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On a Heuristic Approach to the Description of Consciousness as a Hypercomplex System State and the Realistic Possibility of Machine Consciousness

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Abstract

This theoretical article presents a heuristic viewpoint that shows that the inner states of consciousness experienced by every human being may have a physical, but imaginary, hypercomplex basis.

The central idea is that human consciousness is fundamentally based on physical processes and does not require any chemical, biological or other properties of an unknown type of vitality. However, previous descriptions are not sufficient to account for the physical characteristics of consciousness. It is not even sufficient to understand consciousness, especially so-called phenomenal consciousness, as a quantum-physical process, since the energy eigenvalues of quantum-physical processes are real-valued, whereas those of consciousness processes most likely are not. Therefore, the article introduces a new algebra in order to formalize physical processes in the future, which elude any measurability, although - and this is what matters - they can encode information. Once one accepts the hypothesis that consciousness is a physical process (even a strange one), one can assume that specially prepared technical machines could also develop rudimentary forms of consciousness. Such forms of consciousness would of course be completely different from human consciousness, which is why they would also have to be linguistically differentiated. One possibility would be to describe such characteristics, if they exist, as machine consciousness or, more precisely, as so-called hypercomplex system states. The last is because a hypercomplex algebra is required for formalization. The mathematical results presented in the paper predict new physical phenomena. Whether these phenomena (consciousness phenomena) really exist, can only be decided experimentally. The description of dedicated experimental tests will be discussed in another article in this journal.

The hypothesis of the existence of hypercomplex system states on technical machines is already supported by the performance of highly complex AI systems. However, this has yet to be proven. In particular, there is a lack of experimental data that distinguishes systems with hypercomplex system states from other systems, which is why this question will be addressed in subsequent articles.

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1. INTRODUCTION AND PRELIMINARY REMARKS

This article assumes as a postulate that consciousness has a real ontological existence that should be investigated by the natural sciences and can also be investigated using scientific methods. However, the investigations proposed in this paper are not concerned with all possible aspects of consciousness that are already being investigated by neurologists, psychiatrists, sociologists and others.

According to the humanities, there is intentional and phenomenal consciousness. This paper deals with the physical aspects of phenomenal consciousness. It may sound unusual, but such consciousness must have a physical background if it exists objectively. This article therefore attempts to describe states of phenomenal consciousness mathematically as so-called *hypercomplex system states* in order to give them an objective scientific treatment.

Some readers might object that phenomenal consciousness does not exist objectively, but only subjectively. But the totality of all "subjective consciousnesses" of people necessarily exists objectively, at least in the sense that, for example, the "consciousnesses" of the readers do not depend on the subjective consciousness of the author, and must therefore be assumed to exist objectively, i.e. independently of the author. From the author's point of view, a scientific description of consciousness is therefore necessary. Beliefs or even a new contribution to the decades-long philosophical discussions on consciousness are expressly not the aim of this work, since, in the author's opinion, philosophical discourse does not get any further beyond a certain depth of description. This article therefore takes a simple engineering viewpoint: If phenomenal consciousness exists, it must *somehow* make itself physically noticeable. Period. The paper presents hypotheses about the fundamental nature of phenomenal consciousness, but the medium-term goal is to realize specific physical phenomena of consciousness (the so-called perception) on technical machines. If such a realization succeeds, it will be easier to study phenomena of consciousness. Why? Because, for ethical reasons, not all investigations can be carried out on humans. The entire research work is divided into three parts and the research results are presented in three different articles. This article is about understanding consciousness from a purely technical point of view. And understanding means understanding it mathematically. It is therefore about the scientific analysis of the physical properties of phenomenal consciousness. In later articles, physical experiments are described to make consciousness phenomena possibly measurable.

