Unexpected applause for the human mind: the limitations of deterministic approaches in neuroscience – allowing us to become who we are

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Abstract: Amazon, Google and others seemingly know more about our own wishes and belongings than we do. It has been announced that artificial intelligence will soon take over human expertise (i.e., deep learning systems). Neurological investigations explore functionality but also seemingly misconceptions of the human brain (see book titles like *The Idiot Brain* and *The Self Illusion*). We are putting forward a logical and physical concept in neuroscience (which we call 'OMB': oscillating mind-body model) which abandons the classical neuro-scientific methodology with regard to a physically inspired concept of (human) imagination, and develops in formerly physically forbidden zones of imaginary-valued system states. The nature of such imaginary-valued states is based on deep participation at a greater, dynamically emerging wholeness, which – when re-entering into the real-valued states of the species – creates consciousness (in the sense of sharing knowledge with oneself about something greater). This approach lays foundation to newly understand and putting forward major pillars of our society: dignity, faculty of judgement and creativity. We provide a first analysis with regard to an emerging double standard, as induced or at least supported by determinism. How to overcome this dilemma? The deep nature of our knowledge strives us to 'become who we are'.

Keywords: double standard; determinism; thinking; imagination; information; oscillating mind-body model; OMB; neuro-quantology; third truth value; anthropology.

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Biographical notes: Gerhard Luhn obtained 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 (Academy for the Exploration of Human Potentials)' in Göttingen. He 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.

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1 Summary – science of the mind on the path from deconstruction to mere applause

The classical scientific worldview (determinism) lays the foundations for both neuroscience and AI, and heavily influences the overall technological roadmap of homo sapiens. However, while focusing on deterministic features, classical neuroscience fails to explore the main features of modern culture: dignity, faculty of judgement and creativity. As a consequence, humanity is lacking a roadmap for a common future, and moral imbalance is growing worldwide. Astonishingly, the defenders of the deterministic/materialistic paradigm have nothing substantial to say with regard to the growing problems in modern human society.

Causality is a major concept of the universe, and humans (as all living species) are very good at determining and exploiting causal chains and mechanisms. One outcome of this is that modern society is approaching a new level of material well-being. However, we are losing in parallel our belief in the validity of the roots of such material well-being. Everything seems to be determined by physical laws. Based on such a mindset, people tend to control and measure other people as well, and to make other people to easily controllable objects – treating others (and oneself) as zombies. Zombies are a machine-like species which behaves like humans but does not 'feel' anything: they are purely based on causal mechanisms.

A main argument to justify the term 'artificial intelligence' is that humans are indeed zombies. Given such a mindset, Amazon recently invented "lifetime anticipatory shipping: uses your search history, cookies, and an advanced algorithm to determine everything you will ever want, need, and likely purchase", (Garrett, 2017). Analytically speaking, such telos reflects the aim of transforming the entirety of humanity into algorithmically characterisable zombies, and serve them bravely on an intercontinental supply board. One could argue that this seems to scarify scientific progress. However, the inventors of the scientific methods strived to liberate individuals and the humanity from external control, and increase the freedom and connectedness of people (i.e., Johannes Kepler, Galileo Galilei).

Do our internal/subjective feelings exist in reality? Does not artificial intelligence and even philosophy tell us that we are zombies? What else may exist behind our causal view of the world? A recently held conference, which has for the last 30 years annually assembled specialists in microelectronics, created the following outcome (Moyne, 2018). One would expect that those designers and producers who invent and produce precisely the substance and ingredients that comprise the dreams of AI-tinkerers themselves are deeply intertwined in the AI-web. However – ahead of their highly innovative inventions and strengths during the last 50 years – the microelectronic specialists are partly sceptical in how they see the role of AI. They think that AI seems to lack any innovative power or imagination, including the creation of innovative artwork. Consequently, specialists have made the issue of 'subject matter expertise (SME)' part of their agenda for the forthcoming years, in order to make their contribution to a necessary humane dimension in modern-day projects. The core concepts of 'SME' are phenomenological rich models, which are seemingly directly imagined by engineers and conceptualised in engineering systems as 'phenomenological models' [see the contribution of Luhn et al. (2018) at the abovementioned conference].

The painter Sophie Cau (brought up in the French city of Royan: https://sophiecau.org/) dedicated Figure 1 to this paper.

Figure 1 Joie, Freude, Joy, by Sophie Cau: 2014; with kind permission (see online version for colours)

The deterministic worldview and corresponding ideas in biology and cognitive science does not see that there is something more fundamental behind mental processes and states – something like a true self (Strohminger et al., in Press), which may unleash real innovations as fundamentally new structures of the world.

The scope of this paper is to work out a fundamental human capability, which underlies any causal activity. This layer is made up of a physically inspired logic, which does not act as a function or get stimulated via any input, but serves as a general logical form. We argue that any living species possesses a primary activity which does not react to anything (as a function), but which continuously transforms each species in order to increase its phase space. Any newly discovered phenomenon goes along with such a primary self-transformation. Any species – besides reacting in a functional manner to any input – continuously dissociates itself in its most fundamental pattern of altering, oscillating meanings. We show that imaginary states (trust, love, … any 'qualia') cannot be objectively measured, but only experienced within interactions between minds (which is, however, another kind of measuring). To conclude, less abstract states, which incorporate higher degrees of motor/sensor activities show higher degrees of real-valued system states, which could theoretically be measured. The more abstract the concept, the higher is the degree of imaginary-valued, only via other minds perceivable/ measurable content.

We are not alone – as materialism tells us – but creating and sharing imaginary states in formerly unseen dimensions. We need to learn that the interaction between body and wholeness holds the capability to "step out of the dust (actions primary controlled by causal chains)" and may create moments of insight/overview, which themselves are creating our inner compass. We need to learn that a non-material wholeness gives direction for morality, dignity and faculty of judgement.

In simple words, we are continuously striving to make up our mind.

Science usually strives to reconstruct and predict the behaviour of any system under investigation. Galileo Galilei and others invented this method in order to free themselves from dogmatism. However, when entering these spheres to discover the human mind, the scope of science inverts itself. Throughout this study we will examine that science is expected to transform from a pre-describing to a more liberating (or 'applauding' – in literal sense) undertaking, shifting the focus from pitying amusement while discovering so-called dysfunctions of the mind to a deeper understanding of mindful participation, following the intuition of Galilei.

This paper puts forward a detailed analysis of the deeper logic and meaningfulness of our thinking and acting. Today, our concepts of 'knowledge' is primary based on reflections on how we are in contact with things and object. We think that knowledge is causally organised, because interacting with objects typically holds a causal structure. And we are indeed very good in causal thinking and acting, as the rise of modern technologies and products show. However, there seems to be another dimension as well. It seems that our knowledge, which is especially based on contact with other humans (and ourselves) holds a different, at first glance more complicated structure. This dimension seemingly covers human potentialities and the sources of imagination. The physicist David Bohm once mentioned that practically all the problems of the human race are due to the fact that thought is not yet proprioceptive. Because of this, we do not trust in what an opposing human being might do. However, it seems that we all want to participate in and create a greater wholeness. This paper hypothesises that we can indeed participate in the sometimes-overwhelming work of our mind. We will analyse and promote the structure of rich and mindful activities, thereby enabling a better future for all of us.

But hold, might one state, does not the deterministic worldview argue that knowledge of a deterministic cause of crime leads to more compassion and leniency towards offenders. Many representatives of science, including well-known neurobiologists such as Wolf Singer or Gerhard Roth, argue that our thinking and acting on the basis of clear laws of nature is completely inevitable (so-called determinism). Therefore one should treat offenders rather mildly, since their actions are determined by coercion.

Do you, dear reader, notice something about these words? Do you recognise the double standard behind it? The protagonists position themselves – perhaps without even realising it – outside of the (deterministically described) moral system. What knowledge determines what is good and what is evil? Is there a natural law that grants (or prohibits) the right to asylum? What prohibits the construction of nuclear power plants, or even nuclear bombs?

A double standard is the application of different sets of principles for situations that are, in principle, the same and is often used to describe freedom that is given to one party over another (Wikipedia). Countries like ex-GDR practiced intensively such double standard (one of the authors escaped from ex-GDR). However, they failed. We argue that the deterministic worldviews in general will fail, because they promote ‘unnatural behaviour’ from within an intrinsic and deep perspective.

Determinism propagates double standard and intrinsically inconsistent morality.

To summarise, we propose that scientific work should follow what free and creatively acting people are somehow doing anyway. This especially holds true for so-called ordinary people (who actively practice ‘damping down’ modern days information overload and marketing-driven overload), but who on the other hand are very open-minded while interacting with foreign people or even refugees. Nature encourages us to free our minds and follow the impulses in opening new phase spaces.

Our feelings seem to intrinsically point out the possibility and necessity of a new world view. They tell us a story that we have forgotten to listen to today. It is the story that deals with the fact that today, in the deterministic view of the world, we cannot imagine what we will be. We want to make a contribution to this story with this essay and cordially invite you to take it with you: “become who we are” (our emphasis goes with the idea that we are literally and fundamentally not those we will once be – this of cause cannot happen in determinism; idea goes back ancient Greek philosophy).

2 Intro: toward a participatory universe

For hundreds of thousands of years, humankind has been exploring valleys, mountains, oceans, the entire planet, the moon, the solar system, and ultimately (and maybe since the beginning) the universe. Starting in smaller communities, they have invented agriculture and built up big social systems, causing growing and sometimes huge impact on their individual members. The invention of democracy presented a greater and more informative level of participation for all people. The invention of the scientific method freed people from dogmatic religion. We know now from neuroscience that brain processes (and our thinking) always tends to minimise energy consumption. However, the now existing worldview has preserved the scientific method (invented by Galileo and Bruno), but has replaced the personal and participative involvement (as practiced by Galileo and Bruno) with a mental-/brain-energy-saving scientific approach, which places human subjectivity (including morality) outside of nature. This overall trend gives the rulers of science legislative empowerment:

a to declare such ‘laws’ as they discover to be truths as ‘dictated by nature’

b it releases and excuses scientists from any sense of moral responsibility for what they say and do

c gives power to the rulers of a society which uses science in a primarily deterministic manner (which empowers materialistic economy, because values such as fairness and trust are not part of determinism).

It seems that modern deterministic science is a reason to further expand the gap between poor and rich, and to further destabilise the social connectedness of all communities of this planet.

But what if the deterministic worldview were not true? What if the most fundamental structuring of our own knowing and acting finds itself not outside, but at the centre of nature? Now, physical ideas in these areas are not new and have been alive since the dawn of quantum mechanics. "All things physical are information-theoretic in origin and this is a participatory universe" [Wheeler, (1989), p.311]. However, it might be somehow advantageous for all of us to think deeper about this approach. It will (re-)introduce the relativeness of information/knowledge (and lay down foundations for meaning), and will pull us out of a comfortable and 'long-armed' determinism into an oscillating mind-body perspective. This specific architecture enables 'endless' and fractal-esque nested oscillations, which tend to stabilise themselves in what we call 'future' ('future' is a projection and further stabilisation of the system and its environment through multi-threaded extensions of current activity profiles). Now, unexpectedly, such an extension may transfer imagination-/imaginary-valued energy back to main oscillatory profiles within the human, and will at the same time feed psychological processes which we call 'free will', 'motivation', or 'imagination'.

What does that mean? The idea behind classical physics is to solve an equation in one (or few) steps. We confront this approach with a setting in which the solution is not a single root of an equation, but also includes in principal endless convergences (or divergences). Based on this concept, on the one side we fulfil physical-methodological strictness, but on the other side provide the required interpretational spaces for biological and humanistic considerations.

Basic candidates for such unifying solutions are physical oscillations. Any physical system is a composition of waves. However, within living systems some highly influential architectural advancements occur. Living species can oscillate with themselves, and when they interact with their surroundings, 'participation' happens. Additionally, different oscillation modes codify 'information', as we will see in detail.

Now, systems always tend to transform themselves toward patterns of lower energetic level. During creative work, they might step out of the borders of the current universe and create new, formerly unseen phenomena. Within the course of this study we will study the inherent relationship between such phenomena and dynamically new physical laws or relationships, as they emerge and dynamically materialise through the oscillating mind-body (OMB) system. Such phenomena are usually bound to an overall wholeness or meaning (we take the notion of such 'wholeness' from an ontological perspective as dynamically appearing physicals laws, creating and enabling new, physically describable phase spaces). However, when such wholeness loses consistency, people tend to expand their own decoupled universes within fractal dimensions of egocentrism. More generally stated, deeper states of egocentrism always correlate with less open communication, but to higher control and steering needs.

We see the possibility of anchoring a physical-biological concept of thinking and acting within a logical base form, to potentialise senses of knowledge and morality (Knobe, 2010). Simply spoken, we all 'know' and participate in a logical form, which leads to expanded connectedness and freedom at the same time.

A.1 *Physics, subjects, objects.* We assume that any action – including moral action – can be subsumed under measures of phase spaces; we claim that any action always strives to expand the phase spaces of actors. We may distinguish between subject-object related (between living and non-living systems), and subject-subject related (between living systems) interaction. On the subject-object level, such states may unravel new phenomena such as physical or technical discoveries. On the subject-subject level, such states develop societies of animals and humans, up to the first democratic systems. However, thoughts easily combine those different levels, and may transform subjects into objects in order to causally control them. This process was especially fostered when human societies began to grow – long before the invention of democracy. Hierarchical forms of organisation in human societies grew and expanded due to the invention of agriculture. Unbalanced scenarios appeared, where only one or a few actors are harvesting the fruits of their activities. Later, the invention of democracy was a step back to a more balanced scenario. Additionally, the latter scenario maintains a higher probability of a transformation of the entire system toward more efficient usage of energy, and further development of knowledge and culture. In simple words, the core impetus of subject-object and subject-subject interaction is to increase the phase space. So – for example – it is better to invite your enemy to a further discussion, because he deeply wants the same thing: phase space extension.

Now, how can it be that a 'mind' influences the body? What is 'mind' anyway? If we step out of determinism, then we see that colours and human rights express similar legacies: such states express so far not yet conceptualised 'forbidden zones' of oscillating, complex-valued system states. We will expand the topic of any living species oscillating with the environment, but also with itself; and such self-oscillation will foster – from a mathematical perspective – imaginary-valued target structures.

The informational content of such oscillating structures is identical to the structural law or the lawfulness of the global attractor – the 'target' of such oscillation (we take in this paper the term 'lawfulness' in a physical sense – however, we stick with concepts in neuroscience which conceptualise neuronal dynamics in terms of 'lawful nonlinear pattern' [Le Van Quyen and Petitmengin, (2002), p.3)]. Now, the 'mind' emerges if we further embed this oscillation-law into 'resonant cell assemblies' (Cosmelli et al., 2007; Varela et al., 2001; Varela, 1995). However, the outstanding mind-body interaction seems to happen in following simplified manner. The body creates and exposes a growing set of sensing and capabilities to move. Points of convergence appear, which indicate self-forming capabilities. Such points are holding an imaginary-valued mathematical status, because they are no real movements, but something similar to moving capabilities (dynamical physical laws). Each body may create one of the multiple worlds, which interact on a quantum-physical level. Now, such interactions are creating a wholeness, which itself causes restrictions to the bodies. As such restrictions (or 'directions') are imaginative, consciousness appears. However, this interaction between body and wholeness holds the capability to "step out of the dust (actions primary controlled by causal chains)" and create moments of insight/overview, which themselves are creating our inner compass, or inner eye.

Concepts for conscious information processing have already been developed, including innovative proposals to clarify phenomenal experience (i.e., Das, 2007). Das (2007, p.4) proposes that a subject perceives specific phenomena when "she has a sense of perceiving these features within the context of yet more elementary features extracted at lower levels without actually shifting her attention to those lower levels." Now, this holistic approach needs to be mapped toward a scenario where we not only access information from lower levels, but primarily from resonant points of convergence in complex (real and imaginary-valued) dimensions.

Now, from an epistemological perspective, something new happens: we need to treat the existence of systems in separate 'worlds' so that the 'mind' holds the capability of operating and mediate between different worlds: the environmental world and the world of the body. We hold that these two worlds are somehow separate from each other (each holding distinct physical structures), but nevertheless close to each other, so that interaction can take place, and creating the formerly mentioned wholeness. This interaction is called 'mind'. However, in classical physics such 'multi-worlds' do not exist. We lay down in detail what this means. Each living system develops rich capabilities for sensing the outer and inner worlds. Humans became capable of states of rich seeing, intrinsically combining sensory experiences within bodily contexts. We conceptualise the truthfulness of such 'rich seeing' with a further increase in the phase spaces of living systems.

