer-Brown’s model makes sense because the so called ‘many-world-interpretation’ as proposed by Zeh and others enables a consistent interpretation of the overall proposal, as noted in this paper.

Given these preconditions, any interaction between replicating systems may enforce the informational existence of many different possible convergence points (or ‘solutions’), whereas the traditional set-up could only identify one single solution.

‘Informational existence’ means the emergence of new structural couplings in the complex plane (physical parameter like energy or space show up in real- and imaginary-valued components).

We propose one single identifier which represents the progress, or the value of any activity: it is the measure of the size of the phase space of the interacting systems (experienced as personal mood and sociocultural atmosphere). Interactions will always take place in shared phase spaces. It is understood that systems are capable of measuring their own size; we assume similar capabilities of continuously measuring their phase spaces (Laughlin, 2015).

Systems will always tend to maximise their phase spaces. A major driving force behind this kind of behaviour comes out of the low entropy of the universe, which becomes continuously transformed into new potentialities.

In summary, whereas the classical model fails to deal with a physically consistent explanation of mental causation, our model takes additionally into its focus a dimension which up to now has only had an illusory state of existence: our own future.

The structural law of a first simple self-replicating system contains explicit information about the (e.g. statically described) existence of the components required for replication as well as of the information for embedding this process in the ‘active’, i.e. selection-effective, physical framework. This means that the internal system descriptions develop the range of phenomena, which become selection-effective in the shape of the updated structures emerging in the process. Due to such a structural regularity and the respectively developed shape,

new state spaces become evocable whereby
another unbalanced distribution of energy is achieved.

Hence, the following is typical for the further replication process:
Hypothesis of the immanent principle of living systems: The Production of information is the immanent principle of the development of living systems:

a. The shape of each replica is developed by its structural law (depending on the individual, specific characteristics emerging through interaction with the environment; also distinguishable classes of replicas due to systemic environmental influences).

b. The meaning (i.e. the information content) of each replica is shown by the structure of the ongoing replication process. The latter is driven by the elimination of the internal inconsistencies and/or energetic imbalances that create such replicating systems. This implies: organisational structures of living systems that do not support the development of the potential of all individuals will generate higher energetic imbalances than cooperatively organised systems. Or put in another way: cooperatively organised systems create a higher energy gain for all the involved individuals (through the transition in new phase ranges), and/or much less waste. Moreover: when cooperative systems create an overall situation that is energetically balanced, it is more likely that the system as a whole will perform another transformation process towards the creation of new structure and state spaces, wherein all the involved elements will participate in these new state spaces. Further, this implies: freedom and unity are interdependent and conditional on one another. Growing phase spaces create more freedom, and also more connectedness (giving a balanced weight to the connections).

c. As a consequence: personal freedom and mutual interconnection are created out of all of our compositional interactions (and including any species). Freedom is multiplicity, divergence and convergence combined.

From the beginning, the structural law of these replicating systems has had a causal form that is effective up to and/or starting from the smallest particles of the replicator (molecule, atom, quark, etc.); i.e. its status is identical to the uniform physical regularity that has already been sought by Schrödinger. Each of such systems has the characteristics of traditional information storage (structure and/or structural regularity as an information medium for the replication) and interaction with other molecules (communication as an exchange process with the environment), and/or the environment. It is basically an interaction molecule that can use other molecules to build a replica or alternatively destroy other molecules. Eigen and Schuster have discovered the so-called hypercycle as a model of the emergence of life (Eigen and Schuster, 1979). Their work has inspired our approach - we added the oscillating, imaginary dimension. The initially explicit transfer of the complete structure of the replicating system creates the preconditions for enrichment of this structure by later versions up to the formation of multi-cellular systems. However, this can only be possible if previously achieved levels of development are still informationally present in developing systems. The formation of replicating systems enables the development of previously non-attainable state spaces, because the fundamental laws and/or dispositions of nature are contained in each of such systems as immanent information up to the smallest particle (structural laws of the system). Otherwise, no consistent development of larger state spaces would be possible: the system would collapse informationally. Or, seen from a different perspective: the structural laws of living systems are ‘naturally suffused’ by the state spaces that could
possibly develop during interaction with the environment. The balance or the gains of the effective structural laws is therefore immanent to the core of these laws: they ‘know’ their own structural laws.

Replica and replicator are connected extremely closely in the replication process. This means that precisely in this moment, the structural law not only of the replica, but also a version of the state space of the unforeseeably ongoing replication process, is generated informationally through interaction with the environment up to the last atoms of replica and replicator. In the process of system replication, replicate and replicator are connected in such a way that

a causal dimension: the structural law in the process of replica creation is energetically active; and simultaneously

b ‘non’-causal dimension: the molecules being created in the replication process start interacting with the environment whereby the possible state spaces are also tracked energetically in an active way, leading to a selection of those with maximum information content, which will constitute the developing potential of the system.