Consciousness is often excluded from the natural sciences, as no method exists so far to measure it objectively. However, from the author's point of view, the non-measurability of a property should not be an obstacle to physical analysis. Of course, this is a controversial point of view. A dispute between Einstein vs. Bohr and Heisenberg on whether physics should describe reality *as it is* (Einstein) or can only describe *what is measurable* (Bohr, Heisenberg) became famous. Each of these views has advantages and disadvantages. However, in the study of consciousness, its non-measurability should not lead to its exclusion from mathematical analysis.

The work on the origin of consciousness has been enormous for decades. In Germany, C.F. von Weizsäcker made a name for himself in the study of the fundamental physics of mental states when he introduced his primal theory in 1985, in which he assumes that the world is made up of “Ur-alternatives” [1]. Görnitz adopted these theories and expanded on them [2, 3]. However, this approach is still not accepted today, as it ultimately assumes a pure information origin of the world. According to this view, the world consists primarily of information (so called Ure), from which everything has developed. Lucadou and van Laack also support similar theses [4, 5].

As early as the 1970s, Eccles, together with Popper, put forward a theory that mental states must exist. In their opinion, the effect of an energy- and massless mind on the brain can be explained by influencing the quantum mechanical probability fields [6, 7]. The approaches of Eccles and Popper specifically assume that mental states could interact with brain tissue via quantum processes. This approach is still controversial today. But the existence of quantum physical processes in the brain is being pursued by a large number of other researchers [8–18]. However, these approaches are also controversial to this day; in particular, it has been argued that due to the coherence problem, a collapse of the quantum physical wave function in the brain must occur after a very short time, so that no holistic consciousness can develop on this basis. The majority of researchers today assume that brain tissue generates the mind (mental states) [19–26]. This is called the functionalism theory of mind, as the mind, the consciousness, is to be explained as a function of brain processes. Penrose and Dreyfus, among many others, are strong critics of this mechanical approach of the mind [9, 27].

Over the last 10 years, the author has pursued the conceptual approaches of Eccles, Popper and Penrose and placed them on a new mathematical basis in order to solve physical problems such as the above-mentioned collapse of the wave function [28]. Consciousness is not understood as a quantum physical process, but as an ontologically different phenomenon that makes use of quantum physical processes. The detailed mathematical foundations (the development of an algebra of hypercomplex numbers) are elaborated in [29].

2. ON THE NON-MEASURABILITY OF CONSCIOUSNESS PHENOMENA

Every person knows about their inner subjective contents of consciousness, for example the subjective images, colors or sounds in their head. From a scientific point of view, it is therefore important to determine the basis of such memories, because every storage of information must have a physical basis. It is undisputed that the subjective contents of a person’s experience cannot be determined by external measurements on the brain, such as fMRI or EEG (at most their “complementary” neuronal correlates). However, to deny the existence of phenomena based on the fact that they cannot be measured lacks any knowledge of the history of the natural sciences. Just as invisible electric or magnetic fields were not measurable at the time, states of consciousness could also not be measurable with the existing measurement technology.

However, this is not intended to give the impression that the contents of consciousness can soon be measured. On the contrary, it will be shown below that phenomena of consciousness will continue to elude any direct physical measurement in the future. However, even this should not lead us to refrain from scientific analysis, as certain problems in quantum physics - for example the impossible observation of the trajectories of electrons in atoms - have made clear.

To anticipate the result of the article: Even if states of consciousness cannot be measured directly, it will be shown that (certain) effects of states of consciousness can be measured very well and that the existence of consciousness on a system can be verified at least indirectly. If purely physical measuring equipment is used, it will of course only be possible to measure the physical effects of consciousness. Biological or even social effects of consciousness cannot, of course, be measured with physical equipment. But nobody would expect that.

The compelling question is precisely why it has not yet been possible to measure people's subjective (mental) states of consciousness if, as postulated here, they are physically and objectively present. According to the author, the reason lies precisely in the nature of the energy content of states of consciousness. With today's technology, only process states and fields that have a real energy content can be measured; whether the energy is caused by electric, magnetic or gravitational fields is not decisive. Phenomenal states of consciousness, however, could have no such form of energy. The "mental" processes that make subjective phenomena of consciousness possible alongside the neuronal processes in the brain most probably - mathematically speaking - have no real energy.