A.2 *The mind.* The mind is not an object, but is based on a self-oriented (subjective) logic, which forms demands of (physical/psychological) work in order to develop potentialities towards an increased wholeness (increased phase space). Based on a fundamental logical-physical form, the mind possesses an ability to primarily initiate mental activities and states, and thereby approach new wholeness.
Given this ability of primary activity while creating new wholeness, the mind initiates altering states of consciousness (wakefulness, sleep, hypnosis, and hallucinations), perception, thinking, judgement, language, feeling and memory. The (physical/psychological) work of the mind is thinking.

The interaction between body and wholeness holds the capability to "step out of the dust (actions primary controlled by causal chains)" and may create moments of insight/overview, which themselves are creating our inner compass.
A non-material wholeness gives direction for morality, dignity and faculty of judgement.

The mind is a faculty of nature for somehow establishing and operating structurally independent worlds while approaching imaginary-valued states. Such imaginary-valued states are non-causal but 'lawful' structured states. Classical selection theory cannot be used because this would require a set of available real-valued states upfront, upon which selection could perform (Gabora, 2005).

A.3 *Growing phase spaces instead of Darwinism.* Whereas a core concept of Darwinism is to argue for the survival of the fittest (selectivity by competition), we argue that it is not nature that selects, but instead species that create new emerging phase spaces (new wholeness). Of course, species may be hunted and killed. But we explain a perspective which puts an overall trend toward the growth of phase spaces into the foreground, covered and participated by the activity of all species. Such phase spaces cover real and imaginary valued dimensions. We argue that as we create access to remote – imaginary – attractors, the overall aim is not to win over others, but to create worlds of enhanced, interconnecting phase spaces.

We see the mind in a state of potentialities, whereas the selfness of such states creates subjective worlds in a radical sense. Such worlds are primarily not made in terms of a selection of memes, or cultural ideas. Our impulses continuously spawn networks of formerly imaginary connections, with a tendency to make us 'better'; that is, any morality is deeply anchored within all our activities.

A.4 *Reality.* While science objectifies thoughts and makes them interpersonally common (or 'real'), free will and action immanently goes beyond such physically real states. We assume that people's understanding of human action and free will is fundamentally different from any 'objective' science. Typically, science does not pay attention to transcendence. Contrary to this, we conceptualise a radically different perspective on future science (see also Knobe, Forthcoming).

This text proposes to integrate subjectivity using a radically different approach. We will work out a concept of 'rich seeing', as based on active participation, and though anticipating automatically a positive morality.

The mind in this sense is a far better theorist than any scientist, because it constantly strives to imagine so far unknown 'unproved statements'. That is, the mind continuously trespasses the borders of any information which is so far known or available within the entire universe. In other words, the universe is founded on the basis of a fundamental logic that continuously creates statements (or questions) which the entire universe cannot as yet answer by itself. If this is true, then we may indeed offer some applause for such minds, operating in imaginary spheres far beyond what is actually known. We propose to inverse this perspective. The goal is not (only) to deconstruct and analyse deterministic molecular mechanisms, but to participate in the wholeness which such minds strive to form.

Such states of 'rich seeing' are capable of modifying or entirely transforming our so-far causally coded action schemes. Here, something like 'willing' appears, which creates new perspectives of an organism [we use the word 'perspective' in the same sense as Damasio (2018)]. In summary, we propose that the multiverse perspective may provide a concept for overcoming the current dilemma between the idea of free will, and the deterministic scientific vision. In short, we feel ourselves to be in a restricted and unfree situation if we rely on a deterministic one-world-perspective.

We also discuss the scope of so-called 'deep learning' systems. A core idea of DL-systems is to replace intelligent human behaviour and knowledge. We suspect that this motivation comes out of a superficial concept of learning. We further suspect that current DL-systems will not have the capability for 'active participation'. This is a core capability of humans, especially required in order to learn about and develop new phenomena; and defects in this field may lead to schizophrenia or amnesia. However, DL-systems have the ability to assist people in complex environments. On the other hand, efforts are spent in creating humanlike androids (Fung et al., 2016). All these systems are based on a deterministic worldview which by default masks the outstanding capability of humans: active imagination. To summarise, while underestimating the depth of human knowledge and imagination, we risk unrealistic expectations.

We base the proposed *OMB model* on one of the most important findings made in the field of neurobiological research in recent decades: the discovery of the enormous experience-dependent plasticity of the human brain (Merzenich, 2013; Hüther, 2006a, 2014). Such plasticity mediates within a process of self-synchronisation and self-development. Although inconspicuous at first glance, this reciprocal structure (the concept of a 'self'), especially in human brains, yields to a fundamental recursive structuration, exposes itself in the process of 're-entry' and leads inevitably to the altering of real- and imaginary-valued system states. A structural singularity (phase transition) causes the higher-dimensional emergence of an infinitely OMB process. However, this process stems from much simpler primary recursive oscillations, initially developed by the most primitive forms of self-initiated movement and sensing (details in Sections 5 and 6). Now, as humans have evolved, the structural rules of building the living systems have become flexibilised within a fundamentally new architecture: the rules of building the system have been parameterised in such a manner that the system may transcend its present (current activity schemes) toward a so-far unseen future. In simple words: humans are becoming scientists in the spirit of Galileo Galilei.

In this paper, we bring SME into the relationship with imagination. We introduce an example of SME in the semiconductor industry, and clarify the criticality of SME with regard to modern technology.

After an introduction paragraph, Section 3 ('overview: on the deepness of knowledge and imagination') highlights the main idea of this approach. We introduce 'knowledge' as a recall or a transformation of an input signal to an output signal, typically based on structures of causality. Contrary to this, 'understanding' appears when recall conditions free up in a certain manner and further transformation toward complex competences (Rychen and Salganik, 2003). Finally, 'imagination' ('thinking') gets introduced as the ability to create 'unproven statements' as physically 'forbidden' (imaginary-valued) system states, transcending mind and body toward an intrinsic concept of 'future'. While 'objective knowledge' is based on a simple input-output characteristic, 'understanding' requires self-reference. Such self-reference mediates as 'imagination', and is related to self-modification (in terms of a conceptual dissociation and further modification of the self-concept). Artists strive to re-invent themselves anew.

Section 4 ('theoretical background – state-of-the-art in artificial intelligence') analyses three theoretical levels which need to be differentiated, and highlights the new conceptual approach. We conclude that the usage of DL-applications requires not less but more expertise in comparison to classical or legacy computer applications.

Sections 5 and 6 ('3. The phenomenon; 4. The proposed solution – logical dimension') introduce a physically grounded concept of information, and expand this concept toward human knowledge. The interplay of explicit and implicit knowledge supports the proposal of a new logical account as a fundament of our thinking. While classical logic tries to statically determine the truthfulness of certain thoughts, our proposal explains the structure of the underlying logic, and concludes that life itself is engaged in unlimited oscillations, producing 'true' or 'false' statements. However, there is an overall tendency toward further extension and growth of the phase spaces populated by living systems. On this level, 'truthfulness' serves as an indicator of how far our imagination and imagined future states may become real, and extend our phase spaces. Our idea is that the proposed approach helps to decide on valued paths towards a common and ethically reliable future.

Section 7 ('the proposed solution – physical dimension') roughly sketches a quantum-physical grounding for this approach, which ends up in an analysis that all living species are showing a fundamental primary activity (contrary to the deterministic worldview, which is still used in common neuroscience and also in 'deep learning').

Based on those findings, Section 8 (on the deepness of human knowledge – the difference between knowing and remembering/imagination) expands on the specific depth of human knowledge, which enables us to change things, and ourselves, respectively. We explain how new physical phenomena may appear in a computer-assisted environment, and we introduce a main scenario with regard to the interplay of SME and systems incorporating machine learning. We argue that new, interesting features of machine learning might be preferably used in a more technical sense. Simply spoken, computer systems should be designed in a manner so that they behave deterministically and with full transparency. Humans are very good at developing causal chains and causal knowledge. These are good preconditions for bringing computing systems into the game. Social interactions may become more complex and more imaginary. Computing systems based on current DL-technology may support our causal reasoning.

This approach leads to another unexpected conclusion: it is becoming clear that the goal of science is not to increase our knowledge, but instead to develop our capability of imagination and the capability of meaning. Seeing this, we may also re-examine challenges in society. A major challenge is human dignity and human rights. The existence and value of imaginary states or meaning will add evidence to a kind of moral behaviour which typically strives to increase personal autonomy and the richness of personal interactions at the same time. Within our current worldview, the idea of equivocally balanced autonomy and connectedness seems to fall behind egocentric forces. It is worth remembering that nature always tends to smoothen uneven distributions of energy at a large-scale, and may at the same time develop optimised possibilities to unleash further potentials.

Section 9 (conclusion: become who we are) concludes that – based on our deep internal structure, and based on the deterministic worldview – it is logically and practically impossible to imagine what/who we will once be. To put it another way around: this is a good sign and gives us freedom from an intrinsic manner. No reason to think of us as zombies!

3 Overview and main thesis: consciousness and the depth of knowledge and imagination

In this section, we foster a new or updated understanding of ourselves and the world. We start with a logical concept of consciousness, bring up the apparently existing relationship between semantics, meaning and imagination; and we argue for a 'room of reason', which seems to be inherent to our understanding of freedom.

Any natural learning takes place in newly emerging phase spaces, continuously enriched by spontaneously appearing, multiverse-grounded, new physical-structural relationships and competences. These phase spaces are fields of physical evidence which create a holism between new phenomena, the object of human interaction, and our subjective connectedness within. This trinity of subject/object/phenomenon-holism is grounded in a physical-biological framework, governed by an unorthodox logical approach which replaces classical determinism (dominance of external/causal stimuli) with a concept of multiverse-self-organised activity. Determinism teaches us that we are living in a grey world, and that colours, consciousness and human responsibility are pure illusions based on evolutionary algorithms.

However, the human esprit is not grounded on algorithms (albeit on inventing and using them), but on a deeper logic. This logic manifests itself in competences of recursive self-organisation, to propagate so-called 'unproven statements'. These statements are called 'phenomena' and are important inputs to further stabilise and extend the capabilities of the system. Subjectiveness enters the terrain when the internal organisation (we take the 'self-concept' as a physically derivable 'structural law') becomes by itself an explicit part of the phenomenon. Damasio (2018) calls this 'structural law' the *perspective* of an organism, incorporating the competences of an organism.

B.1 *'Unproven statements' build the connection between physics and a deeper logic of life:* When a system perceives its own self [its biological perceptiveness (Damasio 2018) – its structural law] as 'unproven statement' in the context of a multi-perspective world-model (multiverse), and thereby approaching new wholeness, the system becomes conscious. This scenario emerges as based on a phase transition in the evolutionary record, fostering the appearance of higher-dimensional structuration (fractalisation) of the base configuration of the system. Systems learn to 'imagine' the future within a multitude of potential contexts, including 'good' and 'bad' perspectives.

Since the first publishing of the human genome, researchers have tried to figure out the difference between the human and chimpanzee genome (Lander, 2011). There are already hints about a parametrisation of the human genome toward unleashing high-dimensional phase spaces (from the evolution of the opposable thumb to the evolution of language). Nevertheless, most of the work needs still to be done.

Due to the low entropy of the universe, nature tends to increase and develop 'unproven statements'. From a neurobiological perspective, consciousness mediates in transient and fluctuating groups of cells (assemblies) firing in concert (Greenfield, 2016). The accessibility and modifiability of these higher-dimensional phase spaces constitutes the main architectural difference between humans and animals – although apes like chimpanzees, gorillas, orangutans may already show portions of this structural change toward subjectiveness. We will develop a model for how this process can happen at all, and what follows out of it.

While living systems are characterised by their main capacity to enter into their own configuration space, humans not only enter, but also virtually dissociate and change their current configuration – without falling into chaos or losing consciousness. On the contrary: from the perspective of the multiverse-concept in quantum mechanics, the unity/wholeness which connects these multiverses into higher dimensional horizons of sensation is given through the OMB process. However, when passing the phase transition toward further fractalisation, the categorical difference between mind and body increases, until within the human mind the self and its entire world diffuses (in a physical sense) toward new attractors, conceptualising and potentially changing the world-body system within newly emerging, 'mindful' perspectives: the dawn of stabilised, complex-valued competences which enable the system to step out of the present toward multivariate future scenarios and rich contents of episodes.

However, this development enables conflicting mental states, including the mental states of other actors, to be displayed simultaneously. Those scenarios are glued together in 'episodes' and 'mimetic modes', based on the participation of such mental states to newly emerging wholeness and meaning (Gabora and DiPaola, 2012). Evolutionary research indicates that only humans hold such an ability (Suddendorf et al., 2009). This ability leads to the development of further relationships and strives to develop a common perspective for all members. Such a perspective mediates itself in what we call meaning and culture.

A common approach in biology is to describe the behaviour of animals by algorithms. Contrary to this, episodes do adapt and intrinsically maintain the 'algorithm' – due to emerging 'unproven statements' – and embed such unproven statements into overall consistency or meaning. This process is embraced by an overall tendency for all living species to continuously strive to enlarge their current phase space, including modifications of the base organisational principle of the living specie itself. For humans it leads to the so-called conscious mind.

Now, 'objective knowledge' (semantics) appears when recall conditions are cued to specific events. That is, specific events (patterns etc.) map to specific outputs, called 'objective knowledge'. We may also subsume 'recognition, finding' under this level (as 'recalled knowledge').

Contrary to this, 'remembering' or 'understanding' appears when recall conditions become 'free' in terms of the recall itself maybe taking place without external triggering. That is, to let different kinds of perspectives develop, including modifications of the self within rich contexts and episodes. There is a great deal of evidence of this, because it makes clear that any kind of 'stored' information gets continuously transformed towards growing phase spaces.

Within this background, Suddendorf and Corballis (1997) have analysed the evolution of mental time-travelling. They argue that this capability shows a discontinuity between humans and animals, because it requires the capacity to mentally reconstruct personal events from the past (reflecting personal trances/episodic memory) and project out of them varieties of possible events in the future. A main capability is of 'damping down' current inputs, and of dissociating imagined mental states from the present given this ability, a new kind of 'understanding' develops, because these new scenarios automatically create aspects of empathy.

However, we all know that mere 'understanding' may not lead to a modification of our acting. This only happens when we deeply connect with a new phenomenon and inevitably become part of something bigger: we develop our will and overall intent as part of a greater wholeness We know from our daily experience that this is not an easy job. However, new empirical studies suggest a relationship that seems to exist between belief in free will and life satisfaction (Li et al., 2017). Within our approach, we conceptualise 'life satisfaction' in terms of having the possibility to extend and develop personal phase spaces and competences, leading to an enrichment of personal activity. This is also the daily business of engineers. Engineers may be confronted with situations in which they are forced to throw away or structurally transform their objective knowledge. Given this background, the main difference between humans and systems of 'deep learning' becomes visible:

B.2 *On the structure of deep learning (DL):* DL-systems are based on the concept of recalling 'knowledge' in associations of specific events. That is, patterns are classified based on sample data, using neural networks (NNs) with multiple layers. However, DL-systems are not based on a framework of physical evidence, but of statistical association. For this reason, DL-systems do not 'learn', but they provide (a growing number of) association functionalities.

B.3 *On understanding:* 'understanding' appears when recall conditions free up toward higher dimensional perspectives. Judea Pearl proposes a concept of 'causal reasoning', which permits an ability to model counterfactuals within a causal framework. This approach tries to cover a 'symbiotic collaboration of data and models' [Pearl, (2018), p.7]. However, it still lacks the main feature of all living species: self-reference; and of humans: self-modifiability.

B.4 *On imagination:* 'imagination' ('thinking') is the capacity to create 'unproven statements' as physically 'forbidden' (imaginary-valued) system states. Those statements are non-algorithmically created through an instantaneous, quantum physical-based overlay of modifications of the self-concept (the structural law of the self), during or based on further interaction, and lead to the creation of new competences.

DL-systems are made of semiconductor circuits. For the moment there is no concept that DL-systems will modify themselves by modifying the circuits they are made of, and the body they are integrated in. However, the semiconductor industry is demanding competitive systems to further assist the development of SME (see Section 4.)

In 1985, the conscious experience of accomplished British musician Clive Wearing (b.1938) changed dramatically (Wearing, 2005). At that time, he was infected with the herpes simplex virus, which left him profoundly amnestic. This does not in fact touch his so-far acquired semantic memory, although his episodic memory is impaired. He lost his orientation in time (losing the ability to create new competences, or even to maintain existing ones). He can still play music, or recall facts about the world, but his conscious experience is entirely in the present (Suddendorf et al., 2009). He continuously feels that he has just woken up. Patients like Wearing suffer from the fact that the phenomenological richness of imagined events as well as the number of such events decreases. Clive Wearing cannot imagine future or remember past episodes, nor creating further meaning of his life. He has lost contact with higher dimensional phase spaces, which would require further structural development of the self.

