WHAT DOES CONSTRUCTOR THEORY CONSTRUCT?: KNOWLEDGE AS A PHYSICAL PROPERTY

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ABSTRACT

"Constructor theory of eigenbehavior" is the most appropriate short way to describe what this paper is about. To those who have encountered the idea of eigenbehavior for the first time through this text, let's say that it is related to recursions within and emergence of consciousness and information in general (Füllsack, 2016). In a back and forth manner between constructor theory of possible tasks (Deutsch, 2012) and eigenbehavior as a viable (since it passes the test of existence; Josephson, 2012) phenomenon, we shall try to tell something about the fabric of reality (Deutsch, 1998). This author uses in an already published paper (Malecic, 2016) the metaphor of systems as footprints and wonders what kind of "animal" (constructor) might leave them behind. This text goes further in combining and criticizing Deutsch and Marletto's work with the concept of eigenbehavior. Interpretations of quantum mechanics and physical principles are also elaborated.

Key Words – anticipation, autopoiesis, self-awareness, universal constructor, determinism

INTRODUCTION

Causation, the arrow of time, consciousness, and computability cannot be resolved only by additional empirical studies. The problem is unresolved if scientists add conscious entities as an afterthought and refuse a systems perspective and transdisciplinarity.

How to use the systems perspective in order to gain insights not possible by any other approach? Where do physical principles (vs. subsidiary theories) come from? How to set an agreement (collective eigenbehavior) about conclusions? Different ideas are compared through the systems perspective in order to support those that unify and criticize those that do not unify.

David Deutsch and Chiara Marletto's constructor theory can be used to both assess their own opinions (eigenbehavior) and reveal something about thermodynamics, quantum mechanics, and causation (if people ever reach a consensus – itself a challenge for second-order cybernetics).

Consciousness (thinking about thinking and memory) is a possible task within our realm. It belongs to viable (since they exist) systems and viable physics of viable systems. The conclusions reveal something about a viable (possible) reality and us within it.

Similarities between constructor theory and constructivism go beyond similar words, especially because Deutsch himself (Levey and Trehub, 2012) announces that there might be some publications on cybernetics not known to him that could improve his and Marletto's ideas. Just as physics is valuable for naturalization of metaphysics (Ladyman and Ross, 2007), it is valuable to look for physics of constructor theory and constructivism and in a back and forth process akin to Troncale's (2009) abstraction and deabstraction question viability of approaches (for instance Maturana and Varela (1980), Rosen (2012), Hofstadter (1979), and Deacon (2012)) and physics.

CONSTRUCTOR THEORY AND EIGENBEHAVIOR

First of all we should elaborate two still not widely known (in times still reluctant to transdisciplinarity (Rousseau et al., 2016a)) concepts that are the key part of this article.

Constructor Theory and the Fabric of Reality

The following definition (Deutsch, 2012) is the central idea of this article. We shall insist on it even in cases when something looks unexpected, (counter)intuitive, or inevitable.

Constructor theory is the theory of which transformations

input state of substrates --> output state of substrates

can be caused and which cannot, and why.

It is a search for physical principles allegedly more fundamental than physical laws. Instead of doing physics as usual based upon initial conditions and physical laws, Deutsch and Marletto are foremost interested in fundamentals of quantum computation, but also want to know deeper truths about other phenomena such as information (Deutsch and Marletto, 2015), life (Marletto, 2014), and thermodynamics (Marletto, 2016a). All of them are for different reasons closely related to what we call here eigenbehavior. This idea isn't entirely new (see for instance Troncale (1985)), but the way Deutsch and Marletto frame the discussion with their definition is. Worth mentioning here is also General Systems Theory (GST), a term defined but inconsistently used by von Bertalanffy (some of its facets resemble cybernetics (Ashby, 1956)). Rousseau et al. (2016b) suggest a star to von Bertalanffy (1968) and Boulding's (2004) concept (and Hesse's (1994) vision (von Bertalanffy, 1968) in order to use GST* (GST-star) for principles behind isomorphic behaviour.

Similarities behind (loosely understood) constructivism (Dodig-Crnkovic, 2014) and constructor theory are not just in similar words, but also in their approaches to expectations from reality and scientific work. It is a similar mindset when we try to understand minds by shadows they cast (Penrose, 1994) or systems by footprints they leave behind (Malecic, 2016). It makes sense to focus on the four strands of what Deutsch calls the first Theory of Everything (the four strands are taken over from Deutsch (1998) and elaborated by this author):

1. Quantum physics – Quantum physics (mechanics and field theory) arguably goes deeper than any other physical and scientific theory in defining and understanding building blocks of reality. Deutsch sees Everett's Many Worlds Interpretation of quantum mechanics as the ultimate theory of physical reality.
2. Epistemology is related to knowledge, what can be known and how. Deutsch disagrees that the main role of science is to predict phenomena, but rather to explain them. According to Deutsch, the major epistemologist is Popper with his idea that any scientific data, rather than directly, can only be interpreted through theory.
3. The theory of computation – The goal of a developed constructor theory would be the universal constructor. Universality is achieved when a set of characters, rules, regularities, or some abstract entities can fulfill the role of expression or sharing of meaning within a system. Turing machine is a universal computational device, but not a single strand (including this one) represents on its own the whole reality.
4. The theory of evolution – Besides the obvious association with Darwin's theory, this strand can also be about causation and emergence within physical and natural (and why not also engineered) systems.

It should be open for discussion whether the theory developed from these strands can reveal something about General Systems Theory, but a theory capable to do that would be a strong counter-candidate or improvement to other suggestions such as Miller (1978), Sowa (2000), Palmer (2009), Prigogine (1997), and Rosen (2012).

The strands should be modifiable if they under modifications provided better explanations of reality and communication/unification of each with the other three strands. Deutsch himself sees his work on the strands as unfinished and the research on constructor theory is a continuation with its search for physical principles. If we assume that the strands and the principles as defined by Deutsch and Marletto (see them elaborated by Malecic (2016)) or in some other way are on a comparable level of abstraction, it isn't clear how they emerge (or whatever is needed for them in order to interact) from each other. The principles suggested by Deutsch and Marletto (2015) look arbitrary because they are being added on a list until they seemingly cover reality. On the other hand, the aforementioned list of strands (the author of this paper arguably takes the concept of four strands more seriously than Deutsch himself because he never again mentions them as a list or as they are suggested here as the four "bones" of the skeleton of science (Boulding, 2004)) seems to be difficult to vary (but also far from obvious) as something that someone from another planet might suggest as the same or a very similar list of strands the fabric of reality is made of. Let's take for instance computation. Logic and Boolean algebra do not exist out there as physical objects directly accessible to laypeople not interested in mathematics, but that doesn't make them less real or less difficult to vary by a different scientific theory (as opposed to for instance mythology and religion). Any civilization that cares about scientific rigour would develop the identical theory of computation (and use bits or qubits) even if it had its own Gödel (Sieg, 2006; Tait, 2013) and Penrose (1994) looking for a broader theory.