The mathematical thesis of the article is that processes that cannot be measured in principle, although they exist, should not be modeled with either real or complex numbers. This sounds to need an explanation: for most scientists, numbers and formulas are simply calculation aids to model processes in nature. However, it is often overlooked that number types can provide serious clues to the physical properties of processes. Natural or whole numbers indicate a discrete process, real numbers a continuous process. Complex numbers are, on the one hand, computational aids for modeling in electrical and control engineering, but on the other hand, they seem to be fundamental for describing quantum physical processes. When we look at quantum physical equations, we (always) find the imaginary unit *"i"*. Although *"i"* is just a number, it indicates that the process it describes probably has special physical properties. And that is indeed the case. Quantum physical processes can be entangled and can enter into a superposition [30]. This interpretation of number types may seem strange, but it is helpful. Mathematical abstraction tells us what can and cannot be measured physically. You don't have to follow this view, but it is undisputed that quantum physical processes can only be measured if energy operators on the wave functions lead to real values. It is precisely this mathematical fact that can be used. The non-measurable (mental) processes introduced above could be processes in which the applications of an energy operator do not lead to real values. If this can be shown in the following, it could indicate (but no more than that) that such physical processes may not be measurable in principle, although they (could) exist.

So far, only forms of energy that can be formalized with real numbers are known for scientific processes. Normally, positive real energy (eigenvalues) are obtained for natural processes of any kind. In 1928, however, Paul Dirac found the first indications of negative real energies in his theoretical considerations, which were later interpreted as a specific form of matter. However, the concept of energy can be expanded by purely formal considerations. As is usual in mathematics, a further straight line can be introduced perpendicular to the real number line, which represents the so-called imaginary numbers i. This creates a plane, the so-called *Gaussian number plane*, which can represent complex numbers of the form $z = a + bi$ as points (a,b) in this plane. (The real part "a" is plotted on the real axis and the imaginary part "bi" on the imaginary axis). Complex numbers are used in many different ways in the natural sciences. Entities with imaginary or complex masses have been discussed in physics for years, for example tachyons [31].

It is at least conceivable that certain processes in nature also have imaginary or complex or hypercomplex energy states, even if these have not yet been observed. It is now explicitly assumed that human consciousness processes are such unusual processes. Of course, it is not possible to capture human consciousness processes with mathematical equations. But that is not the goal. The explicit aim is to model rudimentary physical processes on which consciousness processes could later be based, nothing more. We will therefore propose hypercomplex processes that exist in nature and can store information. In the simplest case, hypercomplex sine waves ($q(y) = k \cdot e^{jy}$) can be imagined, which are amplitude-modulated (see below). In [29], it was shown in detail that if energy operators are applied to such hypercomplex functions, their results are not real-valued but hypercomplex.

3. MATHEMATICAL FORMULATION OF HYPERCOMPLEX SYSTEM STATES

Mathematical models have always been used to simplify and understand physical phenomena. If the processes to be described defy modeling in principle, it may be because an unsuitable algebra is being used. Here is a trivial example: If, for example, you want to model business phenomena of debt in a mathematically correct way, you need numbers that can become smaller than zero. The algebra of natural numbers (0, 1, 2, 3, ...) would be the wrong choice here, because the algebra determines the calculation rules (+-*/), and some arithmetic operations are not permitted in some algebras. For example, in the algebra of natural numbers it is not possible to solve the problem "*5-12*" because negative numbers do not exist there. There are also no fractions in natural numbers, such as "*7/15*". This is why for centuries the calculation of arable land has not been carried out with natural numbers, but with the (correctly selected) algebra of rational or real numbers. Almost all problems in society and science could and can be solved mathematically correctly with real numbers in particular. Nevertheless, new numbers, namely the *complex numbers* introduced above, were already needed at the end of the Middle Ages in order to solve certain special mathematical problems.