Wearing's life reflects the relationship between semantics and imagination/meaning. It is far from clear whether DL-systems might eventually be able to incorporate 'causal reasoning', because semantic knowledge only seems to be created in the context of meaning and imagination. However, his life and career highlight some grounding principles of the richness of human thinking and acting. The neuroscientist Gerald Edelmann discovered the process of mental re-entry: the entire system re-enters into its own configuration (Edelman and Gally., 2013). This process is a key enabler in creating meaning and timely ordered episodes.

Seeing this, we want to defend and improve human responsibility within a further-developing technical world. In fact, none of the most prominent philosophical ideas brings those levels (B.1)–(B.4) systematically together. The most prominent philosophical ideas nowadays are determinism, libertarianism and compatibilism. In short, determinism states that everything is caused by fixed natural laws, which seemingly exist somewhere beyond the logical foundation of our universe. Libertarianism holds that freedom exists independent of nature. In addition, compatibilism explains that determinism and libertarianism are compatible to each other. However, while determinism does not catch physical fundaments of freedom (and is by itself a reason for growing egoism and imbalance in the world), libertarianism is unacceptable from a physical perspective (and overestimates real existing freedom: see the difficulties in democratic processes), and compatibilism does not provide a reasonable guidance for our actions.

The proposed approach is neither a dualistic nor a monistic theory, but strives to set up our imaginations and imagined worlds in a manner such that our freedom – and at the same time our responsibility – becomes an intrinsic part of our acting and feeling [enabling a 'room of reasons', which supports free argumentation and discussion (Habermas, 2004)].

The interplay of body and mind tends to maximise imaginary system states within newly emerging higher-dimensional phase spaces. In simple words: we are equipped by nature to strive for imagination, but we have on the other hand to hear and work with our bodies in order to overcome and extend the current borders of nature. Today, however – based on the deterministic worldview – mind and body are becoming seemingly unbalanced, because we have no idea about their unity and relationship. Determinism tells us that there is no relationship at all; if so, such a relationship would be pure illusion.

Albert Einstein once mentioned that imagination is more important than knowledge. Hence, our task and purpose in this world is to expand our capabilities so that we will expand nature, and maybe gather more insights and freedom.

For this reason, we need to dive deeper into a more profound understanding of the nature of physical phenomena, and the deep nature of human knowledge. Our aim is to show that besides objective knowledge, there is something tremendously more powerful which helps to make up our mind on a daily basis: our meaning and deep participation as a precondition for inherent freedom, and for consistent development of the mind-body system.

4 Theoretical background – state-of-the-art

> "On the status of 'deep learning' with regard to a logical-physical concept in neuroscience."

In this section we sketch the state-of-the-art within deep learning, and its relationship to the proposed OMB model.

Concepts of artificial learning have a long, but also changing tradition. Rosenblatt's first perceptron was built in 1957 [for the historic record see Schmidhuber (2015)]. In the early '60s, the dawn of symbolic computing (Marvin Minsky) pushed structural approaches into the forgotten. Just 5–10 years ago, applications in structured learning made visible progress (Krizhevsky et al., 2012).

Deep learning is a statistical technique for classifying patterns based on sample data, using NNs with multiple layers (Goodfellow et al., 2016). NNs 'learn' a mapping between speech sounds and labels (words); similar to object recognition. They work well in stable domains, and have made progress for example in translation (however, as long as they are not related to imaginary-valued episodes they do not 'understand' what they translate). Even newer applications which operate with types of intermediate language structures do not 'understand' anything; as we will see in detail.

Many new applications have appeared (autonomous car driving), and we are wondering whether robotised healthcare in hospitals and retirement homes will replace human nurses. The book on *Deep Learning* by Goodfellow et al. (2016) provides a comprehensive methodological and mathematical introduction, with an emphasis on probability theory. The book gives an excellent overview with regard to current systems and methods used in DL. However, the book lacks any relationship to biological concepts of learning, consciousness and the concept of free will. Goodfellow et al. (2016) introduce interesting methods of storing and managing certain kind of data, including the development of new kinds of data structures.

Nevertheless, the term 'deep' in 'deep learning' refers to an architectural property (the growing number of hidden layers used in modern NN's), rather than to a neurologically 'deep' conceptualisation of learning. The deep learning architecture does not 'deeply' conceptualise fundamental physical domain structures. Consequently, such systems may not predict newly emerging physical phenomena.

To illustrate the problem, let us take gravitational law as discovered by Galilei and Newton as an example. Researches might implement heuristics, which analyse variabilities between the distance which an object might have fallen down, the time it took, the weight of the object and other parameters (temperature, time of day, phase of the moon etc.). Some researchers even assume that they are 'distilling free-form natural laws from experimental data' (Schmidt and Lipson, 2009). The idea is to extract abstract structures like Newton's laws out of pure data. Schmidt and Lipson want to automate the finding of natural laws with systems of deep learning. This would disprove our proposed approach. However, Hillar and Sommer have already shown that the proposed method is inadequate (Hillar and Sommer, 2012). In effect, such proposed methods do not create any new information, but just transform data within a predefined framework and logic.

However, researchers are aiming to discover convergences between neuroscience and machine learning/deep learning (Marblestone et al., 2016). It is assumed that neurons in a brain change their properties in order to optimise certain cost functions. Such cost functions rely on statistical computation. One such example is the so-called 'free energy principle' (Friston, 2009). The idea is that "self-organizing biological agents resist a tendency to disorder and therefore minimize the entropy of their sensory states" [Friston, (2009), p.293]. Any perception may create disorder (or 'surprise'), which can be calculated as a deviation from a prospected internal model of the world. Therefore, actions are lanced in order to minimise such disturbed sensory input. The success of deep learning applications is mostly based on the good intuition of the researchers in setting up useful internal models – at least of parts of the world (see 'go' and other success stories). Then, deviations of the model can indeed be successfully analysed within statistical methodologies [the 'free energy principle' is just one example – more details in Marblestone et al. (2016)], and methods can be defined in order to make pattern recognition, action representation and other concepts work.

To conclude, these approaches omit a plausible physical fundament. For example, Fristons 'free energy' has nothing to do with thermodynamics. Friston gives a statistical, but no physical, explanation. To conclude:

- Because of the high demand of DL-systems of well-prepared data, the usage of DL-applications requires *more* rather than less expertise in comparison to classical or legacy computer applications.

A main reason for the conceptual weakness of DL comes out of the still-dominating deterministic approach in neuroscience. However, while most approaches in neuroscience relate to a deterministic worldview, quantum physics does not. A synthesis between neuroscience and quantum physics is still lacking (although authors like Gabora, Aerts and Conte provide inspiring material). While Schwartz et al. (2005) provide a base concept, Koch and Hepp (2006) argue against this approach. However, both paradigms (the neuro quantological paradigm and the classical paradigm) are unclear and confusing with regard to one fundamental concept – the concept of 'information' – and how far 'information' can be understood in a physical and logical sense. Sometimes information is understood as a physical base category, and sometimes as the base category of computer science (in terms of data only being able to be transformed into information subjectively). We propose a path out of this dilemma, which nevertheless is based on intrinsic quantum aspects of life and consciousness. The current state in neuroscience may be summarised as follows:

a DL-systems relate to models of neuroscience which are seemingly based on the 'physically closed world/causal world model' paradigm, including detailed analysis of statistical characteristics.

b Models including capacities for self-organisation, yet still relying on a deterministic model according to (a).

c Models covering a new logical-physical approach based on a non-deterministic approach, which conceptualises the primary activity of systems (based on a multiverse interpretation of quantum mechanics, and Gödel's incompleteness theorem).

Deep learning covers parts of option (a), and unsupervised learning addresses (b) (but not grounded on physical fundaments). However, new neurobiological results highlight the lifelong plasticity and creativity of the human mind based on a non-deterministic, multiverse enrolment of thinking and imagination (neuroplasticity) (Hüther, 2014). For this reason, the neuro-biologist Francisco Varela was one of the forerunners in conceptualising option (c), which serves as input for modern interpretations of the human mind. This contribution will focus on option (c) [accompanying details in Luhn and Hüther (2017)], covering phenomena such as imaginary-valued system states.

What is meant by 'imaginary-valued system states?' What does it mean to see this specific colour, or hear this specific sound? For example, the blueness of the sky (or the sea) may relate to historic foundations and events (such as the intense perception of the seemingly blue-coloured water while having learnt to swim), but also to future expectations and plans. Only a minor part of it has to do with the physical wavelength of blue-coloured objects.

Now, our OMB model explains that such oscillations indeed create a flow of energy based on such complex-valued oscillations. That is, if we experience a certain colour or a specific sound we transcend into another (maybe future) universe, which however relates to our personal history and experiences.

Now, such imaginations may lead to new phenomena or 'unproven statements' from the perspective of the currently dominant structural law of the system [Damasio (2018) calls this 'structural law' the 'perspective' of the system]. Now, this 'unprovedness' or 'uncheckedness' of the newly appearing structural law leads to two things:

a It firstly enables the new phenomenon to be seen or experienced as such.

b It generates the content of so-called 'qualia': it creates the specific 'what is it like to experience this colour?' feeling (see Sections 6 and 7 for discussion on qualia).

Such structural law is always unproven; it represents a tendency. It is also non-algorithmically created, because it is the outcome of a superposition of the interacting system, yielding a new wholeness. This emerging wholeness cannot be derived out of the system's existing organisational principles ('knowledge'), because it appears during a structural reorganisation and simplification of the system itself.

Nature continuously feeds us with structured energy, which by its own means creates new kinds of order, enabling current systems of order to be bypassed. In environments with few stimuli this process will stop, and we may also degenerate.

- 'Colours', or 'music tones' are good examples of imaginary-valued system states. The imaginary dimension unleashes imaginary-valued energy ['impedance' in physical systems (see Section 5)], which corresponds directly to hitherto unchecked virtual system states.

- While Darwinism tries to work out, for example, whether identifying different shades of red (to identify ripe fruits or poisoned fruits etc.) helps living species' to survive, it fails to explain how a new phenomenon will emerge at all, and how it relates to a possible future. The term 'phenomenon' comes from the Greek 'phainetai': what appears, what manifests, what appears as a description. We conceptualise this in following manner. If critical points within the phase spaces of systems are exceeded, further, nomologically distinguishable state spaces can be differentiated, which lead to a further diversification of the system behaviour in dealing with the environment. There are experimentally observable 'phenomena' (e.g., condensation of water droplets on the molecules ionised by elementary processes; reactions of particles and quanta with single ones in the double-slit experiment), which are called 'expressions' of micro-physical (elemental) interaction processes (by 'actions of realisation').

- Given this background, it becomes clear that colours do hold close relationships to emotional events, connected to personality traits – even in dreams (Hoss and Hoffman, 2004). It is known that some animals (bees, butterflies) can differentiate between many more colours than humans. Even bacteria hold a highly-sensitive ability to differentiate between different kinds of stimuli – without neurons. That is to say qualia (which we take as imaginary-valued system states) – the redness of a rose or the specific shape and 'taste' of a piece of music – are statements 'not from this world': they are logically unproven statements, and leave the entire universe behind. They are physically structurised, 'non-physical' (in terms of classical physics) hypotheses.

What would a base model to support such an approach look like?

5 The phenomenon; and some deep digging into SME

This section expands on the structure of knowledge, information and meaning, and gives an interpretational horizon for the dilemma of 'information': we conceptualise the two aspects of information:

a the correlation of information to structural laws (including Shannon's idea)

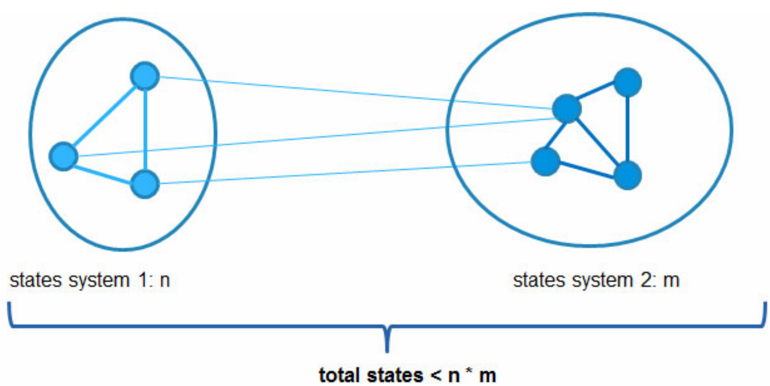
b the potentiality of associated phase spaces.

The physicist Carlo Rovelli introduced the following concept of information:

C.1 *Information* is given by the structural coupling between two systems, whereas this coupling reduces the number of system states which the two systems might populate (Figure 1) [Rovelli (2017) developed this relationship within the context of Claude Shannon's theory of information: for the sake of simplicity we leave the details out; more details in Luhn and Hüther (2017)].

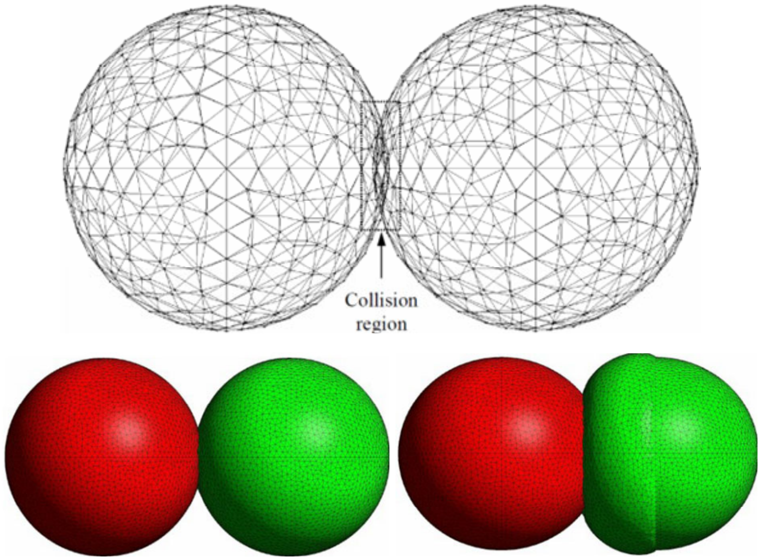
C.2 Complementary to this, the new system might exhibit new overall system states, exhibiting new phenomena with regard to the outside world. Within the context of quantum mechanics, such coupled systems might populate new configurations, which have not been accessible to the non-coupled systems.

Figure 2 Structural coupling between two systems as a foundation of the concept of information (see online version for colours)



One very simple example are metals. Metals may exhibit magnetic properties, when many metal atoms are coupled or arranged together. We take such new phenomena as 'imaginary information'. That is, we conceptualise that such information comes out of a potentiality of the interacting system, which can be explained from within a quantum-physical interpretation [the many-worlds theorem in quantum physics (more details in Section 6)].

Figure 3 Collision and deformation of two balls – expressing certain laws of solid-state physics (see online version for colours)



Now, during dynamic interaction, systems exhibit the structural law of their construction. For example, when two balls collide, they exhibit kinds of solid-state physical laws (Figure 3).

C.3 The meaning of something is reflected in the lawful description of its effect. Thus, the meaning of malleable objects is their mathematically described regularity, which then realises itself in the actually assumed forms (which gives the phenomenal area a unique *form*). We take this meaning as *structural/abstract information ('structural laws')*.

C.4 Applying Shannon's concept of information, the complement to any structural/abstract laws (abstract information) are the *physical system states (phase spaces)*, which the systems might populate, and which are in information science called 'data'.

C.5 During the interaction of systems, *new structural laws* might appear. In such cases, systems couple themselves together, and can no longer access all states which they could have populated while not coupled. In our example, the balls would glue together and create something different from a ball. However, such a new system might populate new states which had not been accessible for the separated systems. Within biology, Damasio (2018) calls this 'structural law' the 'perspective' of an organism. We assume physical evidence of this perspective, or structural law, because it will cause an appropriate increase of entropy (this is also a selection criterion for the choice between different stored or created schemata to act). In addition, the concept of episodes is associated to such perceptiveness. Each perspective holds unique context information, which indicates the specific traces/actions which may occur within such a context.

C.6 This indicates the *relativeness of any information* (including our knowledge). However, systems tend to maximise phase spaces and therefore hold the capacity to participate in other configurations. In the human mind, this leads to meaning.

During interaction, the mathematical formula of the structural law is therefore already included as information in the structure. Gabora and Aerts (2005) discussed evolution as context-driven actualisation of potential. They also developed an elaborated quantum-physical formalism to demonstrate the non-deterministic qualities of the enfoldment of potentialities. Readers who are interested in the corresponding formalisms are encouraged to consult the material of Gabora and Aerts.