Eigenbehavior

Eigenbehavior (Pangaro, 2011) is an attempt to bring back observers into the physical system with their self-organization and self-reference (von Foerster, 1991).

It resembles what Dodig-Crnkovic (2012) calls physical computation, dynamics (Juarrero, 1999) embodied within and distributed through a system rather than written as in a software or hardware. The meaning and causation are more compatible with Peirce's representational relationships of icons, indices, and symbols than with de Saussure's element-by-element mapping between signifiers and the signified (Deacon, 1997). It is about the difference between the physically real and the modeled (pretending to be physically real).

Let's find together the longest word in English language out of the letters: g, n, a, i, p, n, i, t. The author will wait for a few seconds before you find it. Alright, now when we found the same word (How can I be so sure?), let's try to recall how we did it because that's how physical computation seems to work. Were you permuting letters and looking for matches in your inner dictionary, did a few seconds of parallel computation the way a good neural network would, or miraculously pulled out a single word as if it were a rabbit (shaped in a strangely looped way resembling hands drawing each other from Escher's graphic mentioned by Hofstadter (1979)) in a magician's hat? Whatever you did, that's how physical computation (Dodig-Crnkovic, 2012) works. There is a difference between before (trying to find the longest word) and after (finding it), but was it really a causal chain with causes taking place before effects or rather a fog lasting for a few seconds out of which the word was gradually emerging in front of you (other examples of how minds work may be solving an IQ test or decision making)? How would a deterministic computer do that? Permuting and looking each time in a dictionary or parallel computation of an artificial neural network are both good deterministic approximations of how we deal with this task, but are they the whole story? If I try to set myself into a contemplative and self-observational mood, it seems to me that it is similar to the handshake in the (possibilist) transactional interpretation. Mind you, this doesn't mean that (the PTI of) quantum mechanics implies consciousness or that a question whether or not it implies consciousness can be properly posed – we are just comparing physical computation as dynamics of form in quantum objects and mind to its desktop equivalent. To be honest, it would be cheating not to mention that artificial and deterministic neural networks (or for instance fuzzy logic) as opposed to regular computation and algorithms do get closer to some aspects of physically embodied computation (such as hologram as a good metaphor of both neural networks and physical computation) and that this essay (just as for instance Rosen's publications on anticipatory (alive and/or conscious) systems) on its own fails to be universally convincing. It's up to the readers to do some extra thinking and contemplation on the topic and see for themselves whether or not this essay at least provides hints about why PTI and emergence all the way down is the most physical-computation-friendly interpretation of quantum mechanics (or at least where and how to look for a better theory). If the Many Worlds Interpretation is right, does that mean that some (How many?) of your parallel selves have no idea of which word I'm talking about at the beginning of this paragraph?

Constructor Theory of Eigenbehavior

An alternative definition of constructor theory is about which tasks are and which are not possible and the word "possible" in both this definition and the possibilist transactional interpretation of quantum mechanics (Kastner, 2013) is far from coincidence even though Deutsch and Marletto refuse to leave Everett's (1957) burden behind. If we eliminated or didn't insist on the use of its definition, we wouldn't have constructor theory (as an unbiased search for possible tasks) anymore. That being said, it's a strange situation that Deutsch and Marletto rarely apply their own definition and prefer short metaphysical statements without asking whether or not that is how reality functions and why. For an example on how to prove that a theory (the Everett interpretation) is impossible (and why) see Jeknic-Dugic, Dugic, and Francom (2014). Instead of just mentioning that something is "inevitable", provide a reference and move on, Jeknic-Dugic, Dugic, and Francom's article provides an in-depth elaboration of systems and Brownian motion.

CONSTRUCTIVISM

The author is implementing in this paper an approach similar to constructivism, but does that in a way that other proponents of constructivism might not approve. Systems science requires a radical change of perspective and this is where the constructivist approach is helpful – in encouragement of open-mindedness about reality and ideology and playfulness with mental constructs. Serious modifications of everyday thinking are necessary in order to comprehend "counterintuitive" aspects of reality. Constructivism in its radical form denies any ultimate truth and this is the point at which we should stop playing and get serious and rigorous. Glasersfeld (1986) for instance is inconsistent when he asks for denial of objective reality and at the same time suggests (in a form of religious worship) Kant's philosophy as the ultimate approach to ethics. This author is probably among less violent human beings, but pretending that violence doesn't play its role (stealing and having what is stolen) in nature (just think of how brutal you were to a piece of nature that became your latest meal) and society won't contribute to our understanding of what is going on around us in order to consciously choose our values and behaviour. On the other hand, the radical form of constructivism applied to physical reality means that "we" shall never know for instance whether or not we are living in a computer simulation (Bostrom, 2003). It is a tiresome and annoying exercise (try to walk while questioning physical reality of each step) in empty philosophizing and a futile attempt by someone who doesn't understand to deny the right of anyone else to understand or get closer to understanding. Even if humans will never be able to understand everything, that's because of our limitations rather than physical reality being arbitrary. A defeatist and nihilist approach to thinking and doing should be discouraged. It is just plain wrong to insist (and still be sane) that physical and/or societal principles and the Universal Constructor are whatever we want them to be.

INTERPRETATIONS OF QUANTUM MECHANICS

Interpretations of quantum mechanics (Zeilinger, 1996; Tegmark, 1997; Penrose, 2004) are elaborated not to (directly) contribute to discussions such as whether consciousness is a quantum phenomenon or quantum mechanics implies consciousness (Abbott et al., 2008).