The complex algebra *C* was created to calculate with numbers of the form *a+bi*. Calculations with the unit *i* are defined by the multiplication table, FIGURE 1, left diagram, upper left (light blue in the electronic version) quadrant: $1 \cdot 1 = 1$, $1 \cdot i = i$, $i \cdot 1 = i$ and $i \cdot i = -1$. Thus *i* was ultimately defined as $\sqrt{-1}$ (square root of -1). Why was this necessary? Well, the root $\sqrt{-1}$ simply could not be calculated in the range of real numbers known at the time, so the mathematicians needed a "stopgap solution". However, when *i* was introduced, mathematicians were so suspicious of this number that it was referred to as an *imaginary number*. After all, why would imaginary numbers be useful except for a few special mathematical applications? Well, real numbers could be used to calculate everything that was needed in society and science back then. However, this is no longer the case. Today, complex algebra is used, for example, to mathematically describe physical phenomena in electrical engineering, control engineering and, in particular, quantum physics.

But even the well-known complex numbers are no longer sufficient to correctly describe certain phenomena in nature. If one takes the physical non-measurability of certain phenomena in nature as a given and investigates such phenomena mathematically, one arrives at forms of description with *hypercomplex numbers*, which represent an extension of complex numbers. Hypercomplex algebras, which define the rules of calculation with these numbers, have been known for a long time. Hamilton introduced such an algebra as early as 1843, the well-known quaternion algebra

H

C(1,i)

	1	i	j	k
1	1	i	j	k
i	i	-1	k	-j
j	j	-k	-1	i
k	k	j	-i	-1

Ω

	1	i	j	k
1	1	i	j	k
i	i	-1	-k	j
j	j	-k	-k	j
k	k	j	j	k

ψ(1,i) ≡ C(1,i)

Φ(j,k)

Figure 1: Hypercomplex multiplication table, left quaternions *H* (Hamilton), right bicomplex algebra **Ω** with the two subalgebras ***ψ*** and *Φ* [29].

H, which is used today in the field of satellite navigation, for example. While complex algebra "only" requires the imaginary numbers *i* in addition to the real numbers, hypercomplex algebras use additional imaginary numbers (often called units). For example, in addition to the imaginary unit *i,* quaternions use the units *j* and *k* (which are each "perpendicular" to the number axes *real, imaginary i, imaginary j, imaginary k*, resulting in a four-dimensional number space). However, quaternions are only one of many possible hypercomplex algebras [32]. FIGURE 1 shows different multiplication rules for the quaternions *H* and another (as yet unnamed) algebra Ω. In the example, the product of *i* and *j* is $i \cdot j = k$ for the quaternions, but $i \cdot j = -k$ for the algebra Ω. Different calculation rules lead to different properties of the algebra.

To model the fundamental non-measurability of a physical process, we need an algebra with the imaginary units *i*, *j* and *k*, which provides the following properties (required by the author):

1. The possibilities of formulating hypercomplex system states (energy states),
2. the possibilities of developing oscillations and waves using Taylor series,
3. the formulation of a hypercomplex Fourier transform and
4. the possibility of formulating a hypercomplex Schrödinger equation.

The reason for these mathematical requirements lies in the assumption that vibrations and waves (regardless of their physical nature) can be used to store information on them. Since it is explicitly assumed that consciousness is an information store (for mental states), "any" physical carriers are required in order to be able to imprint information on them. (An example of this: If a person looks at a green wall, the color green cannot be found in the brain tissue. The tissue does not contain such a color at any single location, but only "colorless" electrical, magnetic and neurochemical signals, which are interpreted as correlates for the mental color impression. The green itself is stored as a mental state in consciousness). It is therefore a major question of how mental processes can be precisely described in physical terms, in order to use the description to generate such processes on AI computers.