Let's take as another example the interaction of a bar magnet with magnetism-responsive objects. These possible interactions describe the phase space. Thus, the law describing the structure of the magnetic phase space is deposited in the form of the interaction of the system (the bar magnet) with its environment. In this sense, each physical property of a system as a phenomenon expresses the effect of the possible interaction of the laws active in the system. This also includes potentialities which have not been expressed so far. Another example is magnetic properties which suddenly appear above the so-called Curie temperature.

These laws may not exhibit all details in all depths of the interacting systems. Consistent with the concept of entropy, the laws cover kinds of abstract, maybe macroscopic descriptions of the systems (Rovelli introduced this notion). As a simple example, when atoms are moving within a tube, the lid of the tube might interact with another gas (another type of atom). Now, the pressure of both gases transfers the forces at this lid. The macroscopic forces are expressing certain laws of pressure while having no information about the movement of specific atoms. This is the concept of relativity of information.

In addition, it is easy to see that any classical physical law exhibits the highest values of structural coupling [see Manin (2012) for details]. Taking Newton's law as an example, the coupling of the movement between planets exhibits a high and mathematically precise order. Other effects like ebb and flood are visible traces of such structural coupling. At this point, we can already imagine that the movement of bacteria implements such coupling as well, enabling bacteria to unleash complex manoeuvres in three-dimensional, viscous environments. We denote that basic biological movements (e.g., most simple movements as induced by most primitive bodily pulses) implement Newton's law (and laws of fluid mechanics etc.) without the need for neurons; these laws are already part of the most primitive transformations of the shape and bodily structure of such species.

Consequently, the 'knowledge' of bacteria to manoeuvre in a three-dimensional world is not a copy or a representation of a purely physical structure; rather, it *is* this process of movement itself – within a new wholeness, which covers the three-dimensional world and the capability to move in. It creates a new holistic unity or competence, based on Newton's law in combination with certain abilities to manoeuvre within fluids or other complex environments.

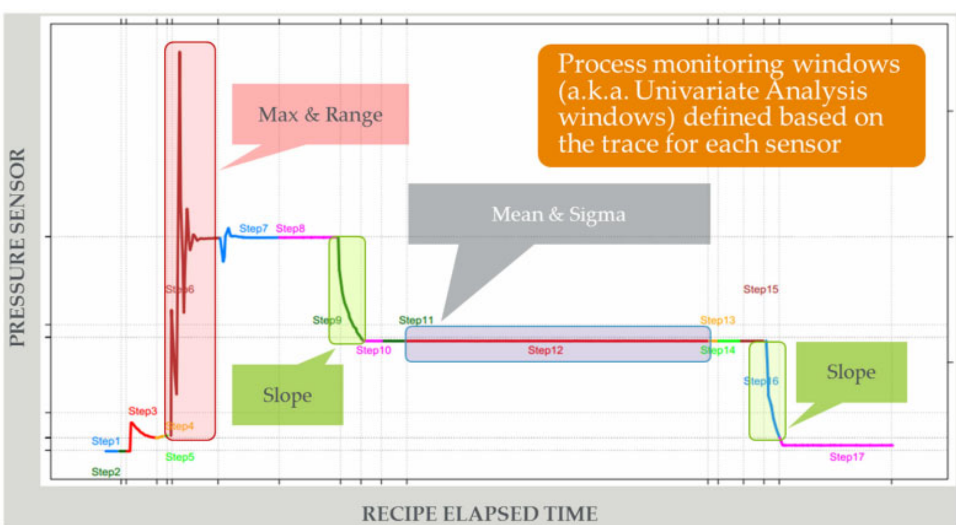
However, what is the 'motivation' of bacteria to initiate and take ownership of its movement? Are their movements 'meaningful'? Can a concept of meaning be introduced based on this physically inspired concept of information?

This is an important topic. Let us think for example of a complex etching process in semiconductor manufacturing. A semiconductor manufacturing process is composed of many hundreds of operations. Some of them create complex photolithographic patterns on a semiconductor device (such devices are called 'wafers', and look like very flat and round, grey pizza slices). Now, within a next step an etching process will happen. This stage of the process attacks the entire surface of the wafer, and removes material. However, some parts of the wafer are protected by photolithographic pattern. In those parts only, it is the photolithographic resist that will be removed. Figure 4 shows a technical characterisation of such an etching process. It is not necessary to go into the details here. The point is that human expertise is required in order to define something like a target shape of such an etching process. Basic shape fragments in the picture are called 'max and range', 'slope' and others. All of them comprise the entire etching process. Engineers are responsible for setting up exact process windows and warning limits. They have invented the categories 'max and range' and 'slope' based on an intelligently invented phenomenological model (Figure 4).

C.7 Such phenomenological knowledge can be neurobiologically and physically characterised as holistic phase spaces of knowledge or competence.

Consequently, phenomena like an 'endpoint detection' within an etching process exist ontologically only within the context of human interaction (although many classical physical parameters like etching temperature, pressure, gas composition, etc., seems to exist independent of human intentions). This kind of rich knowledge is different from what we usually call a physical law. The deterministic worldview conceptualises the world within the perspective of 'causal closure' [there is a longstanding debate on 'causal closure' of the world (see http://www.informationphilosopher.com/freedom/causal_closure.html)].

Figure 4 Phenomenological model of an etching process in semiconductor industry (see online version for colours)



According to causal closure, all physical laws exist right from the beginning, independent of the universe itself. We reject this approach, and argue that physical laws might dynamically emerge [see Laughlin (2005) for details]. We state especially that certain kinds of such new laws only become real within the context of human acting. In consequence, such newly emerging laws have the same ontological state as physical laws, which may have existed before life evolved.

It might be helpful to demonstrate the sudden creation or appearance of new phenomena/knowledge. With older technologies, the timely length of an etching process was strictly defined by time duration (let's say some minutes/seconds). But somehow, quality issues of the etched material showed up (for example high variances with regard to the etched material/unexpected over-etching). Then it was discovered that the composition of the etch plasma changes during the etching process. This change resulted from interaction with the wafer; because the wafer itself changes its material (photo resist gets removed etc.). Based on this, the engineers found out that a specific change in the etching plasma gives a good indication of when to stop the etching process.

This is where meaning enters into the scenario: "in its broadest sense, endpoint detection refers to the control of an etch process by measuring some property of the process that changes when the desired etching has been completed. This corresponds to the point where the film has been completely removed vertically" (Bergeron et al., 1982). We do not need to go further into details; the point is that a formerly unknown phenomenon has been discovered and is now used to control the etching process ('endpoint detection conditions'). This is what in philosophy is named 'qualia'. In engineering science those relationships are called 'phenomenological model'.

Here we can differentiate sharply between objective and subjective information. In terms of Rovelli's concept of structural coupling, we note the following. Prior to the conceptualisation of endpoint detection, the corresponding phenomena had only been known and developed by certain engineers. They had been guided by their prior knowledge, which had then been combined with the targets (i.e., the objective) of their current work. They had to improve product quality – without yet knowing the details of how to achieve this.

This prior knowledge usually has been written down in scientific books, and becomes usable if we recall certain boundary conditions, and apply them to a problem statement (example: physical etching parameters and their application). Such recallable 'objective-information', seems to be accessible to all humans in a more-or-less direct manner (explicit knowledge).

Now, given the situation of quality problems during the etching process, engineers were required to free up some of those simple recall conditions. Since then, explicit (maybe documented) knowledge has become outdated. Then, imagination gets introduced as the capacity to create 'unproven statements': the discovery of so-far unknown physical phenomena (here: the details required in order to invent the concept of endpoint detection). Then, the engineers learnt, due to self-reference and imagination, modified their own behaviour and thinking, and solved the problem finally. Formerly 'forbidden' system states have become possible. The term 'forbidden' indicates that it has been difficult to re-combine certain abilities, including implicit knowledge. For example, the old methodology in etching did not allow the etching time to be changed. Now, during an *Aha!* Moment, the engineers were freed from this limitation. We now also understand why it is difficult to articulate implicit knowledge. The point is that the organisational principle of the *Aha!* Moment is a structural law, and as such not spelled out in sentences. It is an organisational principle of the entire mind-body-system, glued together via formerly imaginary-valued system states.

This also includes the reorganisation of implicit knowledge. Such implicit knowledge could, for example, cover the detailed way in which operators do their job. It is acquired by experience; it is knowledge of 'what works' and it is characterised by the relationship between causal ambiguity and context. It covers intuition, gut feelings and subjective insights. Implicit (tacit) knowledge is knowing more than can be related in words (Hacker et al., 2005).

That is to say, it is not an easy job to 'automate' this knowledge. Human knowledge is a primary driver which leads to a stepwise automation of production processes. However, using the flexibility of computer-integrated manufacturing (and nowadays smart manufacturing), scenarios of highly automated production processes are achievable. Here, operators are migrating from simple transportation executors toward more highly responsible process monitors.

A main pillar of this process is that the situation frees itself up from complexity. A somehow simple 'endpoint detection' solves many issues and problems. In this sense, less can be more. Similar processes happen in art. There are artists or engineers creating new inventions every day, but they typically do not (and maybe cannot) express their personal organisational principles. They capture high levels of automated, implicit knowledge at the same time.

Meanwhile, modern technologies like data mining or the application of artificial NNs support the work of engineers. However, we need to highlight that the phenomenological characterisation of such a highly sophisticated process cannot be done by DL-systems, because they do not conceptualise any physical parameter in a physical and holistic sense (at least not with the currently implemented DL concept).

C.8 'Objective information' deals with an ability to recall 'knowledge' in association with specific events (pure reactivity). That is, any such 'recalled knowledge' holds a passive structure: it gets retrieved after certain input. 'Knowledge' is usually understood as 'justified true belief'. Within this perspective, everything is already proven (and 'objective'). That is, such an understanding of 'knowledge' excludes the perspective of newness, likewise the association of knowledge to so far 'physically unproven statements'. Within this restricted perspective, 'knowledge' holds a passive and dead structure.

C.9 Contrary to this, 'subjective information' appears as newly emerging 'unproven statements' (phenomena), which may realise themselves while analysing certain data. Based on this, further self-guided development and active learning may happen. Such 'phenomena' may hold in the beginning a more hypothetical, private character, and are based on primary activity (self-guided activity). When communicated and accepted in teams or groups, they can become 'objective information'.

Our main thesis is that it is not knowledge or any real-structured 'target' which nature follows. Contrary to the common sense of science, we argue that nature strives to increase physically imaginary-valued states of living species, which are dedicated to conducting actively driven episodes/richer participatory context (covering new phenomena), rather than to acquiring passive knowledge. Those states are responsible for further enriching the bodily existing, real-valued states of living species.

C.10 On the relationship between knowledge and imagination. Not only knowledge (real-valued system states), but imagination (imaginary-valued system states) are the structures which enable the creation and development of our potentials. "Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand" – Albert Einstein.

In the remaining part of this text we use the term 'knowledge' in the sense of 'rich knowledge' – that is, any knowledge that includes an intrinsic capacity for imagination. Although our somehow objectified knowledge might grow, nature strives to increase the primary-activity-based, multiverse-oriented potentialities in the further development of living species. Consequently, the meaning of the activities of species are given by the conservation or the further extension of its populated phase space. There, the classical physical evidence holds that any activity tends to increase the entropy of the world segment in which it takes place (2nd law of thermodynamics).

The only real-valued outcome of this striving for meaning is an overall growth of such imaginary-valued states. This goes together with the second law, because imaginary valued system states do not consume energy. However, we will see in detail that in complex oscillating systems, imaginary-valued energy may transform the entire system toward the discovery of new phenomena and knowledge (Section 5). The major extension of this proposal in comparison to classical physics is twofold:

C.11 We assume that systems do hold information (the 'physical lawfulness') about their own, complex-valued structural law.

C.12 This information includes complex-valued dimensions (in the case of recursive organisation).

5.1 About the relationship between data and information: breaking out of the zombie world

Given this background, it becomes clear that as of today in computing science, it is widely accepted to assume that only human beings can associate certain 'information' (or 'meaning') with kinds of data. Given the relativity of information, data does not *per se* contain information, because both are required:

a data (in terms of the measure of the populated phase space)

b structural coupling (the organisational principle/lawfulness of the interacting phase space).

Now, people who use data create the meaning of this data through an association or an identification of 'structural laws' to the data. This is the interpretation of the data, based on their own intrinsic structural organisation. If people have different opinions, then they are working with different structural laws (perspectives), hence the same data having a different meaning.

Only the context (perspective) of data and the context of its usage (meaning) creates information. A measurement dataset may lack specific setup conditions of the measurement device, as well as specific knowledge which is required to interpret the data. It is important to see that, especially in expertise-focused environments, the dependency of data to the need of subjective interpretation in the context of phenomenological models is very high (as it is in the semiconductor industry).

Contrary to this, in neuroscience the word 'information' is widely used in an objective manner. Researchers speak about "the integration of information from otherwise widely separated regions of the brain" [Lamme, (2010), p.213], "studies over three decades lead to the suggestion that individual elements of information are encoded not by single cells, but rather by populations of cells" [Fingelkurts and Fingelkurts, (2006), p.17]. "The patterns of information flow seem fundamentally different across brain areas, suggesting that they solve distinct computational problems" [Marblestone et al., (2016), p.2]. All these researchers assigned certain amounts of information to a system, which the system held, or should held, according to their belief. Sometimes they applied Shannonian information or something similar, but they never applied a physically grounded concept of information. The researchers are using the term 'information' because Claude Shannon introduced this concept into the scientific world. His notion that 'information' equals the amount of questions which need to be asked in order to figure out the current state of a system, however, is widely accepted. This is the notion of a certain objectiveness of information. Consequently, we could only speak about 'information' if the theoretical approaches of these researchers are included.

Within computer science and software engineering, it is well known that any user group may have their own interpretation about the meaning of any data. For this reason, following systematics about the concept of information seems to be evident:

C.13 Relativity of information: information is data that has been logically formed within a context of meaning, so that it becomes meaningful.

Complementary to this, the above-cited scientists assume that their theoretical frameworks contain all the required items and structures (which then should be sufficient and necessary), so that the 'data' which might be processed by a theoretical brain will automatically transform into meaningful information – according to their theories.

What does all this mean? It follows that we have to be careful in our use of the word 'information'. In this study we try to combine both perspectives of the notion of information: the subjective perspective (that is, a human being is the one part of the structural coupling, whereas the information-object is the other part), and the objective perspective (here we assume less subjective influence with regard to the information-object).

On the other side, the term 'information' holds the potential to help bridging the gap between subjectivity and objectivity However, researchers use 'information' without any further hesitation in an objective and/or subjective manner. These approaches treat subjects as zombies, if the relativity of information is omitted.

Now, how can the process of newly emerging meaning get mediated within the interplay of objective and subjective information, of implicit and explicit knowledge? How does one break out of the zombie world?

6 The proposed solution – logical dimension: foundations of the OMB model

> "On an unorthodox logical account – how to bridge subjectivity and objectivity re-entry and Gödel's theorem."

In this section we propose grounding aspects of a non-deterministic, albeit physically and logically organised, worldview. This view is based on Kurt Gödel's incompleteness theorem and provides a foundation for the fundamental oscillation of recursively-organised systems, thereby striving to continuously enrich their phase spaces via real- and imaginary-valued mind-body oscillation.

The usual concepts in science and also in neuroscience limit themselves by relying on the concept of a 'causally closed world': the deterministic worldview. Given this view, nothing intrinsically new can happen because all natural laws are already given, and everything happens within a closed deterministic framework (including complex, nonlinear systems etc.). New phenomena are handled in a manner as follows: "if we suddenly know the theory of everything (TOE), then all mysteries are solved, and every event becomes explainable." Contrary to this we assume that the phenomenon of physical emergence negates any TOE (see Laughlin, 2005). Additionally, we argue and will show in detail that living species in particular are continuously creating new, physically evident structural laws.

Let us reconsider the example of magnetic properties, which show up above the so-called Curie temperature. This would indicate an inconsistency of the physical model itself: above certain conditions (temperature etc.) a specific law applies below this temperate another law seems to apply.

Now, for the first time, Chinese physicists have demonstrated imaginary states in physical systems (Peng et al., 2015). They have showed that magnetic properties are also present above the Curie temperature as an imaginary-valued system state. The sudden appearance of magnetism has hitherto been treated as a discontinuity. While introducing a physically inspired imaginary dimension, the unexplainable discontinuity of a system which is only described in real-valued parameters transforms itself into a consistent physical system description. Other approaches in physics explain similar phenomena [see Luhn and Hüther (2017) for more details]. Imaginary valued system states are impossible in determinism, because here the concept of closed causality seems to be broken (see also Gabora and Aerts, 2005). However, we argue that within structural coupling certain information about imaginary valued system states is present. The main idea is the following: within the classical physical framework, imaginary valued system states are allowed, but they cannot become real. However, within our thinking we create imaginary states (imaginations) based on recursive, damped oscillation. That is, imaginary states may become real in terms of knowledge about the complex-valued physical structure of reality.