There are more interpretations of quantum mechanics (Rosenblum and Kuttner, 2011), but the two arguably addressing constructivism/structuralism more than others are the Everett many worlds interpretation and the possibilist transactional interpretation. Zenkin (2004) compares actual infinity and Cantor's diagonal proof to the “Liar” paradox. This kind of infinity resembles infinite regress and as such is disconnected from physical reality. Also, it should, whenever possible, be avoided from any new physical theory (out of competing theories, those that include actual infinity should be discouraged). The Everett interpretation (Deutsch, 2016) claims that every possible quantum event actually happens in some kind of parallel world and the transactional interpretation (Cramer, 1986; Kastner, 2013) is about offer waves, confirmation waves, and quanta. The possibilist version of transactional interpretation (Kastner, 2013; the possibilist transactional interpretation (PTI) is supported in this article) sees space-time as emergent (symmetry-breaking of time) and possible transactions “negotiating” outside of space-time and empirical realm. These two interpretations are “arch-enemies” because they are both related to systems worldview applied to fundamental physics (see Dugic and Jeknic (2006) about quantum systems). In a way similar to Cantor’s failure to acknowledge the difference between potential and actual infinity in set theory (Zenkin, 2004), the transactional interpretation is about potential (possible) events and the Everett interpretation (the Many worlds interpretation (MWI)) insists on an infinite amount of actual events (like the PTI without symmetry-breaking). Out of other interpretations, it is worth mentioning here the Copenhagen interpretation because it is about consciousness causing collapse of the wave function (without going into details about how consciousness does that) and the objective reduction interpretation (gravity causing collapse).

We’ll keep the promise of not directly talking about consciousness and quantum mechanics and do that indirectly. The question whether consciousness is a quantum phenomenon makes as much sense as whether a molecule is alive. The aforementioned interpretations do not require consciousness for the existence of quantum phenomena just as consciousness is actually rare and still relatively short-living on the cosmic scale. The sub-empirical world Kastner (2013) writes about might be the realm from which consciousness has emerged, but it doesn’t require consciousness for its existence. On the other hand, the fact that eigenbehavior *does* exist might reveal something about reality we live and eigenbehave in.

Retrocausality (Price and Wharton, 2015) is related to the transactional interpretation. See Kastner’s (2016a) elaboration of this concept and critique of time-symmetric interpretations.

TWO STORYLINES

This section will have two parallel story-lines in order to allow the reader to compare strengths and weaknesses of Deutsch and Marletto's approaches and what the author has to say about it. The author is first and foremost interested in understanding the truth and open to critique (it would be tiresome to read every sentence beginning with "In my opinion…"). For a more detailed overview of other candidate concepts of reality (and not just the two compared in this article) see French (2010).

We shall add here a few quotes from Deutsch's and Marletto's papers and analyze them.

"inevitability of Poincaré recurrence" (Marletto, 2016a, 8) – Both Deutsch and Marletto tend to make metaphysical statements such as this one in a part of a sentence without further explanation why that is obvious, even though every available theory is in a terrible condition and probably about to be eliminated. Poincaré recurrence is an idea that particles inside a "box" can have all possible states, including the very unlikely and rare state of every particle in one half of the box. Prigogine (1997) disagrees with that and sees diffusion as inherently irreversible (Poincaré recurrence not inevitable) and asymmetrical in time (similar to Kastner's approach to quantum mechanics (Kastner, 2013; 2015)). This kind of discussion (temperature and pressure (Füllsack, 2016) vs. large numbers (Poincaré recurrence)) can be only (if ever) properly addressed by a relevant systems theory.

"none of the laws, in the constructor-theoretic formulation, use probabilistic statements" (Marletto, 2016a, 15) – For some reason they claim the monopoly on both constructor theory and how to use it, i.e. they are attempting to sneak their opinions into constructor theory and make them "inevitable" and beyond dogmatic (a scientific idea about reality is for some reason supposed to be more relevant and real than reality itself).

"Traditional 'collapse' theories are also inherently far worse explanations than Everettian quantum theory, by criterion (i), since they neither explain what happens physically between measurements, nor what happens during a 'collapse'." (Deutsch, 2016, 9) – This is another example of their "hit and run" style of making metaphysical statements. Each time their approach stumbles, Deutsch and Marletto simply ignore it and move on. Add quotation marks to a problem and it will miraculously vanish. Also, a statement that a (Everettian quantum) theory is terrible and other theories are even worse doesn't sound optimistic and enthusiastic. "Between measurements" and "during a 'collapse'" are metaphysical statements meaningless to some other approaches (see the rest of this article).

"Thinking within the prevailing conception has led some physicists – including the 1963 Nobel Prize-winner Eugene Wigner and the late US-born quantum physicist David Bohm – to conclude that the laws of physics must be tailored to produce biological adaptations in general. This is amazingly erroneous. If it were true, physical theories would have to be patched up with 'design-bearing' additions, in the initial conditions or the laws of motion, or both, and the whole explanatory content of Darwinian evolution would be lost." (Marletto, 2016b) – When a Nobel

Prize-winner is amazingly (a word instead of an explanation) wrong about something, it doesn't help if we claim about him something that he isn't (a creationist; the prevailing conception somehow according to Marletto supports creationism) if we want to prove that we aren't amazingly wrong. When can we expect constructor theory to prevail?

"we do not understand how creativity works. Once that has been solved, programming it will not be difficult." (Deutsch, 2011) – What if "creative" is just another way to say "not programmable", i.e. programmable creativity is an impossible task? In that case at least some of "us" (for instance Rosen (2012)) have understood for decades how creativity works. It is about infinity, but a different kind (although related) of infinity than Cantor's set theory, i.e. about complex systems in Rosen's sense that cannot be programmed.

"But this is another story, and shall be told another time." (Marletto, 2016a, 46) – What if Poincaré recurrence isn't inevitable, probabilistic statements are more relevant than Deutsch and Marletto are comfortable with, and/or collapse of the wave function does happen? What if a theory that doesn't explain "at the moment" simply can't explain the phenomenon in question?

Deutsch criticizes bad philosophy of the because-I-say-so variety even though his own approach to constructor theory is built on multiplicity of such claims. Also, since Deutsch addresses evil human activities as committed by those who are missing proper knowledge (Levey and Trehub, 2012), it makes sense to wonder how much Deutsch and Marletto as opposed to the approach encouraged in this article contribute to systems worldview and quality insights and decision making.