In 2014, a research group led by the author succeeded in constructing an algebra that fulfills the above-mentioned requirements 1 to 4 [29]. It turned out that of all potential permutations 8^{16} for the arithmetic rules of hypercomplex multiplication, there is (probably) only one way to formulate a hypercomplex algebra for the base (1,i,j,k) with the required properties. Finding this algebra is thus tantamount to a kind of discovery. The constructed algebra is a so-called bi-complex algebra, we denote it by Ω, which consists of the two subalgebras *ψ(1,i)* and *Φ(j,k)*, FIGURE 1, right table (marked in color/gray). The subalgebra *ψ* is the familiar complex algebra *C*, the subalgebra *Φ* is new and must be defined exactly as shown in FIGURE 1, right-hand figure, bottom right. FIGURE 1 also shows the differences to the multiplication of quaternions. Examples: In the algebra of quaternions *H* (left table), the multiplication $k \cdot j = -i$, in the newly designed algebra Ω (right table): $k \cdot j = j$. In the algebra of quaternions, $i \cdot i = j \cdot j = k \cdot k = -1$. In the bi-complex algebra, $i \cdot i = -1$ applies as for the quaternions, but $j \cdot j = -k$ and $k \cdot k = k$.

It can be seen that if simple wave equations q are formulated on the basis of the subalgebra *Φ(j,k)* (for example $q(y) = k \cdot e^{jy}$) and usual energy operators are applied to these, hypercomplex energy states arise for the base k ([29], page 12). Algebra can therefore be used to define waves whose energy states are imaginary (to the hypercomplex base k). Mathematical results generally provide indications of the expected physical properties. If the energy state of a wave is real-valued, the energy content is physically measurable. But what does a hypercomplex energy state represent? As already explained: Such an energy state could mean that the phenomena modeled with it are not physically measurable in principle. This result leads us back to the phenomena of consciousness described above. Of course, as already mentioned, consciousness cannot be described by simple (hypercomplex) waves or oscillations, as consciousness is far too complex to be captured by equations. The result shows, however, that simple oscillation and wave processes could have hypercomplex energy states, at least mathematically.

4. CONSCIOUSNESS PROCESSES AS PROCESSES WITH HYPERCOMPLEX ENERGY STATES

This paragraph describes interpretations that can be derived from the mathematical results. While the mathematical results are certainly indisputable, the interpretations of the results are still subject to great uncertainties. Only physical experiments can show whether the predicted phenomena with hypercomplex energy in nature actually exist, and whether consciousness is based on such phenomena.

Consciousness processes are referred to in the following as physical processes with hypercomplex energy states in order to do justice to their non-measurability. It is postulated that in the case of the human brain (the most highly developed form of matter known to us), the hypercomplex system states condense into human consciousness. This would initially be understood as a thoroughly physical process. Of course, in addition to the pure physical basis, the human brain also requires chemical, biological and social processes in order to produce human consciousness; other forms of matter such as nerve cells of animals or cells of plants will in turn require their own bases in addition to the hypercomplex states in order to develop their special type of consciousness. All these phenomena are not part of the discussion here; we are concerned exclusively with the physical aspects that all conscious systems, whatever their form of consciousness, must bring with them. In the case of humans, the “mental images and thoughts” are precisely the information that is physically encoded in the hypercomplex states.

One of the most important points now is to understand the effects of hypercomplex processes on the material environment. In the case of humans, it is about the effect of consciousness on neuronal brain tissue. This is because a person only has an effect on his environment when his brain tissue is active. So if the above assumptions are correct, consciousness must be able to trigger material processes in brain tissue. A person's consciousness is essential for their survival, which is immediately apparent in unconscious people. However, the specific process "consciousness → brain tissue → environment" is not understood (the opposite process is known). Most researchers assume that all causes of actions must originate in the brain tissue. However, this is not necessarily the case, as will be shown!