As an example, the physicist Stephen Hawking introduced a specific concept of time, which covers real and imaginary values (Hawking, 1988). He used the imaginary dimension to represent all different kinds of possibilities which exist, in addition to the actual configuration of the universe. With this concept, he avoids the singularity point 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. The next state of the universe has already 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 energy.

Many states are potentially possible, but only some will become real. However, the information about other possible, yet still unreal system states is available within the physical framework. This interpretation is consistent with Peng's treatment of imaginary physical states.

From a more fundamental perspective, the universe itself started out as a recursive function: the next state X(n + 1) of the entire universe follows as a function out of the current state f(X(n)). Usually, physics tries to avoid recursive relationships. The 'typical' physical law holds the structure y = f(x), where a state of system 'x' will be related to another physical observable state, 'y'. That is, physics strives to directly solve certain relationships. In Newtonian mechanics, equations are directly solvable so that a future state X(n + 1) does not depend on the current state X(n); example: Newton's law about the fallen distance of a free-falling object: $y = 1/2\ gt^2$ [y: fallen distance; g: gravitational constant and t: time]). A counter example is exponential growth. The population of a given 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.

Theoretical biology endeavours to understand living systems as based on the notion of level of organisation (Longo et al., 2012). Based on this concept, 'critical phenomena' are introduced which "disrupt, by the appearance of infinite quantities, the mathematical (possibly equational) determination at a given level, when moving at an 'higher' one" (Longo et al., 2012). Critical transitions in living systems are not confined to a point (as in physics), but to an interval of one or more parameters. That is, biological systems can behave as fractal-like structures. The different levels of organisation interweave via structural coupling, as was worked out in this study. Nevertheless, despite its changes, each organism tends toward internal stabilisation (which is called 'homeostasis' by A. Damasio). However, at the same time any living system approaches the enrichment its phase spaces, and tends to pass critical transitions, fed by 'structured nurture'. Consequently, modern neuroscience uses the concept of fractals in the same spirit (e.g., Werner 2010, 2011).

On this level the concept of spontaneity is interwoven. Whereas in physics spontaneous activities are more seldom (such as the spontaneous decay of a radioactive atom), living systems manoeuvre with the senses of their multidimensional criticality to adapt spontaneous behaviour in environments offering rich potentialities. The required multiple levels of spontaneous sensing and acting are theorised with the aid of the concept of fractals.

The concept of fractals hails back to recursion, and focuses on continuous – but not differentiable – function. It was the mathematician Benoît Mandelbrot who first coined the term 'fractal' (coming from Latin *fractus*: broken). Mandelbrot (1983) understood fractals as "fragmented geometric shapes that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole" (see Figure 5). He claimed that many patterns of nature are so irregular that "nature exhibits not simply a higher degree but an altogether different level of complexity" [Mandelbrot, (1983), p.1].

However, Hawking and Hertog (2018) concluded in one of his last essays that our universe is not "an infinite fractal-like multiverse, but is finite and reasonably smooth." If physicists were to accept that the number of distinct scales of natural patterns is infinite, then indeed nature would not exhibit any continuity, and physical equations would not be differentiable.

In this study, we built the bridge between physics and biology in the following manner.

D.1 We assumed that the phase space of living systems and of physical objects can be treated within a unique conceptual frame.

D.2 We further assumed that the concept of structural coupling and the 2nd law of thermodynamics can be applied in the same manner for physical and biological systems.

D.3 We assumed that biological systems – based on their changes and development of structural couplings – are predominately related to their history (the history of physical systems is better defined by 'natural/causal laws'). Those changes emerge via critical singularities, which lead to the continuous formation of several levels of organisation (Longo et al., 2012).

D.4 We further assume that fractal structures of biological systems evolve by a statistically smoothed, approximate implementation of recursiveness, and do not fall into real infinite circles (because of finite physical boundary conditions). However, they implement a concept of infinity via the logic of 'unproven statements'. Although mapping to infinite systems in theory, the mapping of such statements will be finite, as they are caused by a limited available amount of energy.

Figure 5 Fractal organisation of a broccoli (Wikipedia) (see online version for colours)

Now, by applying the concept of fractals, three different kind of solution types appear:

a Solutions showing a solid core, that means stability. The execution of the recursion approximates a stable value, or stable period (as in non-recursive physical laws). Typically, physics does not consider such recursiveness at all.

b In the outlying zone the results do not converge: they approximate the infinite in different velocities (stochastic, 'random' events); this covers a most simple oscillation as well.

c In the intervening zone, infinitely deep embeddings are created which are also characterised by self-similarity. The recursions do not produce converging stability, nor do they slide off into infinity. Rather, they incessantly create complexity (new structures) that dynamically change with the interaction partner (including the observer's perspective). This concept is applied in biology, life sciences and in neuroscience.

We now need to bridge the gap and find a principle of correspondence between above points (a), (b) and (c). As a first example, we might think of a simple electronic 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 any electric contact. This in turn 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, thereby 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:

D.5 ON = 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 (see below).

The engineer and mathematician George Spencer-Brown proposed that besides the logical states *true* and *false*, there exists a third, 'imaginary' truth value (Spencer-Brown, 1994). From a mathematical standpoint, this is true for equations of the form $Y(n + 1) = f(X(n))$, in which the roots hold imaginary numeric values (example: $x = -1/x$; the roots of this equation are +/–i; i: $\sqrt{-1}$). In Spencer-Brown's interpretation, the solution oscillates infinitely. Interestingly, the linguist Ulrich Blau (among others) proposed a three-valued logic: true, false, indefinite (Blau, 2008). We draw out of those attempts the fundamentality of the required 'imaginary' truth value.

These are the logical basics of our proposed OMB model. We maintain that the concept of fractals does not deny classical physical approaches. On the contrary, it contributes toward investigating the base logical structure of living species, and also new approaches in neuroscience (Werner, 2010, 2011).

It is the task of humans (and other living species), however, to interpret corresponding data and to aim for a common and meaningful usage of the abovementioned levels (a), (b) and (c).

To summarise, the universe holds the potential to expose new physical laws/relationships (emergence). This can be written down in the following formula:

D.6 $Y(n + 1)) = f(X(n))$.

Now, a most simple form of a recursive function holds a relationship to Kurt Goedels incompleteness theorem and the imaginary dimension $(i = \sqrt{-1})$ at the same time.

A most simple, elementary 'oscillating' function (we remember $x^2 = -1$ -> $x = -1/x$).

$$Y(n+1)) = f(X(n)) = -1/X(n);\ n = 1, 2, ..., X(1) = 1$$

$$f(1) = 1$$

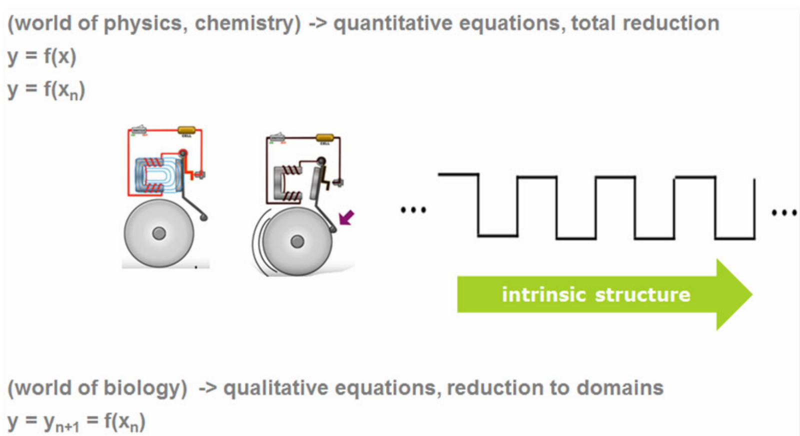
$$f(2) = -1/1 = -1$$

$$f(3) = f(-1) = f(f(1)) = -1/(-1) = 1$$

$$f(4) = f(1) = f(f(f(1))) = -1/1 = -1$$

etc.

Figure 6 Recursive systems, and the dawn of a most elemental logic, covering 'true', 'false', and 'imaginary' as roots (see online version for colours)



Briefly stated, we conceptualise that the system is in state '1' [f(X) = 1], in order to transform itself to state '–1' [f(X) = –1]. This is a similar structure to Gödel's incompleteness theorem (Figure 6).

The mathematician Kurt Gödel showed that the mathematics used in physics is incomplete. Specifically, this means that even with a complete description of all the physical systems of this universe, new sentences (new physical relationships/laws) may still emerge which are formed with already existing building blocks, but which cannot be derived from the contexts already described. A most popular example, which cannot be solved in bivalent logic, is the sentence "I am lying now."

If the sentence "I am lying now" were true, he would say that he was wrong – and vice versa. Generally, this sentence is dismissed as an antinomy (in bivalent logic). More precisely, however, we have a structurally identical situation in front of us. A system that makes such a statement will change state in the next step. But this gives us a very interesting construction: the system has an indefinite state. By applying this approach to more complex, viable systems, the statement "I am lying now" is transformed into

"I am continually changing my condition." Surprisingly, this corresponds exactly to the basic constitution of all living things. Figure 5 indicates the systematics of recursive systems, which shows the oscillating mode of the solution to the elemental function Y(n + 1)) = f(X(n)).

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.

It seems that within biology, self-replicating systems implement this imaginary dimension in an even more fundamental manner. There, a molecule can be seen in a situation in which the next state would cover the molecule in a state in which it is combined with some more components, which all together exhibit the seed of a replication cycle. From a logical perspective, a single component or molecule may hold a certain state (let us call this state '0'), while anticipating the next state in the replications process (which we may call '1'). This state '1' covers combined molecules, which themselves later separate from each other again in order to start the next replication cycle. As a consequence, such systems expose a principally infinite sequence of system states (0, 1, 0, 1 …). Why should such a characteristic exist at all?

Let's think about the somehow wondrous interplay between electricity and magnetism. We intuitively understand that a projectile which has been shot in a certain direction may continue its movement ad infinitum. No forces interact with the projectile. However, how would the story go if we were to replace the projectile with a light beam? Light waves oscillate up and down continuously, and somehow propagate their own movement. Are not there forces interacting continuously? We know today that such forces fall off inversely, enabling a light beam to travel in an unlimited manner "let there be electricity and magnetism, and there is light!" was Maxwell's thought when he discovered the nomologic relationship between magnetism and electricity.

The mathematician Alan Turing developed a theory about the formation of patterns in biological systems (Turing, 1952; Diego et al., 2018; Mainzer et al., 2013). Turing showed that stable cells while interacting become instable, and form pattern. Patterns of tissue (leopard, cow, tiger) are prominent examples of this principle. While Turing's approach was on linear models, Stephen Smale investigated nonlinear systems (Rajapakse and Smale, 2017). He found that two stable cells when interacting under diffusion (nonlinear coupled) show newly emerging global periodic attractors: the dawn of self-oscillation [Smale (1974) noted that the cells when coupled become 'alive']. That is, the physically inconspicuous process of diffusion between stable cells causes complex patterns to emerge as formerly non-derivable, 'unproven statements'. In general, oscillation with regard to periodic attractors is also one of the most influencing neural capabilities, including the re-entry function (Edelman and Gally, 2013).

In cybernetics, von Foerster (2003) conceptualised 'unproven statements' as kinds of 'cognitive eigenvalues'. The concept of 'structural coupling' was introduced by Humberto Maturana and Francisco Varela. "We speak of structural coupling whenever there is a history of recurrent interactions leading to the structural congruence between two (or more) systems" [Maturana and Varela, (1987), p.75]. Structural coupling seems to be the prerequisite for generating cognitive eigenvalues which make cognitive objects in the sense of newly emerging structural laws possible. In this study we extend the notion of Maturana and Varela with regard to a physical interpretation of information and structural coupling (C.1–C.12). The main difference between this proposal and Maturana's and Varela's idea is to dedicate physical meaning to eigenvalues. In the most fundamental interpretation, each action (or eigenvalue as converging points of action) increases the entropy of the world. This structural law (or eigenvalue) stands for the physically described schemes of behaviour, which – as a consequence – cause an increase in the entropy.

We now add to the concept of cells as self-replicating systems the idea that cells can also initiate self-guided movement (Suzuki and Ikegami, 2009). We assume a single cell, but interacting with itself. However, how could this happen? Here we assume a most primitive and fundamental characteristic of recursive systems (as outlined in Figure 6). We assume that the system 'knows' its recursiveness: its law of oscillation is represented in an abstract manner. Contrary to the two colliding balls, such a system would collide with itself, and thereby be capable of modifying the parameters of a self-initiated oscillation. Now, we assume that the system might control its self-oscillation with regard to external influence. Let us assume a simplified notion, where the system may receive a kind of 'nurture', or structured energy (showing low entropy).

- Let us assume that, based on quantum-physical effects, the structural law of the self-oscillation might slightly fluctuate.
- Then, the system would produce multiple overlays of possible 'movements' (according to the floating self-oscillation).
- Next, according to the 2nd law, the system will automatically steer itself toward this 'nurture' (this is the solution with highest probability). This comes out of quantum-based decoherence processes, in so far as the multiple overlays collapse to macroscopic, causally effective structures.
- Based on this, the system will show a 'steering fluctuation' pulse, and will manifest the ability to move in a certain direction. Symmetric oscillation will not lead to controlled movement – a kind of controlled floating is required [see also Ma and Yoshikawa (2009); or more general (https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/bacterial-movement)].

This most simple scenario exhibits the sources that show the influence of imaginary valued system states. We know from oscillation models (including quantum physics) that real modes are standing waves (i.e., oscillation when damping is light or evenly distributed: oscillation of a cell in a fluid). Such real modes are visible as frozen patterns. Within complex modes, there is a flow of energy. Energy might flow to the outside (as in movement). There, the outside world 'stores' the transferred energy – mostly in the form of heat dissipation. An example could be the self-initiated movement of a cell within a fluid: in order to move, the cell has to exceed the resistance of the fluid.

However, the contrary can also happen: something like 'noise' might pump energy into the system (Méndez et al., 2011). Here, for example, the outside world might force a new pattern to emerge within the system: the former 'noise' transforms into a developing structural coupling, according to the 2nd law of thermodynamics. This could be the case for 'sensing' new kinds of nurture.

Those simple scenarios exhibit the basic principle of the OMB model:

D.7 OMB base model:

1 The real part of the structural law of a bodily oscillation shows the standing wave pattern, and the imaginary part represents the flow of energy (source: the simple harmonic oscillator).

2 Energy transfer in motion from the system toward the outside world goes hand in hand with friction. Given only imaginary values, the system would become unstable (Lyahov and Nechshadim, 2001).

3 During an inverse energy transfer from the outside world into the system, new internal patterns and structural coupling emerge. From the systems perspective, 'noise' pumps energy into the system, and increases the internal energy to create new patterns of internal organisation, which give meaning to the former 'noise'.

4 The 'mind' (steering activity) gets separated from the body and becomes 'alive' in terms of newly emerging patterns of possible thoughts ('unproven statements'), actions and movement (new and enriched flow of energy). The main difference between physical and biological systems is that biological systems predominantly relate to themselves, and by passing through transitions of criticality they are developing a history of phase spaces.

5 When the own structural law becomes part of those critical transitions, and participates at the creation of an emerging wholeness, the system becomes conscious. Language is created in terms of phonetically articulating 'unproven statements'.

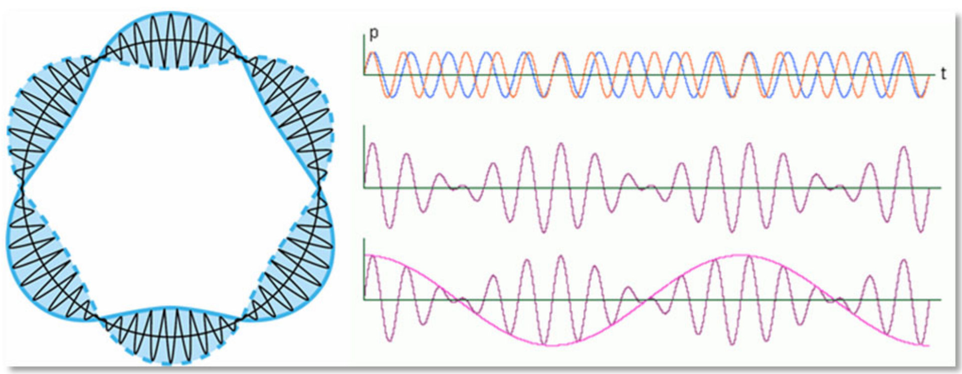
6 Such 'unproven statements' are created based on oscillating interactions of systems with themselves/embedded into emerging structural couplings in terms of newly emerging patterns of activity/energy (resonances – as known in psychology). They are not algorithmically derivable out of prior states (because they are created out of 'noise'), but are self-created through processes of quantum-mechanical overlay of possible system configuration within a multiverse account.