A FEW PROPERTIES OF EIGENBEHAVIOR

Eigenbehavior belongs to possible phenomena. The properties about to be mentioned do not belong to any definition or paper on eigenbehavior per se, but are rather chosen in a way to address what research on constructor theory (a theory of possible phenomena) of eigenbehavior should be about: about science including observers and systems perspective.

Knowledge

Deutsch and Marletto use the term "knowledge" (Deutsch, 2012) for describing a different kind of information than commonly understood. It is perhaps something like "physical computation as dynamics of form" that Dodig-Crnkovic (2012) writes about. Deutsch (2012) sees von Neumann's approach to the universal constructor as incomplete because it ignores the fact that computations take place within physical objects and that this notion (only physical objects can compute) is also a kind of information or knowledge. Note that von Neumann mentioned here was also interested in quantum measurement (Kastner, 2016b) and didn't see it as something his universal constructor should also be capable of. Deutsch admits that his approach doesn't provide theory of creativity, or more precisely he claims that none scientific approach does that. Still, knowledge does somehow mysteriously participate in branching of different (a single observer in parallel universes) observers involved in quantum experiments.

Collapse of the Wave Function

The so-called traditional approach is that collapse (from probabilities and uncertainty to specific values) of the wave function during measurement in quantum mechanics is a real phenomenon (even if that means that the experimenter's consciousness causes the collapse) or that it is at least practical to think this way (consciousness stays somewhat nonscientific or at least irrelevant to physicists). The concept of eigenbehavior is about bringing the observer back as a part of reality. Deutsch and Marletto's interpretation of quantum mechanics of choice is the Everett (1957) interpretation. Wallace (2001) agrees with them and comes to his different conclusion from a similar starting position as this author and referred literature (authors Auyang, Ladyman, Penrose, Dennett) as this article. Still, a decade after Wallace's contribution and conclusions Deutsch and Marletto (they do mention Wallace, but not the paper mentioned here) felt the need to start building constructor theory from scratch (i.e. Wallace's work isn't according to them even a proper beginning). For instance, Jeknic-Dugic, Dugic, and Francom (2014) use a similar structural/systems approach to quantum theory in order to reject instead of support the Everett interpretation. Also, Josephson (2015) sees Kastner's work on the possibilist (transactional) interpretation of quantum mechanics as compatible to his work on structural theory of everything and this author agrees.

The Arrow of Time

See Simeonov (2015) for a detailed overview of the arrow of time and Jeknic-Dugic, Arsenijevic, and Dugic (2014) about time in quantum mechanics.

Although it is a self-proclaimed most consistent interpretation of quantum mechanics, the Everett interpretation ignores time even though there seem to be, according to this approach, a single past and many futures. On the other hand, the transactional interpretation and especially its possibilist variation is primarily focused on time and its emergence. This author fails to understand how a claim that everything can and does happen and that anything goes as a legit decision (since every decision takes place in some parallel universes with an additional unresolved mathematical problem of how likely is that someone will be creative or try and succeed to seduce each woman and man in the world) along the arrow of time is taken seriously, including worlds in which the author prefers to jump through the window rather than to finish this sentence. See also Tegmark (1997) on quantum suicide. The set of everything, the set of every possible decision (especially if that set is affected by awareness of possible consequences), and Cantor's actual infinity seem to be different manifestations of the same conflict between mathematical and physical reality. Deutsch is right about where to look for the fabric of reality (Deutsch, 1998), but he is wrong about conclusions.

Self-Awareness

Self-awareness or self-consciousness (Chalmers, 1996) is important for a mutual understanding (see abstraction and deabstraction in Troncale (2009)) of what the first-person experience and eigenbehavior might be about. The first-person experience is central to what Chalmers calls the hard problem of consciousness.

The Hard Problem of Consciousness

Simpler problems of consciousness are about correlations between sensory, neural, and chemical activities within a neural system and contents of consciousness. The hard problem (Chalmers, 1996) is about why there is consciousness at all and what makes it different from other phenomena. Seager (2016, 43) writes: "The generation problem can be vividly expressed as the simple question: what is it about matter that accounts for its ability to become conscious?"

Strange Loops

Strange loops (Hofstadter, 1979; 2007) resemble algorithms "programmed" in a way that provides emergence of self-awareness through self-reference. It is interesting that Hofstadter (1979) has created this concept, but fails (?) to understand that it answers why deterministic machines will never be self-aware rather than how to "someday" make deterministic computers conscious. Hofstadter (2007) sees strange loops as a way to deny free will rather than the essence of free will.

Memory

We remember past events or more precisely we are better at remembering past than future events. Even if the many world interpretation insists on many futures that actually happen, we still have a single witnessed past that has brought us to the present moment. It is hard to see how anyone would take into account this fact and still claim that this interpretation is more elegant than others. On the other hand, memory modeled as eigenbehavior or recursion-over-experience (Pangaro, 2011) seems to be compatible with the possibilist transactional interpretation as explained by Kastner (2013) as a "knitted" fabric of events (not necessarily deterministic, but still caused somehow).

Anticipatory Systems

This concept is introduced by Rosen (2012). He defines complex systems as nondeterministic systems that cannot be modeled and conventionally computed. Anticipatory systems are complex systems that live and have awareness that allow them to anticipate in advance future events and act accordingly. According to Rosen biology is a more fundamental scientific discipline than physics. The author of this article agrees with Rosen's stance, but that doesn't make biological phenomena more fundamental than physical phenomena. It's just that biological/psychological phenomena and physical phenomena could reveal something about each other and about reality they share. The author strongly opposes the idea that any phenomenon (for instance consciousness or new forms of causation emerging for the first time with life and/or consciousness) can be both existent and nonphysical and fails to understand what "nonphysical" (Chalmers, 1996; Seager, 2016) is supposed to mean. Perhaps consciousness is somehow beyond the material, deterministic, or empirical realm (Kastner, 2013; 2015), but that still doesn't make it nonphysical (see also Thompson (2007)).

Second-Order Cybernetics

Is second-order cybernetics (von Foerster, 1991) out there as a set of phenomena that really differ from first-order cybernetics or is a just a mental construct? Can the second order be modeled and computed by the first order in a manner similar to Bostrom's (2003) claim that reality is in principle computable (Wharton (2015) disagrees) with enough computational resources and that we actually are likely to live in a computer simulation?