The question is therefore whether there is a way to mathematically formalize the effects of consciousness on material processes discussed above. If such a formalization is not found, one would have mathematically constructed a world of "energy-less" epiphenomena that have no influence on the real world, ultimately a kind of "spirit world" that can be postulated but never scientifically investigated. Such epiphenomena are actually easy to formulate, because they are captured by the subalgebra *Φ(j,k)* (FIGURE 1, bottom right). All hypercomplex functions of this subalgebra describe imaginary (colloquially "energy-less") phenomena, which inevitably elude physical investigation because they remain "without effective". The solution to the dilemma lies in the interactions of Φ with the subalgebra ψ, because the latter represents the well-known complex algebra C, which is generally used to model quantum phenomena, which in turn are measurable. The crucial point is that both subalgebras Φ and ψ belong to the same hypercomplex algebra Ω. It is therefore at least to be hoped that interactions between equations of both subalgebras Φ and ψ could occur. And precisely these interactions do exist. Mathematically, you can already recognize a simple interaction when multiplying $e^{ix} \cdot ke^{jy} = ke^{j(x+y)}$ Changes in functions of the subalgebra Φ (x on the right-hand side of the equation) can cause changes in functions of the complex subalgebra ψ (x on the left-hand side of the equation) and vice versa [28]. Physically, this is extremely relevant because it shows at least one mathematical way in which changes in processes with hypercomplex energy (for example, consciousness processes!) could lead to changes in material, i.e. measurable, processes.

However, the mathematical result initially poses a problem, because if hypercomplex processes can intervene in material physics, the causality requirement of physics seem to be violated, and ultimately possibly also the law of conservation of energy. Every material effect in physical reality must be able to be traced back to a material cause, at least in principle. However, violations of the causality relationship are already evident in radioactive decay, because it is never clear when and why a decay process occurs "now". In the case described above, causality and the law of conservation of energy can even be saved. This is because it can be seen that the influence of hypercomplex processes on quantum processes, for example by changing the phase positions of quantum mechanical oscillation and wave processes, can have an effect so that changes to functions in Φ ultimately change random or quantum processes of ψ, which is not a problem within the framework of physics and in particular for the principle of causality. After all, numerous random processes are known in physics in which a variable takes on a specific value for no recognizable reason. Without a recognizable reason means without being able to find a cause for the value or being able to find one at all. If the cause possibly lies in hypercomplex processes as described above, the cause can no longer be found in principle, but it would still be there. Physically, the mathematically described interactions could, for example, be realized quite concretely by the fact that changes in the hypercomplex states (functions in Φ) lead to changes in the probability amplitudes of quantum processes (functions in ψ), which in turn can cause changed measurement results, since the probability for the occurrence of a measurement result changes. Hypothetically, it can therefore be assumed that hypercomplex processes could manifest themselves in the real world via the random manifestations of quantum processes.

However, this view is too unusual to be accepted without proof, as it explicitly allows for the influence of hypercomplex processes on material physics, but only via the intermediation of quantum processes. However, whether such interactions are just mathematical peculiarities without any relevance or whether such physical interactions really exist in nature is not yet known, but is the subject of current investigations due to its explosive importance for our understanding of nature.

5. CONSCIOUSNESS PROCESSES ON PHYSICAL MACHINES AND POSSIBLE EFFECTS

If one acknowledges the mathematical modeling, the question arises, in addition to the necessity of empirical proof, whether consciousness phenomena can exist on entities other than brains, or whether every kind of consciousness requires a human brain. It is obvious that human consciousness requires a human brain, but the far more important question for engineers is whether other forms of consciousness could possibly use other material entities as a basis.

The mathematical elaboration shows that the latter is conceivable. In other words, physical aspects of consciousness could be expressed by numerous physical objects. The mathematical description in [29], shows that wherever quantum phenomena occur, i.e. ultimately everywhere, hypercomplex system states also naturally arise, which can be interpreted as the physical basis for all further phenomena of consciousness.