7 While striving for sources of low entropy (kinds of 'nurture'), the system becomes more complex. This may lead to decision instabilities, surrounded by different boundaries. Small variations can amount to huge impacts. However, systems may create huge amounts of attractors, and thereby approaching a global intolerance for error (Laughlin, 2014). That is, even during growth and transformation to different phase spaces, living systems strive for stabilisation (homeostasis).

8 Such interacting systems may then create overall basins of attractors within a more complex environment (a new wholeness created out of 'noise'). Here, higher values of interaction (like in play) enable a more distributed consumption of energy, and a correspondingly more profound creation of new and distributed interaction/information, as is shown in collaboration. For this reason some bacteria show effective cooperation (Wingreen and Levin, 2006). That is, nature strives to enrich the phase spaces of all species, including a corresponding development of communication, up to the invention of democratic systems. Those conclusions go together with newer game-theoretical results (Lambert et al., 2014).

In biology and systems theory, this process has been named the process of re-entering into the individual configuration space (Varela, 1995, von Foerster, 1981). When magnetism re-enters into electricity, further magnetism propagates, fostering further electricity, etc.

Figure 7 Moving cell – entropy peak, if the direction of 'nurture' is chosen (OMB model 1); the cell oscillates with itself and therefore develops the process of entering into its own configuration space (see online version for colours)



How can such a fundamental physical and biological property be summarised? Based on our current thinking we always try to anticipate kinds of closed system descriptions, or closed solutions. This roots back to the fundaments of a deterministic worldview. However, as shown here, any physical/biological system naturally tends to change/ develop its states. Systems which are coupled to themselves especially exploit a new characteristic: a capacity to infinitely change their own system state. Based on these assumptions we can outline further characteristics of OMB (Figure 7):

- systems which exploit a structural coupling to themselves may instantiate potentially infinitely altering changes between possible system states
- the 'content' of a system state is given by its current dominant physical structure and structural coupling to potentially emerging new states
- as based on the tendency of continuous structuration and the tendency to alter current systems sates (within an infinite open process), any system tries to enrich its current phase space through a process of continuous contradiction or negation

- based on such change, new phenomenon may contradict or put other experiences into another light; however, this process is required to develop the entire system; the notion of 'true' and 'false' roots back to such an ability
- consequently, the ability to 'imagine' structurally new system states via processes of re-entry leads to what we call subjectiveness
- the assumption of a certain 'imperfection' of human thought (Marcus, 2008; Burnett, 2018; Sloman and Fernbach, 2017) comes out of a misunderstanding: up to now, we have not yet conceptualised the richness of the imaginary dimension of human thought and activity
- finally, OMB manifests itself in a 'freedom-function', instantiating the physically and biologically-based responsibility of all actors: the goal (mirroring the overall natural tendency) of all our activities is to enrich our phase spaces.

Nevertheless, this does not tell us anything about the physical implementation of such an ability. How could re-entry lead to physically and biologically explainable universes, mediated in subjective spheres? Can we identify a kind of fundamental primary activity as a key factor to become conscious? Could quantum mechanics help out of this dilemma?

7 The proposed solution – physical dimension: openness of the world

> "On the multiverse theory, and the potentiality as induced by primary activity in any living species: consciousness and the end of determinism."

This section expands on the categorical primary activity of living systems. A more advanced OMB system highlights the point that our capacity to strive for unproven statements causes on the other hand complex structures of fear or dread (anticipatory anxiety).

Determinism is still the most important approach in science. Although quantum mechanics strives to introduce subjectivity and has been striving for many years to break away from determinism, these are still seemingly un-unifiable schools of thought even in physics.

The physicist Dieter H. Zeh recently analysed the ongoing dogmatism in quantum mechanics (Zeh, 2012). On one side are the followers of quantum probabilism. Based on the probabilistic concept, reality does not exist in any fundamental manner, but only statistical measures and corresponding statements. The main drawback of this approach is that physically grounded learning capabilities as described cannot be derived out of this statistical approach, because there is no fundament to rely on. On the other side, Zeh places quantum determinism [as first introduced by Bohm (1980)]. This interesting concept is based on so-called hidden variables, and can explain the existence of fundamental natural laws – but cannot explain the emergence of new ideas. The relational concept of information as mentioned above cannot be derived. Zeh and others instead propose a many-world 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. The physicist Gerhard Grössing developed an interpretation of quantum mechanics which analyses the capabilities of recursively structured quantum-mechanical processes (Grössing, 2000). Bringing Zeh and Grössing together, it can be argued that any interaction between replicating systems enforces the informational existence of many different possible phases of convergence (or 'solutions'), whereas the traditional set-up only identifies single pointed solutions. Many structural couplings exist, whereas the classical view is blind for all those potentials.

The Italian physicist Elio Conte has worked out "the possibility that we think in a quantum probabilistic manner" (Conte, 2010). He uses a logical approach within the same spirit as we are proposing. A system might be in state A, or in state B. This is the classical model. Maybe a cell moves left (state A), or moves right (state B). Within the classical logic (determinisms), the cell cannot be in states A and B at the same time. However, Conte shows that within the context of quantum physics the system can also be in the superpositional state (A + B). And additionally, the capability to hold such superpositional states can be seen as a primary potentiality of living species. Because the system might alter its probability field without changing the (real-valued) energy of the system. Conte (2010, p.S5) further argues, that this process might implement the capability that "mental events cause neural events analogously to the manner in which probability fields of quantum mechanics are causatively responsible for physical events."

What could this mean? Let's pick up Laughlin's idea of self-measurement. The physicist Robert B. Laughlin has shown that living species, while producing electromagnetic waves through oscillation, have the ability to measure their own size and shape (Laughlin, 2015). How can such a measurement lead to action? This can indicate if such self-fabricated figures fall into the framework of an unorthodox logic, as introduced above. That is, the re-entry of such measurements falls into self-fabricated movements. This process of re-entry may be an evolutionary outcome of a preceding optimally-simple pulsating setup, in which such pulses do not yet differentiate between 'measurement' and 'movement'. Now, seen from a quantum-physical perspective, all possible overlays of such oscillating, pulsating activities may exist at any given time as potentiality – some are real, some are holding an imaginary valued state. How does such a system select the 'right ones' to become real?

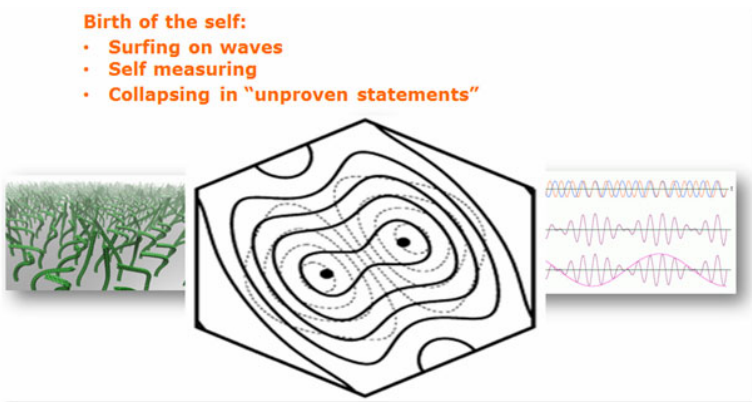
The solutions are fractal self-embedded maps of the system itself, where for example a hint toward nurture becomes stabilised on a certain sub-level. Those sub-levels further on are used by the moving system in order to update its position toward a certain target. This notion is known as 'cognitive maps', and has been extended by Edelman and Gally (2013) in so far as the brain is 'full of maps', all of them related to each other via the process of re-entry, and including other parts of the brain (i.e., hippocampus). Given by the fractal structure of those mappings, they are physical, physiological, and at the same time psychological processes.

Most interestingly, such oscillating, fractal struturisation includes the imaginary dimension via potential flows of energy – a so-far unseen perspective of this process. How could such a solution come to life?

Within the multiverse-approach of reality, a 'world' (or a system) means an entire universe with well-defined properties, determined by the classical configuration of its particles and fields (Hall et al., 2014). Each world evolves deterministically; however all quantum effects arise from the interaction between worlds. That is, waves or trajectories which are near to each other may interact and participate, and produce non-classical outcomes (this is called decoherence and collapse of the wave function). This is where classical systems will show non-deterministic behaviour, as based on interaction. Particles or system configurations will show up in classically 'forbidden' configurations and thereby expose new emergent capabilities. New information, new structural couplings appear.

A biological interpretation of this scenario goes as follows: the abovementioned movement may lead to an ability for the cells to surf on waves, which are propagated by kinds of hairy strings (Figure 8). Additionally, such cells are capable of measuring and calibrating their own size. This leads to the birth of the self, because given such measurement capabilities systems might anticipate more complex, goal-directed movement (in terms of internal complex activation, which are pumped into the system via external oscillating energy). 'Goals' are thus sources of external energy.

Figure 8 Potentialities of a self; the central part of the figure shows the ability of a cell to self-measure via standing waves (see online version for colours)



Source: Laughlin (2015)

A primer to the setting up of 'own universes' comes out of re-entering interactions, so that part of the energy/goals stems from internal activities (the system also oscillates with itself). Then, the number of internal-organisational rules or laws will significantly exceed the set of external-organisational rules. This is where the fractal organisation of the mind differentiates.

Within neuroscience, the pulsating brain oscillation is the candidate, which most likely implements this process of re-entry (Edelman and Gally, 2013). This goes along with the ability of living systems to measure their own phase space (starting with simple measures like physical size). The straightforward argument is that such measures create the basic content of brain activities, and lead to physically-based content of knowledge.

E.1 *OMB model*, embedded into a further physical and biological context:

1. The multiverse-orientation enables the fractal structuration of living systems and the concept of OMB: due to the development of structurally coupled levels, any living system will create its own unique history.
2. Measures of individual activities lead to an internal emergence of structural laws (competences), embedded into a phase space covering the connection between current internal state and possible further movement.

3 Fluctuating, directed movements are the first candidates enabled via a multiverse approach, which dedicates primary activity to any living system.

4 An evolutionary record can be drawn, beginning with the first pulses of single cells and leading to the discovery of pulses of re-entry in neuroscience.

5 Corresponding to this, neuroscientific research is showing that learning occurs mainly when neurons engage in recurrent interactions [Lamme, (2010), p.218].

6 As a consequence, and in a sense like the way Lamme presents the topic, the process of continuous negation, fed by overloaded structuration (creation of 'unproven statements'), instantiates by itself what might be called phenomenal consciousness. The nature of such imaginary-valued 'unproven statements' is based on a deep participation at a greater, dynamically emerging wholeness, which – when re-entering into the real-valued states of the species – creates consciousness (in the sense of sharing knowledge with oneself about something greater).

7 That is, as recurrent activities always combine a couple of re-combined brain areas, any consciousness experience comes out of re-entering into prior experience.

8 A phenomenon, or a qualia, is equivalent to a newly appearing phase space or 'unproven statement' (Edelman calls this 'global mapping; Lamme emphasises on an ability which he calls 'rich seeing'; this is similar to the discovery of new phenomena, as explained above), which may fade away but which might also be stabilised and create new stable information (Tessoldi et al., 2016).

9 The stability of this new formation depends only on the fact of how far the current phase space of the system as a whole extends, within the context of an emerging structural coupling (holism). An extension of the phase space will always relate to an increase in the capabilities/competences of the entire system, which by default will increase the entropy of the world segment which the system populates. However, contradictions are partly allowed and required in order for new capabilities to be developed. Based on this physical indication, functions like awareness and the memorisation of new phenomenon, including fear and anxiety, emerge from within an overall perspective.

10 New phenomena are negations of prior experiences, newly combined in new phase spaces (and leading to the so called 'aha'-experience).

11 This leads to the establishment of episodic memory (based on/in relation to semantic memory).

12 However, the counterpart of the gut feeling of an aha-experience is fear and dread – just on the other side of the oscillation. Our current society is particularly afflicted with growing fears and dreads. The reason for such fears seems to be growing uncertainty of a common and human future – caused by a growing determinism within our daily practices which by nature eliminates and blocks space for freedom.

13 This entire process is the bridging point between objectivity and subjectivity The structuration process creates – besides quantum physical evidence – the macroscopic level of explanation to associate sources of primary activity and meaningfulness to self-oscillating and self-replicating (living) systems.

14 To summarise, nature strives to increase the interaction between systems within a participative universe.

Let's look at an example: the invention of the bow and arrow. Researchers have found that mental imagery, and especially the prospect of possible activity is of uttermost importance for developing such an ability, supported by expert cognition and a developed autobiographic memory. Such circumstances lead to what we call subjectivity. On the other hand, such inventions cannot be extracted out of actions and the structure of actions prior to such inventions (we may recall the example of the invention of detecting endpoints during the etching process in semiconductor manufacturing). They are instantiations of 'unproven statements', become real while participating at a newly emerging wholeness.

For this reason, we have to conceptualise that the idea of 'truth' goes further than mere derivation. This is what we take away from Gödel's theorem, expressing the relativeness of information. New phenomena may appear, and may create important knowledge in order to further develop ourselves, and our interactions within society. Subjectivity creates itself in terms of developing 'unproven statements'.

E.2 Informationally rich environments will with evidence support a common growth of phase space; that is: knowledge, meaning and freedom at the same time, through an active participation in a greater, imaginary unity.

In addition, interactions with kinds of natural objects may lead to substantially different forms of measurement and movement when compared to interactions with other, self-organising species. Interactions with social partners might lead to high levels of potentiality and imagination (imaginary system states). This can already be seen in language.

Some vocabulary in all languages shows close relationship between the phonetic expression or sound of the word and the natural sound, which it describes. Examples are words like thunder, storm, light, heat, which somehow emulate natural thunder, storm or heat. Then, in more abstract contexts (such as the words to name the parts of a house), words are becoming more and more arbitrary.

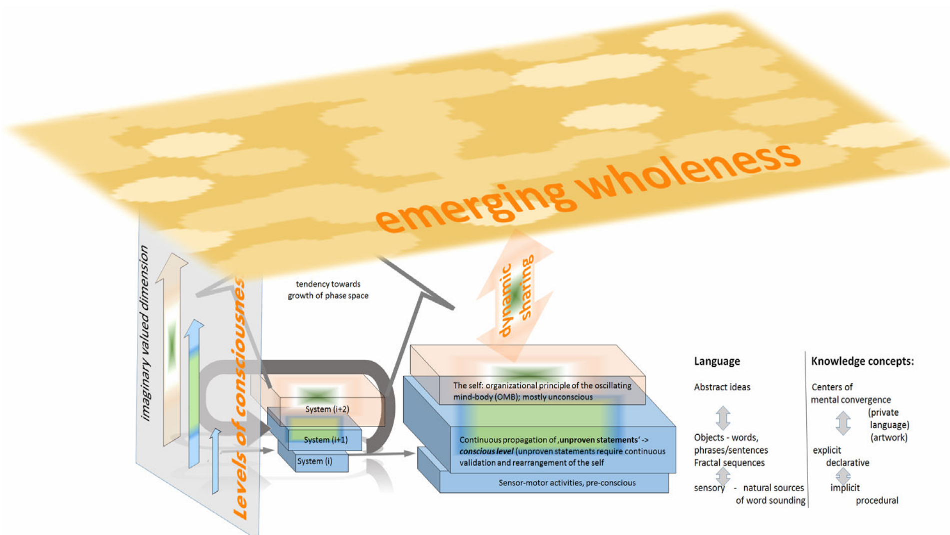
The emerging wholeness represents contributions of each individual via coloured circles. Consciousness develops within a spectrum of somehow objective, real-valued measures (classical physical measures) and more subjective, imaginary-valued states (which cannot be measured objectively, but the content can be communicated, or introspectively discovered). Neuroscientists like Sam Harris conceptualise the irreducibility of subjectivity, which we see as a deeper logical level of existence, and as shown above. However, when Harris (2014) speaks about the 'illusion of the self', we conceptualise instead the introduced multiverse-approach, which holds the capability to interconnect nomologically different self-concepts. Based on this approach we argue that the knowledge explosion of humanity becomes explainable, because the emerging wholeness (which act as a structural law/coupling between all participating species) is a real, however imaginary-valued entity. That is, the concept of self emerges within the spectrum between:

a more objectively manifested and measurable structures

b highly imaginary-valued dimensions (personal developments of art etc.).