In this author's opinion, the four strands of the fabric of reality are the reason why there is a need for more than one order of cybernetics. There will always be difference of informational content between a model pretending to be a physical system and physical computation in its real form. De Saussure's theory (Deacon, 1997) is incomplete because it stays within first-order cybernetics. Complex systems as elaborated by Rosen include all for strands or, more precisely in his case, four Aristotle's causes (Mikulecky, 2000).

Autopoiesis

Autopoiesis is a concept described by Maturana and Varela (1980) as a way to explain what differentiates entities (such as us) capable of self-cognition, plasticity, reproduction, and evolution from machines that cannot do that. Autopoiesis, aforementioned strange loops, and eigenbehavior resemble in either metaphorical or genuine way circularity as described by Füllsack (2016). This article supports genuine causal and temporal circularity, but it must be consistent and avoid paradoxes (Edwards, 2013; the reason why it is so difficult to tell the difference between determinism and circularity).

Anthropic Principle

The anthropic principle (Stenger, 2011) is about finely-tuned ratios of physical forces or seeming coincidences that allow the existence of the universe as we know it, including us as observers. Suggestions about how it has happened are from the mere fact that we couldn't perceive the universe not "finely-tuned" for us to observers somehow participating in the cosmic "design". Wheeler's (Josephson, 2012; Wheeler, 1983) participatory universe, if true, seems to be related to the anthropic principle (If it isn't, why?).

Qualia

A short explanation of qualia is phenomenal qualities of consciousness (Chalmers, 1996), i.e. components of innermost conscious experience (an observed object for instance having a specific colour and being perceived as such) not understandable and explainable from parts such as neural activities. Chalmers supports this concept and Dennett (1991a) disagrees with its relevance. Seager (2016) disagrees with both approaches and he would rather replace isolated discussions about physicalism and qualia with wondering how qualia could be physically generated (and perhaps learning something in the process). Seager's approach resembles Ladyman and Ross' (2007) work on naturalization of metaphysics (physics as the place for trying to change a paradigm and as the ultimate explanation of any phenomenon), although in Seager's case such naturalization introduces nonphysical phenomena.

Fading Qualia

Chalmers (1996) wonders whether human consciousness would notice if it were gradually replaced by functionally identical artificial parts (microchips). In order for that mental experiment to make sense and in the spirit of constructor theory, one must see whether or not design of chips functionally identical to parts of a natural neural system is a possible task and why. Seager (2016) on the other hand notices that no brute feature of the world is causally impotent and that in the opinion of the author of this article means that functionally identical entities can only be absolutely identical. That doesn't mean that identical or very similar outcomes aren't possible over different pathways (see the two "properties" below), but rather that in the long run only identical objects can behave identically. Besides of that, the discussion about how and why qualia might cease to exist is like looking for an exact line between the conscious and unconscious (alive and dead, tall and short, awoken and asleep…) or the minimal number of grains of sand that can still create a dune.

Intentional Stance

This is a concept developed by Dennett (1989). Noise-emitters exhibit intentionality or aboutness (Dennett 1991a), meaning that Dennett is more focused on meaning than how (the specific content of the message) it is delivered. Perhaps "ambiguity" is the most appropriate single word for explaining what intentional stance is about. Juarrero (1999) suggests with hermeneutics a similar point of view when she writes that the underlying story behind a made decision is at least as important as which input causes which output. The difference between Dennett and Juarrero (1999) is that Juarrero uses her approach to suggest Aristotle's four causes (a suggested theory instead of pessimism that no theory would do justice to consciousness in Dennett's case) as an important part of the theory of consciousness. Tegmark's (2007) criticism of Penrose's (1989; 1994) ideas that consciousness has something to do with quantum mechanics equally applies (or not) to classical physics in terms of signal-to-noise ratio. The plasticity of our brains (and parallel processing) and intentional stance are different entities than machines that would lose their minds in a noisy environment. And this is what the following subsection is about.

Cognitive Pandemonium

Seager (2016) calls Dennett's approach to explanation of consciousness "cognitive pandemonium". Different potential decisions fight for their primacy in our brains and somehow some of them prevail. Seager takes Dennett's ideas seriously, but sees them in a pure form as too radical and a dead-end.

Seager (2016, 161) writes: "Indeed, a large part of the burden of the problem of consciousness seems to be the lurking threat that no scientific theory of it which could credibly tackle the generation problem is even so much as possible." Since consciousness is closely related to eigenbehavior, it makes sense to at least assume that a more accurate approach to constructor theory might be that scientific theory or its significant part. In a manner akin to the definition of constructor theory we may ask: Can our approach to constructor theory be unified/explanatory with theory of consciousness and eigenbehavior and why (see a relevant approach to unification by Auyang (1998))? As Seager (2016, 162) claims: "consciousness is the most bizarre phenomenon in the universe as science seems to describe it". The sooner we manage (Is it a possible task and why?) to address constructor theory of consciousness, the better we shall be with constructor theory as a whole.

BEAUTY OF A THEORY – WHAT IS BAD "BECAUSE I SAY SO" PHILOSOPHY?

This section is a beauty contest of two diverging approaches: constructor theory friendly with the Everett interpretation and the one friendly with the possibilist (transactional) interpretation.

This discussion goes beyond determinism, empiricism, and what people usually see as science and scientific methodology (see also Metcalf and Edson (2015)). Proponents of the Everett interpretation try to demonstrate its elegance as a theory that allegedly gets rid of confusion and spookiness characteristic to other theories, but at what price? Such a reality would be like a reverse funnel with the idea of collapse of the wave function turned upside down (one past and multiple futures instead of the other way round; a funnel turned upside down isn't properly used, but it is still a funnel) in the opposite direction from other theories. There is nothing about other phenomena on the classical macroscopic level that would make an observer need quantum theory and its many worlds interpretation in order to understand and explain natural systems. Aristotle needed final cause (and he was either right or wrong when he did that) in order to start suggesting an explanation of life, consciousness, and goal directedness. The many worlds interpretation isn't an idea that would make a consciousness (or life or systems) researcher run around like Archimedes and shout "eureka". It is an interpretation that tries to fix the damage from the point of view of someone who is already aware of quantum mechanics. Consciousness, anticipatory systems, teleology, causation, and GST* should have physics that explains each. Rather than provide pieces of a puzzle to fit into their place, the Everett interpretation (as opposed to the possibilist transactional interpretation) looks like swallowing of pieces of the puzzle that are difficult to fit in (such as collapse of the wave function and inherent probabilities). Wallace (2001, 16) takes a route characteristic for Deutsch and Marletto that other theories are even worse when he claims that "we have no really satisfactory understanding of probability in any other context either". A part of the functionalist claim as defined by Wallace says that it doesn't matter what a brain is made of, only how it works. It can be translated into an assumption that systems have something in common (general systems theory (Troncale, 1984)), but that doesn't mean that systems can be made of anything (a claim inconsistent in a similar way as Chalmers' (1996) failure to tell the difference between panpsychism and consciousness as an epiphenomenon).