At this point, a structure is ‘design’ and ‘program’ at the same time (in terms of our reconstructed interrelationship of causal and ‘non’-causal processes). von Neumann had already seen this double perspective. The understanding of beings as program-driven systems is by the way based on his so-called von Neumann computer architecture. Remarkably, a ‘monitoring unit’ conceptualised by von Neumann is required to decide whether the current mode is ‘program execution’ or ‘program replication’ (there are no other modes). A programed system cannot make this decision of itself. Living systems, however, can. It gets amplified and exposed in our personally experienced mood and spirit.

We have analysed the logical foundation of this process: interacting systems continuously strive to enrich their phase spaces, and this can be expressed via the imaginary dimension of possibilities.

What is special about this is the fact that the transition from one range of phenomena to the next does not occur algorithmically and is consequently not programmable. Let us take another example for exemplification: We all assume that physical laws hold - given whatever boundary condition, or whatever distribution of matter and energy in the entire universe. We assume that this also holds true for an emerging law, or a new phase space (let us imagine when the first snow crystals have appeared in this universe: we would not think that such a sudden appearance of snow crystals could not happen on one of Neptune’s moons). What does that mean? It means that the content, the meaning of any emerging and real physical law or disposition is true and independent of any boundary conditions. However, this holistic approach may not hinder the understanding of good or better conditions so that new ideas can appear. For living species, diversification of ideas and distribution of knowledge (that is: accessible phase spaces) to all species will support and help to develop new phase spaces together.

Still, this process is responsible for the development of living beings. It is the process that records the development of the holistic structure of the living being in connection with its environment in one point and towards a new law and transforms it in the direction of a new regularity and/or of enlargement and maximisation of the state spaces. Out of this, the process of awareness/consciousness that reaches through all organisational levels will then develop accordingly: we feel what the truth is.
The power of this process in the context of the given environment (that has also been changed by the process) gives us an idea of the potential that can be unfolded by such systems. Therefore, we suggest talking not only about autopoietic, but equally about heteropoietic systems because the connections woven by such interacting systems make them precursors of subjects of experience. The structure of hetero-/autopoietic systems immanent in nature therefore consists of: maximisation of the state spaces through cooperation and exchange of information, i.e. the development of its potential. In short: the continuous meshing of the double aspect of information:

a) the structural law (causal dimension)

b) the distinct shape and/or the range of phenomena (‘non’-causal dimension).

Let us think about a well-known optimisation strategy in biology. A short-term strategy for survival may build on the continuous allocation of new sources of nurture (competition for limited resources). However, competition leads to more stringent selection. It is amazing that there is still a second possibility of self-organisation of relationships to minimise the energy needed to sustain a living system: cooperation, synergy, symbiosis, connectedness (Hüther, 2015). It should be this kind of self-organisation that enabled the formation of the first more complex creatures. The organelles of the eukaryotes are prokaryotes integrated into these cells. Multicellular organisms are cooperative associations of monocellular ones. Social systems and, finally, human communities are also the result of the cooperation of previously autonomous individuals. The common feature of such mergers is the need to conserve and secure the stability and structure of the resulting system. This is their long-term selection advantage, which at the same time it opens them up to a constantly growing possibility, and to the development of their potentialities.

There is a strategy that allows a continuous, unhindered and undisturbed development of the potentials of a living system. This is the constant reconciliation and revision of the patterns of relationships established within a living system to the requirements arising from the most narrow and maximally diverse relationship between the affected Life form with as many different forms of life as possible. For this purpose, a living system would have to develop in such a way that it is optimally able to enter into such relationships with other forms of life. It would have to develop an ever better and time-learning brain and connect the resulting brain with each other. Then it would be possible to combine the whole range of experience gained so far from living systems into a great experience and to use the creation and maintenance of conditions that not only develop their own potential but also the potentials that are applied in all other forms of life. Thus, life becomes a ‘knowledge-winning process’ and we are part of this process (Lorenz, 1973; Eigen, 2013). As we begin to recognise this process, we no longer need to let him run unconscious, we could consciously shape him (Agamben, 2003).

The double dimension of the information creation process of living systems, interconnected by consciousness, is consequently a fundamental, i.e. not subsequently emerging, characteristic of the universe. This is why, for instance, a practically examined physical process with its regularities is isomorphically related to our knowledge about this process. Consequently, our knowledge is not a copy or a representation of a physical process. Rather, it is this process itself. Our practical know-how is further based on applications of such knowledge (e.g. the kinematics or the dynamics of moving objects). Therefore, the regularities do not necessarily have to be known or expressly formulated.
They are available to the organism as potential. It applies this knowledge in a very fundamental sense and always by itself. In addition, we have the potential to connect different levels of reality: this is precisely how all information which is new and important for us is created.