The learning of embodied cognitive models is grounded in the direct experience of sensory-motor perceptions at the lower levels (Figure 9). At higher levels, their learning from experience has to be guided by the contents of language models (including private language items; examples in all creative domains: artwork, inventions etc.). Language representations are sharp after about the age of five; cognitive representations gradually acquire clearer content throughout life and remain vague and unconscious at high levels (Perlovsky, 2013).

Figure 9 Parallel hierarchies of mind, cognition and language – within the context of consciousness and emerging wholeness (see online version for colours)



Notes: Language learning is grounded in surrounding language at all hierarchical levels. Learning abstract cognitive models requires experience and guidance from language. An activity of the system [state (i)], is begun with the purpose of re-entering into the structure of the system within succeeding oscillations and corresponding imaginative activation patterns [states (i + 1), (i + 2)]. This creates self-awareness, mediated by language, mind-body concepts, and abstract cultural concepts. This self-awareness creates structural and logical modifications of the individual capabilities. We assume that our universe is an 'informative' universe, because it is structurised in a manner such that there is a physical-logical tendency toward growth in the phase spaces of any system.

Now, language becomes unclear and 'destructive' if its content gets disconnected from the natural growth of phase spaces (see E.2).

Concepts of 'programs' and 'algorithms' are still key in biology. However, von Neumann noted as early as the '40s of the last century that this concept provides no solution for the fundamental question of when a system should change from the modus 'program execution' to the modus 'adapting the program/re-programming' (Luhn and Hüther, 2017). Our proposal is that each system changes continuously between these two modes (oscillation). Each thought may as an output deliver an input for re-programming.

This includes that the ability to set up a three-dimensional world to execute certain manoeuvres cannot be implemented as a kind of an algorithm, because the setup needs to include the forms (the logic) of any possible algorithm (for example, codified as sequences of movements). Again, this three-dimensional world comes out of the holism between pulses of (self-)measurement and pulses of movement. 'Moving' and 'measuring' have become dialectic states, which have evolved out of more primitive wave structures, to be 'imagined' and executed in infinite manner.

Then, in a next step, frequently used structures might be stored in algorithms. More algorithm-oriented behaviour comes into the game as neurons emerge. However, such an advanced system also implements non-algorithmic behaviour: ad-hoc transformations of the entire system inputs into coherent outputs (the so-called Aha-experience).

Systems will always tend to maximise their phase spaces and minimise their energy consumption at the same time. 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. 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.

Each living species is an instantiation of an 'unproven statement', thrown to creativity and anxiety at the same time.

E.3 Truth goes beyond causality – this is a base structure of the universe, enabling the emergence of living species. We are participating in/with a greater, yet imaginary wholeness.

However, how does consciousness and the differentiation between objective and subjective information come into the game? A first answer is derived from the notion that – based on the multiverse argument – each system holds its own unique history and trace, which may differ substantially from a mono-causal, 'objective' trace of the world.

However, those different worlds are merged together again through interaction. Group dynamics manoeuvre the different and shared worlds into different contexts, then prepare the best conditions for simulating time travel. The requirement to monitor the presence and needs of an infant may have enforced the competence to keep several things in mind. The group has to take care of the infants (which are more fragile than those of apes), and has to make plans to gather more complicated nurture.

Savage-Rumbaugh proposed that this allowed hominids to carry tools that were not related to current needs. The oscillating mind interconnected the possible attacks of enemies and the demands of unfamiliar terrains.

This is a most significant step. Suddendorf and Corballis (2007) reconstructed the co-evolution of bipedalism, growing technical abilities (throwing, controlling fire) and facing greater danger from predators, because Africa became more sparsely wooded, leading to differentiated language and yielding highly differentiated social capabilities (Suddendorf and Corballis, 2007). Socially organised learning and mental time travelling emerged onto the scene. Suddendorf and Corballis introduces a 'mental theatre' metaphor in order to explain these new capabilities, highlighting the gap between humans and animals. Language may have started out as pantomime, using bodily gestures. The language centres are close to the tongue, mouth and breathing control areas, yielding the production of phonemes as transformations of gestures.

How gets meaning and content associated to meaningless phonemes or bodily gesture? How could our 'mental theatre' emerge at all? It seems that participation in a greater wholeness may be a key factor. We discovered the concept of SME primarily with regard to natural phenomena. However, it has been proposed that social interaction drove the development of intelligence. Where does this come from?

8 On the depth of human knowledge – the difference between knowing and remembering/imagination

> "What is it about our knowledge, what separates it (and us) from our nearest ancestors – and from zombies? How does it go with morality? What should we do with artificial intelligence?"

There is a multitude of research with regard to specific effects, mechanisms and phenomena in neuroscience, and AI works with similar and/or other effects in order to understand and re-construct notions of intelligence. A main anchor of scientific progress is a deterministic view of the world. Everything seems to be determined by physical laws, including the 'chaotic' behaviour of complex systems. Based on such a mindset, people started more intensively to control and to measure other people's actions: reification of subjects – treating others (and oneself) as a zombie. Consequently, we are manoeuvring our society into a corner where – despite specific progress in natural science – increasing numbers of people are become dissatisfied, and trust in a human future is being undermined.

Nevertheless, people themselves judge differently. When asked directly, they see causal determinism as a threat to moral responsibility (Knobe, Forthcoming). Parts of the world might follow physical laws (which are represented in the corresponding causal knowledge), but human interaction yielding morality seems to hold a radically different nature. Here, people – even from very different cultures – follow the intuition that they themselves are responsible for what they are doing; hence, there is a growing demand to support people in their personal development of freely acting within a globalising world. It is well known that people (and all living species) hold a huge potential for further development (Hüther, 2006a, 2006b, 2014). What does that mean – how can we move forward in a radical sense?

A major idea in neuroscience is that higher-order thoughts may be served by first-order mental states (which are based on sensory input) and somehow contain 'important' ideas or information. The frontal cortex seems to be engaged in such higher thought, and indeed is connected to planning and self-censorship (self-development). However, neuroscientist Arne Dietrich found that during creative processes, the frontal cortex might profoundly damp down, or ramp up again (Dietrich, 2015). While higher-order thoughts are conscious, creative processes develop themselves unconsciously, prior to entering into consciousness. They may include important parts of already automated implicit knowledge, forming a new overall structure. That is, higher and lower levels of consciousness play together in creativity: the OMB model. Now, during the process of building expertise, implicit abilities and knowledge may grow, integrating multiple associations subsumed consciously under a certain goal (prefrontal activity). Then, during a process of relaxation and lower prefrontal activity, a new and fresh overall pattern might appear, integrating abilities and knowledge structures non-associated as yet into a new shape of meaning (the *Aha!* moment). Where could such meaningfulness come from? Our main idea is that such meaning comes out of imaginary-valued system states, participating in a greater wholeness which is perceived as the meaningfulness of our being.

F.1 Imagination and meaning: based on this overall damping down and resonant ramping up again ability, a threshold is passed: the system steps out of any activity and frees itself from any 'execution' of a task or program. As such, the system reduces its 'real' state to minimal activation levels, and opens up for the imaginary. That is, the system is forced to continuously create so-called 'unproven statements' as newly emerging organisational principles – 'meaningful patterns' – emerge and are interlinked in longstanding episodes. The system becomes conscious: it conceptualises itself in the context of new organisational principles. It seems that only humans have reached this level. However, these 'unproven statements' emerge in personal and inter-personal contexts; they are accessible via communication. They are only measurable with systems showing similar capabilities; that is, with other minds.

F.2 Real roots of unproven statements: systems theory has already proven (Stephen Smale, based on Alan Turing) that two stable cells when interacting (nonlinear characteristics) show newly emerging global attractors (oscillation). That is, the physically inconspicuous process of diffusion between stable cells causes oscillating patterns to emerge ('unproven statements'). Complex pattern emerge in the context of natural damping.

F.3 Imagination and multiverse approach: while classical determinism steers our thinking to accept only one solution (and to accept the status quo), we propose a multiverse-approach, which enlightens the dimension of human freedom and the need and reason for developing free will. While we perceive patterns that create new causal relationships, nature tells us exactly about what our free will strives for: to extend our and anybody's phase space, including the entire biosphere.

F.4 Less can be more: during imagination, higher-order thoughts paradoxically diminish and the entire system discharges from complexity ('less can be more'). Resources are freed up for new associations and conscious work, enabling new phenomena as 'unproven statements' to appear. The system has transformed outside from 'noise' into meaningful patterns. This astonishing transformation signifies a deep and evolving connectedness to a newly emerging wholeness, whereas the counterparts of this wholeness comes out of the potentialities based on the relationships with all other species (Figure 9).

F.5 This emerging wholeness represents contributions of each species in the context of the potentialities as based on the dynamically evolving relationships to all other participating species. Consciousness develops within a spectrum of somehow objective, real-valued measures (classical physical measures) and more subjective, imaginary-valued measures (which cannot [completely] derive the content of brain activities out of objective measures, but the content can be communicated, or introspectively discovered). Neuroscientists like Sam Harris conceptualise the irreducibility of subjectivity, which we see as a deeper logical level of existence, and as shown above. However, when Harris (2014) speaks about the 'illusion of the self', we conceptualise instead the introduced multiverse-approach, which holds the capability to interconnect nomologically different self-concepts. Based on this approach we argue that the knowledge explosion of humanity becomes explainable, because the emerging wholeness (which act as a structural law/coupling between all participating species) is a real, however imaginary-valued entity. That is, the concept of self emerges within the spectrum between:

a more objectively manifested and measurable structures

b highly imaginary-valued dimensions (personal developments of art etc.).

Such 'unproven statements' incorporate newly adapted, complex-valued structural law, re-conceptualising the entire organisation of the human being, and developing the meaning of life. This structural law by itself is not explicitly spelled out or declined (verbalised) within the creative process. It is lived-by in a condensed manner, including reorganisation of implicit knowledge. Interestingly, this imaginary-valued structuration has already been discovered by the neuro-scientist Francisco Varela (Varela and Depraz, 2003). Such imagination leads to the discovery of new phenomena, which we wish to outline in more detail in this paper.

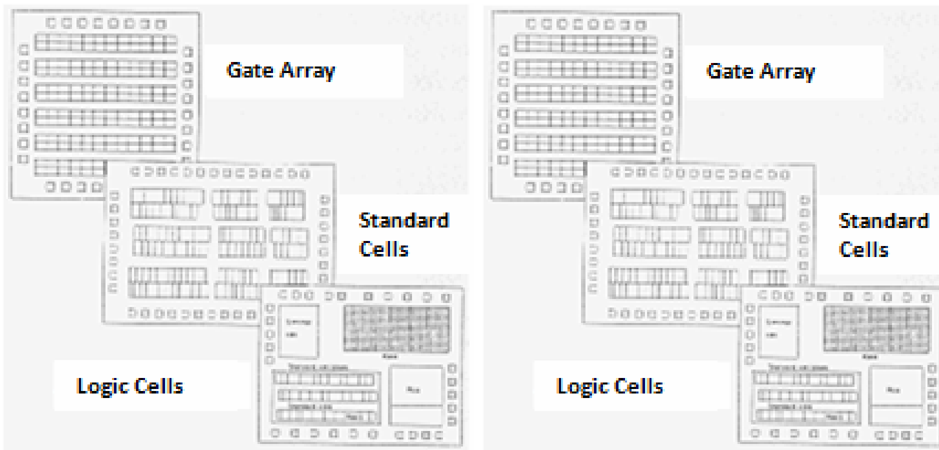
Within psychology and neuroscience different kinds of creative ideation processes have been analysed [such as 'divergent thinking' (Fink and Benedek, 2014)]. Interestingly, Fink and Benedek (2014, p.119) found that "the generation of original ideas (AU tasks) in contrast to the production of typical characteristics of objects was amongst others associated with comparatively low activation (or even with deactivations) in regions of the right parietal cortex." This indicates imaginary-valued activations.

Consciously attacking a new situation or problem makes existing knowledge explicit and fluent again, preparing for new imagination (however, verbally coded, explicit knowledge may become more fluent then implicit, automated knowledge).

From an architectural perspective, the systems capability enables outstanding different activity levels of the mind-body-system, which enables imaginary-valued system states to be entered into within multiple dimensions, thereby approaching new meaning within a newly emerging overall wholeness. Let us look at a next example: the close relationship of the structure of microelectronic devices in comparison to the living world of the engineers, which are creating such devices (Figure 10). We see that strong organisational principles of daily life (such as nearby-ordering, long distance order, further functional differentiation) have been transferred to design principles of microelectronic devices (Rüchardt, 1987; personal conversation). Another example is the fast and successful recovery of the Japans in the 1970s in microelectronics. Their living world shows very similar struturisation and organisation principles in comparison to US based or European cities.

The human mind-body is capable of mapping such knowledge between very different kinds of domains. For example, the design of microchips shows un-intentionally high similarities to the design of cities.

Figure 10 Comparison of the design of microelectronic products (left) and different types of cities (right); recognisable are transferred organisational principles (nearby-ordering, long distance order, functional differentiation, etc.) from: Rüchardt (1987) with kind permission



Very similar concepts are used in both cases [concepts of 'traffic', of 'housing', of different 'services' etc. (Figure 10)]. Once again, by applying the concept of 'structural coupling' it becomes clear that engineers who are living in certain structured cities will apply similar structures in what could be very different domains. This is at the heart of the emergence of new knowledge.

F.6 Subjective, meaningful knowledge in its own dynamics tends to break, to re-structure and to further enrich objective, 'senseless' knowledge in a continuous and unlimited manner.

F.7 'Subjective knowledge' always relates to specific, subjective compositions of 'objective information/knowledge' – however, common 'objective information' is always a source for further, subjective extension or negation.

F.8 Taking into account our oscillating mood, and primary activity, it seems that the following aspects create a new neuro-functional architecture:

1. During the evolution of species, the gap between the 'uncheckedness' of newly emerging 'unproven statements' grew in such a manner that imaginations about the self (and its relationships) grew progressively in complexity.
2. However, a limit was passed: we might 'dampen' any psychic or thought activity down to zero; that is, the system may continuously rest in a critical state [see Section 5 (Fink and Benedek, 2014)].
3. Activities like perception, reflection, attention (which can be executed unconsciously as well) can be manoeuvred and composed in an unlimited manner (sequential as well as hierarchical: fractals).
4. Within a conscious mode we can 'exclude' external stimuli (noise, movement, smell …) as well as internal stimuli (hunger, aggression, egoism, empathy), and create new foci of attention (autonomy).

5 We can conserve and keep active this conscious state in an unlimited manner.
6 Language as a medium of mediation in fractal levels (expresses and mediates all preceding capabilities); however, conscious experiences are not limited to language.
7 To summarise:
   - 'Conscious experiences' are becoming instantiated based on the ability of the system to modulate the individual's internal world within such a configurational and dimensional shape and power, that such modulations are created by an ability to differentiate external stimuli from within in an unlimited manner.
   - Then, consequently, the system will continuously create new qualia (as unproven statements).
   - Such phenomena create the depth of human knowledge.

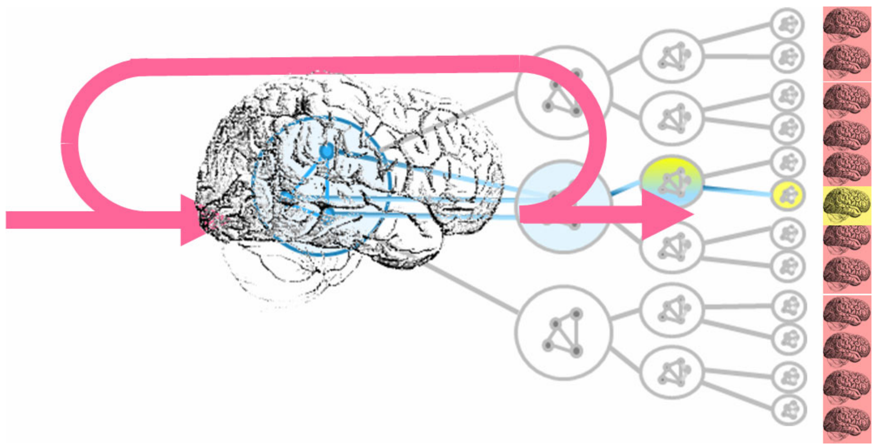
F.9 To view it from a systems theoretical perspective (Figure 12):

1 While animals and even pre-hominids implement higher degrees of direct transformation of signals into action, the human mind developed the capacity for new degrees of recursiveness and re-entry, unleashing a new quality of system characteristics (Gabora and DiPaola, 2012).
2 This led to an unlimited potentiality of imagination (or imaginary valued system states, respectively); which led also to the necessity to continuously rebuild our internal organisation.
3 Establishment of freedom through connectedness (if we understand each other, we can expose unseen potentialities).
4 While the deterministic worldview is centred on a two-state (binary) valued concept of truth (which tends to deliver 'one-and-only solutions'), the imaginative worldview grounds the binary worldview into imaginary dimensions; enabling multiverses of phase spaces instead of one single phase space.
5 In our history, this process is characterised through a move from control-oriented, centralised system organisation toward increasing self-organisation (and enabling democracy).