The core of this whole disagreement can be found in this Everett's (1957) statement: "We can further suppose that the machine is so constructed that its present actions shall be determined not only by its present sensory data, but by the contents of its memory as well." He talks about machines as models of observers (i.e. not complex systems as understood by Rosen (2012)) determined by sensory data and memory and *nothing else*. Rosen's, Deacon's (2012), and Juarrero's (1999) work (Deacon and Juarrero don't claim that quantum mechanics is relevant to their theory of consciousness, but Everett's mechanical approach is still highly incompatible with their work) simply vanish. Wallace (2001), Everett, Deutsch, and Marletto insist on their favourite interpretation of quantum mechanics even if it eliminates consciousness from the list of possible tasks. On the other hand, a nondeterministic machine (randomness for its own sake) doesn't work properly and a reality in which every possible glitch took place wouldn't in any way improve its functionality. In a way similar to the aforementioned funnel, MWI turns reality upside down and observers don't have free will and self-awareness and quantum particles have both (or at least random manifestations within individual universes compatible with probabilities). The Everett interpretation is seemingly derivable from quantum theory and no any other theory. In this author's opinion, it loses the contest against PTI as a theory that doesn't properly explain and unify (see Ladyman and Ross (2007) on unification of knowledge). Or in Deutsch's own words, "That is a good explanation – hard to vary, because all its details play a functional role" (Deutsch, 2011) and "since quantum theory and general relativity are inconsistent with each other, we know that at least one of them is false, presumably both" (Deutsch, 2016, 3) (i.e. the Everett interpretation doesn't seem to be difficult to vary and as such isn't a good explanation). Deacon's (2012) and Juarrero's (1999) ideas for instance are (since they are seemingly true and difficult to vary) similar to the point of accusation of plagiarism.

It wouldn't be fair to evaluate Deutsch and Marletto's philosophy and ideas as utterly bad, but there is a pattern of them looking at the right place for footprints of General Systems Theory (Malecic, 2016) and sooner rather than later stumbling over their prejudices and previously made opinions. Their work is full of statements such as "finitism, like instrumentalism, is nothing but a project for preventing progress in understanding the entities beyond our direct experience" (Deutsch, 2011) that, while allegedly being open-minded, are actually obstacles (the very same authors suggesting and doing harm to constructor theory) to the aforementioned progress. Quantum waves are inherently probabilistic entities vastly different from objects accessible to our direct experience. Quantum mechanics isn't just a way nature prevents electrons from falling onto atomic nuclei, but also a way to get rid of (pardon the anthropomorphism and simplification in this sentence) unnecessary infinities (an infinitesimally precise measurement of a single point would require infinite computational resources, i.e. the whole universe and more). On the other hand, Deutsch in his struggle to defend Cantor's actual infinity absolutely everywhere rightfully feels that the concepts of infinity and MWI succeed or fall together, just as denial of possibility to create perpetuum mobile has nothing to do with “a project for preventing progress”. The outcome of that struggle to defend something that cannot be defended is an annihilation of other systems during the process of deabstraction: quantum entities can communicate over their common probability distributions with their doppelgangers from other universes within the multiverse all the while human capability to make decisions and be creative (i.e. to think at all) is difficult/impossible to explain (“we do not understand how creativity works” (Deutsch, 2011) actually means that our own consciousness can’t share the same reality with neither determinism nor MWI), Infinity Hotel is used as a proof for rather than against actual infinity, and that funnel is turned upside down because Everett and Deutsch “say so”. Dawkins (1976) denies life (genes somehow more real and important than living organisms) and Deutsch consciousness (quantum randomness being creative and making decisions for us) and physical reality for their understanding of progress. Maybe (if we follow their way to progress) you just think that you are reading this sentence, but actually you aren’t.

The problem is as follows: David Deutsch was curious enough to spend a lot of time thinking about which interpretation of quantum mechanics is right and conceives constructor theory as a theory of possible tasks. Combined with his earlier work on the fabric of reality (it can be compared to Marzolf (2014)), he seemingly “bumps” (Troncale, 1984) into General Systems Theory or something related to it. The outcome is a detailed elaboration on infinity and why MWI doesn’t work even though Deutsch himself sees each paradox as a confirmation. His work is full of useful insights and elaborations combined with flawed conclusions (sudden changes of the subject and even his own insightful ideas each time MWI and causation compatible with MWI becomes questionable).

Mind you, if the possibilist transactional interpretation were really accurate, it would rather be a new beginning than the final word about interpretations of quantum mechanics. This author (Malecic, 2015) suggests the “I-Thou” (Buber, 2000) interpretation of quantum mechanics that is friendly to the transactional interpretation, but finds (interesting but) physically pointless any discussion about what is going on in parts of the universe both directly and indirectly inaccessible to observers. If you are curious about other possible worlds and their observers, see Dugic et al. (2012).

DANGEROUS KNOWLEDGE

“Dangerous Knowledge” (Malone, 2007) is a documentary film about four characters: Georg Cantor, Ludwig Boltzmann, Kurt Gödel, and Alan Turing. Gödel and Turing among other systems thinkers (some of them are mentioned in this article) appear in Hieronymi (2012). Besides of their tragic life stories, the danger they were exposed to and the threat they were to other people is also about their far out ideas (challenging to them and their colleagues) and still unfinished work.

Cantor’s work is about infinity in set theory. His approach sees sets with identical cardinal numbers (sets countable from each other) as equally big even if their finite equivalents are two, three (the set of natural numbers compared to the set of every third natural number), or any-finite-natural-number times bigger than each other. A layperson might assume, and rightfully so, there is something wrong with arithmetic operations on infinity or a conclusion that the set of all natural numbers and the set of all even or odd natural numbers are equally big. Quantum mechanics and the uncertainty principle is a way for nature to avoid Cantor’s infinities at the micro scale and the Everett interpretation totally unnecessarily (unless we see stopping asking awkward questions as a necessity) brings back actual infinity and continuum.