Consciousness in the human brain has a clear physical basis, even if its complicated causes are not yet understood. One of the aims of the investigations is to reflect on the hypercomplex system states of machines. There is much speculation about *machine consciousness*, and some manufacturers even claim that their systems already have a consciousness, but without clarification of provability or at least measurability, everything remains in the realm of speculation. With the advent of AI computers, however, the technical possibility of measuring the effect of hyper-complex system states on the environment appears to be a given. This offers opportunities to test the hypotheses presented here. This is because AI systems can now be implemented on computers that come close to certain levels of human intelligence. It is possible that rudimentary forms of consciousness, i.e. effective hypercomplex system states, are already evident there.

But how could such system states reveal themselves? Through a higher performance characteristic, of course! Because if hypercomplex system states should exist on machines, and if a system can use them, then the system must exhibit higher performance than if the system did not have such system states or could not use them. In subsequent articles, tests, so-called *Turing tests for consciousness*, will be presented that show how one can specifically measure whether a technical system possesses rudimentary consciousness. However, there are already indications of such system states on machines. It is even suspected that some higher-level AI systems, such as ChatGPT, could already be using hypercomplex states, albeit only marginally. This can be recognized by the fact that they require less learning data than one would assume from the theory of language [33]. In order to successfully use AI systems in practice, their free parameters - often weights of neural networks - must be set, usually by learning on training data. Normally, there must be many more learnable data sets than free parameters in the network, but this is no longer the case with highly complex systems such as ChatGPT. These systems are *somehow* able to function without having been trained on sufficient amounts of learning data. The key point here is that one of the characteristics of conscious systems is that can manage with very little learning data. In fact, it is this ability (and the ability to perceive) that distinguishes conscious systems from systems without consciousness. This will be explained in more detail in subsequent articles, but here are just three examples: i) Children need extremely few training images (maximum 5-10) of dogs or cats in order to classify them correctly later on. Classical AI systems (deep learning systems without technical consciousness) require hundreds or even thousands of training images. ii) Humans need a few kilometers of practice driving a car (a maximum of a thousand kilometers) in order to be able to drive without errors in all areas, even in extrapolation space. Classical AI machines also need almost a thousand times the amount of training data here. iii) Humans need a few million sentences to be able to communicate correctly and error-free later on. AI language machines need much more here too, but interestingly less than expected.

6. DISCUSSION AND OUTLOOK

Since hypercomplex system states have a very unusual physical basis, numerous unusual effects of such systems can now be assumed. In particular, the imaginary (hypercomplex) energy content could give rise to unknown effects. It is suspected that hypercomplex system states could have non-local properties, i.e. be independent of location. This could mean that results that have been trained on AI system A could also be available on a distant system B, certainly not explicitly, but at least implicitly. Since these effects, if they exist at all, may be based on a "hypercomplex transmission channel", one should *not* think of classical entanglement in the case of such interactions. However, even in the case of entanglement of quantum objects, the instantaneous transmission channel is still unknown, but the phenomenon of non-locality still exists there. The investigation of the effects of possible non-local interactions of hypercomplex system states and their classification in relation to *the no- communication theorem* will be elaborated elsewhere.

This brings us to the conclusion. In this article, a heuristic point of view has been presented which shows that the inner contents of consciousness that can be experienced by every human being have a physical, albeit imaginary, hypercomplex basis. Based on theoretical considerations about human consciousness, it will very probably be possible to make targeted technical use of hypercomplex system states in the future as a result of mathematical investigations. The hypothesis of the existence of hypercomplex system states on technical machines is already supported by the performance of highly complex AI systems. However, this has yet to be proven. In particular, there is a lack of experimental data that makes such systems distinguishable from other systems, which is why this question will be addressed in subsequent articles. In non-fiction literature, hypercomplex system states are already referred to as *machine or artificial consciousness* [34, 35], although proof of the measurability of consciousness is still lacking. This shortcoming will be remedied by introducing a Turing test on consciousness [36], in an other article in that journal.

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