What is the quality or the smell of this rose, the colour of this tomato, or of this etching phenomenon? Looking into the eyes of our partner we might 'see' different universes/worlds [in terms of a 'rich seeing' (Lamme, 2010)]. The qualia problem then turns into expressions of recursively organised systems, which expose themselves between causal and 'non'-causal information. The formerly conceptually not tangible 'subjective dimension' can be found in imaginary-valued system states (painted in a rose colour in Figure 11). These states have the ability to cause further causal actions. They hold the state of dynamic physical laws, but they also create the roots for dignity and democratic systems (Hüther, 2018).

Consequently, there is no place in the universe where the informational content and capabilities of persons are stored other than within the persons themselves, and their connections to other subjects/objects. Each person may exhibit and manage rich universes of experience, and is responsible for their own decisions. The inverse is also true: persons which are not supported (for whatever reason) in the expansion of their abilities will informationally implode. Globalisation and new technologies are challenging human cooperation from within a global perspective.

Figure 11 OMB-many-world configuration; the mind continuously creates numerous overlays of possible worlds through oscillation (see online version for colours)



Notes: Each small circle (right side) holds a relationship to other minds (informational coupling); actual relation is painted in yellow. This is a non-algorithmic, non-computing process; it relates back and holds the same logical structure as to the very first oscillations of the OMB system (Figures 7, 8 and 9). Further algorithmic work ('thinking') takes place in order to sharpen the current action/will.

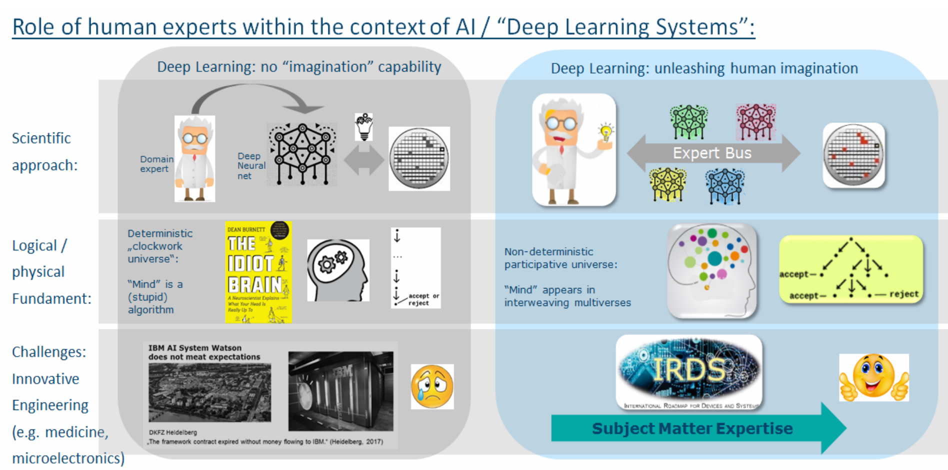
How to proceed with AI systems? It was not until May of this year that Google proclaimed that the entire focus of its research activities would be on AI (see also Google's separate publication, October 2018: artificial intelligence, what it means and how it changes our life/DIE ZEIT). In July 2018 the federal government of Germany also published a corner-paper for a 'new AI strategy' (BMWI, 2018).

A recently held conference, which for the past 30 years has annually assembled specialists in microelectronics, created the following remarkable outcome (Moyne, 2018): goal is not to replace human expertise; instead AI systems should serve as support systems, and control is given by design to experts (this outcome has been put into the agenda of the specialists). After all, one would expect that these designers and producers who invent and produce exactly the substance and ingredients that make up the dreams of AI-tinkerers are themselves deeply intertwined in the artificial intelligence web. The important AI area of 'deep learning' was one focus of the conference.

One would expect that those designers and producers who invent and produce precisely the substance and ingredients that comprise the dreams of AI-tinkerers themselves are deeply intertwined in the AI-web. However – ahead of their highly innovative inventions and strengths during the last 50 years – the microelectronic specialists are partly sceptical in how they see the role of AI. They think that AI seems to lack any innovative power or imagination, including the creation of innovative artwork. Consequently, specialists have made the issue of 'SME' part of their agenda for the forthcoming years, in order to make their contribution to a necessary humane dimension in modern-day projects. The core concepts of 'SME' are phenomenological rich models, which are seemingly directly imagined by engineers and conceptualised in engineering systems as ‘phenomenological models’ [see the contribution of Luhn et al. (2018) at the abovementioned conference].

As a result, the role of AI regarding its promises is viewed partially sceptically. In particular – and this was discussed in detail with concrete examples from the field of microelectronics – for the chipmaker specialists “AI seemed to lack any innovative power or imagination.” The experts in microelectronics have proven their strength for decades with some groundbreaking innovations [supported by James Moyne in the International Roadmap for Devices and Systems (IRDS), 2018]. Specifically, this also enables complex systems that are necessary for ‘deep learning’. Even the failure of ambitious projects – such as the failed use of the IBM AI system ‘Watson’ in the German Cancer Research Center Heidelberg (FAZ, 2017) – highlights this problem. With this in mind, Gerhard Luhn and Gerald Hüther made a contribution to this conference and discussed a new, physically and logically inspired approach (this paper).

Figure 12 Confrontation of two possible scenarios for dealing with AI systems (see online version for colours)



Notes: The left part shows a state-of-the-art approach: AI systems should replace experts. However, the microelectronics specialists are choosing the right option: AI systems should serve as support systems, and control is given by design to experts. ‘IRDS’ stands for the International Roadmap for Devices and Systems; see text above.

The good news is that microelectronics specialists have access to, or continually generate, exactly this knowledge that is exemplary of their open attitude and participation. Unfortunately, this structure is not reflected in the promises of an AI that has not yet discovered the importance of imaginary system states. Consequently, the specialists from the workshop mentioned above have taken this SME issue into their agenda for the next few years in order to make their contribution to a necessary humane dimension in modern day projects. We can only recommend that this approach – and from a logically clear, and in no way romantically transfigured perspective – be implanted in the field of AI (Figure 12).

Therefore, finally, if learning leads us within its core structure toward multiverse and imagination, what is the basic take-away from such a conclusion? Today our modern learning culture is focused on the transfer of causally structured knowledge. However, this causal knowledge is literally dead. Objective knowledge is close to dead, and we can easily look it up on the internet. Contrary to this, living knowledge develops itself within (inter-)phenomenal spheres, surpassing meso-cosmic physical structures. It is based on interaction, rather than on discrimination. We cannot 'learn' such knowledge in the traditional sense (by instruction). It will emerge by chance when we invite each other, because nature expends order and energy for such configurations.

What are the outcomes of those findings – what can we learn and strive for?

9 Conclusions: become who we are

As of today, it is unclear whether our feelings for or trust in one another – if we experience them – are real. "Our minds are made of molecular machines, otherwise known as brain cells. And if you find this depressing then you lack imagination", says the philosopher Daniel Dennett (Buckley, 2017). In public talks, Dennett illustrates the fallibility of human image recognition. When confronted with a fast-projected picture (illumination time 240 millisec), the picture then vanishes (black screen for 290 millisec), and then gets successively displayed again. However, the succeeding picture might be different.

Figure 13 Two pictures of a house, wherein details of the house might be different (see online version for colours)

Source: Dennett (2007)

Then, Dennett (2007) amuses himself while asking the audience when and whether they see the difference. Indeed, the median time for noticing the difference has been measured, and is 5.1 seconds (the reader might validate this). In this example (Figure 13), the original picture displays a house (left part), and the succeeding picture displays the same house in which something is different (the position of the chimney). The conclusion which Dennett draws is: we do not have control over what our mind does. This is not meant in a Freudian sense, but in general. We might eventually find a solution, but it could take a long time. Therefore, Dennett speaks about a 'user illusion', which nature creates to drive something like a conscious mind while implementing and optimising evolutionary learning algorithms [see also Dennett's (2017b) most recent book].

However, this is not an accusation to the contribution of Dennett. It follows out of the current deterministic mindset in science. Another example is the interesting study of Sloman and Fernbach (2017): the knowledge illusion. They show that all of our knowledge stems from human interaction. Each of us has only very limited knowledge, but we are somehow capable to share our motivations, and reach high degrees of participation. This fits perfect to our results.

Now, let us take another example. Figure 14 displays a slightly damaged car.

Figure 14 Slightly damaged car (see online version for colours)

Now, the point is that we *immediately* imagine an undamaged version of this car – within milliseconds. Our mind may create millions of alternative outlooks of this car, but selects very straightforwardly those of most interest. It is exactly this capability which is of interest with regard to this study [thanks to Knobe (2010) for this example].

Another example has already been studied in the last section: the holistic mapping of experienced organisational structures of living environments to modern technical systems (the similarity between the structure of cities and the structure of integrated circuits).

To summarise: everything is condensed down to the deepest 'moral' levels of our life – including so-called objective knowledge and scientific work!

However, the principle is the same: we continuously and very efficiently imagine differences between the actual world and other imagined possibilities. These imagined possibilities are not 'computed' or algorithmically calculated, but are immediately created due to quantum physical overlays based on OMB-many-world configurations (see Figure 11, last section).

But this seems to be changing now. The aim of this study was to expand on a formerly unseen, imaginary dimension of the human mind. The output is simple:

- It requires measurement instruments as complex as the human mind in order to analyse and 'measure' (in terms of 'understanding') the human mind.
- Causal relations of the brain stay within the real-valued dimensions, while the mind ascends toward imaginary-valued levels of activation (the phenomenon of 'enlightenment').
- One of the big mysteries of human evolution is that all other human species have become extinct. Given the abovementioned capabilities it seems that sapiens has 'outsmarted' them, continuously contributing to their disappearance (Suddendorf and Corballis, 2007).

However, the process of developing democratic structures demonstrates that the setup of rules for social interactions can go together with a further increase (not decrease) in personal freedom. The point is that there is an anticipated wholeness (something like an ideal state), which implicitly acts as a guiding principle. This is one of the most important milestones in human development. However, modern science in the form of determinism lacks the capability of conceptualising such a greater wholeness. For this reason, modern science causes our societies to destabilise and deform.

That is what is required is that we deeply understand ourselves as initiator of our activities – with regard to the processes we explored throughout this study. The philosopher Joshua Knobe mentions that "our ordinary way of making sense of free action is deeply different from anything that appears in cognitive science and, indeed, from anything in the sciences more generally" [Knobe, (Forthcoming), p.13].

The scope of this paper is to sensibilise on the imaginative power of human thinking. We propose that there is indeed a fundament which is true for all people, and which serves for trust, truthfulness and morality (and any qualia) at the same time: the naturally given resources and overall tendency toward growing phase space. The science of the human mind will move from a prescribing direction to a mere applauding, or supporting, approach. Each mind continuously creates new theories as 'unproven statements'. Therefore, we should invite each other for creative work. Galileo Galilei once stated: "you cannot teach a person anything. You can only help him find it within her-/himself."

Current scientific research does not inherently strive to reduce the growing social mismatch within our societies. This mismatch emerges out of our deterministic worldview. We conceptualise and treat other primarily as objects, and not as subjects. This lack of subjectivity and personal affinity is just not possible within the current 'objective' mindset of science.

The human mind – while engaging in close and growing interactions with its social/ natural environment (and gaining knowledge) – continuously strives for imaginary system states (imaginations, rich thoughts). By doing so, the human mind steps out of 'program execution', and enters into a lifelong 're-programming' mode. From a logical standpoint we continuously create 'unproven statements' and are for this reason trying to trespass the borders of the universe.

By doing so, we see that the sense of our being in the world is – besides surviving – making it a better world (in terms of enriched phase spaces). Here we find the roots of morality and the limitations of current deterministic approaches in theory and in practice. Experimental philosophy is showing that people have access to this knowledge (Knobe, Forthcoming). All this may help to replace our picture of the world as being filled with zombies. Intelligently programmed machines may support our learning, but the sources of intelligence rely on our capacity for imagination.

Summarising the logic we have uncovered in this study, we propose the following: Dan Dennett summarised the current setup of science [in the words of his friend Bob Nozick (Dennett, 2007)]. Scientists want to bring their arguments and hypotheses to their audience, followed by inferences and a conclusion. However, if the audience do not accept the conclusion, 'they die' (O-tone Dennett). The idea is to provide such powerful arguments that they literally knock out those who insist in questioning or not accepting the conclusion.

This picture deeply reflects the conundrum of modern society. We live in a two-value-based concept of 'absolute' truth, where everything can be projected to an unchanging set of physical laws. The aim of this study to expand on the contrary.

Classical logic may provide reasonable boundaries to mark the stairway we walk. But classical logic and determinism proclaim the void at the place of our deepest essence, the capability of ourselves to continuously transcend and 'leave' the boundaries of the world.

Consequently, science is not (or should not be) made to highlight our non-capabilities and burdens. In simple words: rather than finding arguments to knock out critics, we should try to motivate others and ourselves to reach for new connections. We are made by nature to participate at a greater wholeness; nature encourages us to strive for further extension of our space.

Contrary to this, the deterministic view in science and especially in neuroscience promotes behaviour according to double standards – without knowing or being able to reflect on it. As a conclusion, even popular neuroscientists like Gerhard Roth relativise the influence of reasonable thoughts and reasonable thinking in general with regard to our actions. He does not see that there is an underlying deep structure which promotes direct influence of reasonable thoughts on the way we act: such thoughts (or activities including artwork, music etc.) continuously strive to enrich and develop a greater wholeness.

Roth (2003, p.164) further concludes that the limbic system decides the manner in which understanding and reasoning will be activated. Again, Roth as a scientist puts himself outside of nature, and gives himself the authority to define 'natural laws' which allow a deterministic enrolling limbic system to 'decide' about the proper activation of understanding and reasoning. Gerhard Roth and others claims that the creation of activities is seemingly caused by our 'unconsciousness'. But he appears to have no concept of a greater wholeness, which serves as an ocean of direct participation within newly developing structures of physical, biological, cultural and existential laws.

To conclude, such a limited and restricted scientific approach does not strive to deeply conceptualise the human being. Humanity is seen outside of nature, as a zombie entirely on its own. However, it is clear that our behaviour is in large part determined by external influences and forces. We have also seen that the development of democracy was a major invention of humanity in order to overcome determinism ('determinism' in terms of hierarchical control and power in societies).

Another example is the split experienced in our society, the discussion about the double standard of the Trump administration (and vice versa) and much more.

Never the less, modern science is causing in a dangerous manner growing double standard within our society, because modern science does not offer a concept for discussing and positively criticising (and further develop) forces which destabilise and deform cultural achievements. The common good and the greater wholeness of our societies are not conceivable in terms of determinism.

It seems that our entire society is losing internal consistency.

For this reason, current knowledge is not sufficient to stimulate change. The next level, which we call 'understanding', is still not sufficient to move us forward. A movement will indeed start when we initiate self-reference-based imagination, which may stipulate self-modification and development. We still see ourselves outside of nature, and continue to control others. This creates fear and blocks to see the future. We learn that only the best one will survive, and we do not trust the human opposite to us. However, aim of this study was to sensitise that thought is not yet proprioceptive. We distrust potential partners, because we are not capable to imagine the potentialities and the wholeness, which will embody us for free, and leave the needy ego alone.

One of the authors has created an academy for the development of human potential. The goal of the work of this academy is the transformation of our current culture of relationship (https://www.akademiefuerpotentialentfaltung.org/). Many other people are sharing such understanding, and are already following similar pathways. We encourage everybody to invite one another, instead of more controlling, and strive for a better future. Indeed, this future is 'imaginary' in the deepest sense and will never be accessible to any computing device. However, nature encourages us on this path.

Based on our deep internal structure – and based on the deterministic worldview – it is logically and practically impossible to show what we will eventually become, because a greater wholeness is inconceivable in determinism.

To put it another way around: based on the idea that our entire humanity expands on the third truth value ('imaginary'), which forms our acting and feeling towards new horizons, we are free and do have responsibility at the same time. We are free because imagination is a fundamental category of life and humanity. However, we are responsible at the same moment, because human freedom is based on the knowledge of the dignity of ours.

There is no reason to think of us as zombies!

Science is not made to predict, but help to *enable* the future. So told Galilei:

- let us strive to become who *we* are.

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