Boltzmann’s work (Eftekhari) on atoms breaks Cantor’s infinity on the micro scale into atoms or at least sub-atomic particles (a progenitor of quantum mechanics). In that sense it at least partially tames the danger of infinitesimally small objects that exist in mathematics but not in physics. On the other hand, irreversibility in thermodynamics (Kastner, 2017) is, if ideas announced by Boltzmann are accurately developed by Prigogine (1997), still waiting for a dangerous twist (or two if we add to irreversibility the statistical concept of nature).

Gödel (1931) has proven there are truths that cannot be logically proven by a predefined set of axioms. His already unexpected ideas made an additional twist when he was trying to prove the existence of intuition that could somehow go beyond logic. Is there a possibility of a mathematical/physical theory that is up to this unfinished Gödel’s challenge (Tait, 2013)?

Turing machine (Turing, 1938) is a mathematical idea that is a progenitor to computers. When it halts, it is akin to us making a decision. Turing (1950) and Gödel saw their work (respectively) on computability and incompleteness of logic as important parts of understanding of consciousness (Sieg, 2006). The danger of their knowledge comes from the novelty of their research and from the fact that it is about knowledge observing and trying to understand knowledge. Metcalf and Edson (2015, 10) write about the danger of this kind of knowledge that this paper and the documentary film “Dangerous Knowledge” attempt to capture: “As humans in an ever-changing environment, like many systems, we seek stability. A consequence of stability is eventual dissipation and decay, which humans seek to avoid.”

The combined life work of these four scientists can be seen as constructor theory of eigenbehavior we are talking about here. Quantum mechanics (and the concept of atoms introduced by Boltzmann) accompanied with Heisenberg uncertainty principle eliminates the need for infinite division and precision. Also, big quantities and sizes can only be potentially big, i.e. actual infinities aren’t about real physical systems. On the other hand, the Everett interpretation brings back actual infinity even though its proponents claim it is elegant. A wave function collapsing and a Turing machine (or its natural living and conscious equivalent) halting resemble each other. According to the Everett interpretation such Turing machines explode rather than halt and each “decision” would in that case be random (an epileptic seizure instead of a decision about what to do next) and taking place in some (How many? Which decisions are impossible?) of parallel universes.

ARISTOTLE'S FOUR CAUSES

This sections is actually about Aristotle's ideas developed in the field of systems and for instance developed by this author (Malecic, 2015; 2016) rather than Aristotle's work per se. Hopefully it won't affect too much in a negative direction the reader's opinion about the rest of this article. Criticism is encouraged.

Juarrero (1999), Kineman (2011), and Deacon (2012) develop their theory (or theories) of consciousness and life (Deacon is more focused on life and descriptions friendly to biologists, physicists, and engineers) on Aristotle's four causes. There are many other authors that mention this concept when they discuss about systems without even trying to find GST* – it's a topic that just spontaneously becomes relevant. Hence this author calls it "the lowest hanging fruit" (Malecic, 2016). The table described in this section is actually inspired by Jung and Pauli's work (Jung, 1978a). Table 1 already contained the expression "physical principles" even when the author was still unaware of Deutsch and Marletto's work on constructor theory.

It is adapted for this text with an additional column containing Deutsch's strands and a different order of rows and columns. The order of the strands is the same as on that list. Quantum theory is the most fundamental theory of physical interactions and this is why these two concepts are in the same row of the table. The table doesn't insist on panpsychism (Chalmers, 1996), but rather uses psychological terms because that's what (the strand) epistemology looks like in a world with conscious and curious observers. The most fundamental theory of computation (Dodig-Crnkovic, 2012) should be about the nature of inputs, outputs, and in-between processes, i.e. causes in the broadest sense. Physical principles define what we can expect from a system as it evolves (behaves in accordance with the available ensemble).

The cells of the table with the content emphasized with italic letters contain the "most characteristic" elements. Intuition combined with creativity and goal-directedness is more psychological than other psychological functions because it is more difficult (if at all) than others to describe in non-psychological terms. Efficient cause is causation in the narrowest possible sense. Physical principles define the nature of a system in question, so space-time/context is the most characteristic physical principle. Note the resemblance of the part of the table that (on purpose) isn't in bold letters to a matrix with the aforementioned most characteristic elements on the diagonal.

Explication	**billiard balls**	**teleology**	**contragrade**	**orthograde**	**Strand (Deutsch)**
Physical interaction	*electromagnetic*	gravity	strong	weak	**quantum physics**
Psychological function (Jung)	senses	*intuition*	thought	emotion	**epistemology**

Cause (Aristotle)	material	final	*efficient*	formal	**computation**
Physical principle (Jung and Pauli)	conservation of energy	synchronicity	causality	*space-time*	**evolution**

Table 1: Self-Referential Complex Systems (Adapted) (Copyright © 2015 [IGI Global]). Reprinted by permission of the publisher.

For the concept of synchronicity see Jung (1978a), for psychological functions Jung (1978b), and for an overview of Jung's ideas Jung (1996).

In order to keep the explanation within this article as concise as possible, let's say that strong nuclear interaction is an outcome of nuclei forced (contragrade in Deacon's (2012) terminology) to get closer to each other, weak nuclear interaction is involved in spontaneous (orthograde in Deacon's terminology) decay of nuclei and change of the context for other interactions, only electromagnetic interaction is relevant at all (material) scales, and gravity is allegedly involved in collapse of the wave function (Penrose, 2004) and tilting of light cones (Zee, 2013). Senses participate in direct perception of the material environment, thoughts are either logical (causal in the narrow sense) or wrong, emotions set the context for how other psychological functions will manifest, and intuition (the issue tragically unresolved by Gödel (Tait, 2013)) is goal-directed (final) and affects our decisions (analogous to halting of a Turing machine) to be made in a goal-directed and creative (and hopefully good enough) way. See also Einstein's (2011) four types of thinking elaborated by Auyang (2004) and Malecic (2016) and the four basic functions of management (Norman) compared to Jung's psychological functions (Malecic, 2015).