However, when we newly interconnect such levels of reality we heavily create ‘unproven statements’. Those are new practices and inventions, which have the potentiality to transform our entire society. One of such an unproven statement is that deterministic/objectivistic science hinders our further development. To take it the other way around: as the truth is more than the sum of all algorithmically derivable statements, we have to include a basic human ability into a new perspective. This is our ability to create, view and directly feel imaginary points of convergence of our thinking. In poesy, we call those topics the ‘secret’ of a story, of a poem, or any artful artefact. For the secret of every poem is also and precisely in its rhythm, its measure, its form and form as a whole (Christensen, 2005). The same holds for interpersonal connections, and imaginations.

To make the point: let us envision, create and develop the whole imaginary dimension, which is by default invisible from a deterministic perspective, and illusionary from a libertarian perspective.

5 Conclusion

To summarise, we see universes of possibilities arising within all living species, each creating new physical realities and chains of causes. Living species hold primary activity, and there is no homunculus or other super-world-formula acting somewhere in the unknown background and keeping us as marionettes. By giving us many different types of intrinsic information (structural couplings, intrinsic knowledge of phase spaces), the universe itself is continuously trying to overcome its own boundaries. This is the reason why we are here. We change and develop the entire universe through our own activities.

We are, each of us, a striving and developing universe, capable of creating unseen fields of imaginary-valued relationships and corresponding memories. The concept of information may help us to overcome the current mechano-economical thinking. To achieve this, we propose a synthesis of some important thoughts and research activities. The reader might have wondered why we touched such different disciplines, such as quantum mechanics, biology, systems theory, neuroscience and others. The point is that all of them deliver important content for the required transformation (Kane, 2010).

The main topic is the proposal for the reality of two dimensions of the world: the real-valued and imaginary-valued dimension. The logical anchor for combining these two dimensions is the idea of the openness of the world, including unseen vacant potentialities - all enabled through logically grounded consciousness. This openness is based on an immanent tendency, which approaches by itself contradictions and paradoxes, in order to continuously enrich the phase spaces of the participating systems (which make up our experiences and capabilities). However, the dynamics of such a structuration moves towards a maximisation of meaning and informational content to all species. The evolutionary and historical record tells us that centrally controlled systems tend to lose importance (we may remember the long road to finally inventing democratic rules). Egypt culture developed an advanced military force (of course influenced by their enemies), and was based on a central organisation. The ancient
Harappan civilisation developed even earlier one of the world’s first civilisation in the Indus River valley, without any leadership cults and known wars, but with a high degree of individual lifestyles. Civilisation and the development of the common good may develop hand in hand, based on emerging and free communication and information.

However, aren’t we already living in the information society? Shouldn’t we be capable of enriching our personalities without wondering about a seemingly complicated imaginary truth value? Unfortunately, information science is still moving in another direction. The current decade has already been declared as the ‘end of all theory’ (Anderson, 2008). The underlying assumption suggests that an omnipresent computing and data mining system (computer chips and sensors in all products and spheres of life) already produces quantities of data that are large enough to make any ‘objective’ scientific method obsolete due to subjectivist data evaluation processes. It is correct that institutes such as the NSA or comparable organisations work on the basis of this doctrine. In view of such a potential to decrypt human action, however, any personal effort to find meaning in this world would become insignificant. The ‘end of all theory’ - approach is built on the dogma that any human activity can be mechanically deciphered. Our deterministic mindset and corresponding usage of ‘information’ consequently hits us with blindness, i.e. with a conceptual blindness towards our own potential to evolve and develop.

Any theory should help us to better understand what’s going on. So let us for this moment think of the scientists and programmers who want to predict our behaviour in order to maximise economic output. What would happen, if we could commonly sharpen our understanding of the power and needs of ‘real’ imagination? The philosopher Sartre explained that the imaginary process relies on intentionality, and placed the centre of the required activity into any living system (Sartre, 1940). Today we perceive an increasing passivity and consummation orientation, which hinders the imaginary process and our engagement into a human future.

At the first glance, it seems that this proposal is just another dualistic position - a continuation of René Descartes core idea. However - in the spirit of Schrödinger’s search for a new type of physical (or even super-physical) law - it is something different. It is the proposal that if we engage us consciously to enrich our phase spaces, and develop our potentialities, than the formerly dualistic position (object - subject; material world - consciousness) will be transformed towards a yet imaginary, but interconnected tale and conceptual framework, which will dissolve and melt those seemingly conflicting counter-positions. Such a transformation will support the creation of more potentialities. In the history of life and humankind, many such transformation processes took already place. There is no reason why we should not be able to develop substantially new self-understanding. When the snowflake touches earth, and melts, it creates a still secret universe of organic development. So could we.

What is to do? The discovery of our causal and ‘non’-causal nature might by itself create something; what seems to be disappearing in our modern civilised world: the vision and imagination of a common, intrinsically given future.

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This text is dedicated to all refugee children.
Both authors are working towards a new foundation, and - even more important - a new attitude with regard to the human spirit. Their current and future work aims to bring the imaginary dimension of life into the foreground. Approaching this attitude, the sense of life may become physically expressible, but will remain and will be unfolded in human interaction.

References


Thinking, future and ‘non-causality’