The author is aware that synchronicity as meaningful coincidence is a controversial concept. Rather than over-saturate this article with a discussion about whether and how much it is real, let's treat it for this occasion as something that might interrupt causality and/or determinism and suggest Peijnenburg (2006), Jargodzki (2009), and Baets (2012) to an interested reader.

Dominguez (2015) warns that Ladyman and Ross' (2007) suggestion and ontic structural realism in general imply infinite regress, the same problem that emerged when Gödel was trying to mathematically prove the existence of intuition (thinking about thinking about thinking… (Malone, 2007)). Table 1 according to this author describes itself in a manner that resembles strange loops, even though Hofstadter (2007) tries by force to fit his concept into deterministic machines and claims that humans don't have free will. Table 1 is also related to self-reference, i.e. "Ouroboros avatars" (Soto-Andrade et al., 2011). The metaphor of this snake ((O)uroboros) that bites its tail is used by Vörös (2014) for description of self-constructing and self-observing entities such as us.

WHERE ARE THE PHYSICAL PRINCIPLES COMING FROM?

Besides of its definition about possible tasks, the concept of physical principles is the other important contribution of constructor theory. Where are physical principles coming from? Are they some kind of axioms of reality that affect physical laws in a way akin to axioms and theorems in mathematics? Whatever the case, there probably should be some form of physical or mathematical reasoning behind why they (if they exist) manifest one way instead of another.

Ladyman and Ross' (2007) approach towards naturalization of metaphysics comes from a similar mindset as Deutsch and Marletto's work, although they take a different route. Instead of trying to get rid of probabilistic approach to quantum mechanics or deny collapse of the wave function, they are more willing to explore headfirst reality as it seems to be from modern physics, no matter how "counterintuitive" and bizarre it looks. They prefer nature and physics to speak for themselves, without human expectations of what is supposed to be out there.

If Dennett's (1989) seeming skepticism about theory of consciousness is applied to systems in general, perhaps it is exaggerated, but at the same time his position extremely strayed away from reductionism is a chance for looking for the middle ground.

The game peek-a-boo (Lacey, 2014) reveals that children need to learn about permanence of objects (and their permanence as individuals) that classical Newtonian physics is known of. On the other hand, children and uneducated people learn easily without formal education to understand causal relations (Ladyman and Ross, 2007) and what Dennett (1991a) calls folk psychology. The origin of physical causation is far from clear in known science (Ladyman and Ross, 2007), so what will happen if we assume that object permanence and causality are just fragments of a broader reality?

French (2010) writes about portability of concepts and Seager (2016) about intrinsic properties. That is what physical (and/or of some other kind) principles would be about if they existed: intrinsic portable properties. Are physical principles as defined by Deutsch and Marletto (2015) intrinsic portable properties, i.e. how is nature supposed to keep track of and contain the principles if they are properly defined by Deutsch and Marletto?

Structural realism (Ladyman and Ross, 2007) and especially its ontic version (ontic structural realism – OSR) is an attempt to see reality anew, as if we are perceiving it for the first time in all its classical, quantum, and relativistic manifestations. Quantum mechanics and erasers (Walborn et al., 2002) are real and inevitable to be considered for any relevant attempt of metaphysics. Also, there is absolutely nothing that requires from us to stick to opinions (about what is intuitive and what makes sense from an outdated perspective), ideologies, and methodologies of older authorities who knew less about physical reality than we do. OSR's positions of relations without relata (related objects) isn't about wishful thinking of an OSR supporter (see also Bartels (1999)) – unobserved quantum objects transform into waves regardless of whether or not we feel comfortable about that. Those waves are (in this author's opinion) misinterpreted by the Everett interpretation as Cantor's actual infinity of coexisting particles instead of ambiguity (intentional stance (Dennett, 1989) is another related example of ambiguity rather than infinity). Any attempt to “fix” and bring us back to our comfort zone of what makes sense to us from the classical point of view is futile. Still, OSR is designed as an open-minded framework that allows disagreement and its corrections and improvements, but improvements that let physics rather than “intuition” and prejudices (Kantian, Quinean, Hegelian… – see Dominguez (2015)) have the last word. It is about naturalization of metaphysics (let nature reveal what nature does) and what metaphysics (unification of scientific disciplines and up to date science) should rather than used to be. Naturalized metaphysics (Ladyman, 2016) should be difficult to vary (Deutsch, 2011) and accessible even to civilizations from other planets (If not, why not?) without terrestrial religions and schools of philosophy and worldviews and address the same phenomena (unless they deal with a different “ensemble” (Tegmark, 1998)) in the same way as ours. Dominguez (2015) falls in the same trap (but a trap that in his case contributes to the discussion) that Ladyman and Ross (2007) criticize – he insists on philosophical ideologies instead of letting nature reveal its mysteries (“our world doesn’t make sense when conceived as exclusively made of abstract, *ante rem*, universals, as relations stubbornly appear to be” (Dominguez, 2015, 132)). On the other hand, Dominguez’s criticism of OSR resembles Seager’s (2016) criticism of Dennett’s intentional stance (abstraction (Troncale, 2009) that has gone too far; note that OSR by Ladyman and Ross is actually inspired by Dennett (1991b)), but that is not really the case. Dennett’s too radical position provides a sketch for Ladyman and Ross (2007) what to do next. Also, “a non-relational form of unity” that Dominguez proposes as a solution is like the block universe (in which nothing is ever caused) that Kastner (2016a) rightfully criticizes. Dominguez is right when he claims “the only consistent way in which OSR can be defended (at least the only one that I can see) is as a form of Platonism” (Dominguez, 2015, 134). At this point OSR is like a pointer to a theory (GST*?) that might provide a more detailed description of reality and there is Dominguez’s assertion worth quoting here: “The search for general categories and principles should never lead us to forget our point of departure: the qualitative richness and concreteness revealed in experience, which any general way of making sense of reality as a whole must account for and try to preserve.”

Physical principles as suggested by Deutsch and Marletto are elaborated in another paper (Malecic, 2016), but the bottom line is that from their approach it is uncertain why and how nature would choose specific principles for its systems instead of some others. They just add one arguable principle after another until they seemingly have enough of them in order to describe the whole physical reality. Their model doesn’t bring results satisfying even to Deutsch and Marletto because they provide additional explanations and still don’t see their work as complete more than a decade after Wallace’s (2001) article. Let’s see now whether we had more luck with Table 1.

Deutsch and Marletto are trying to define the physical principles and leaving the underlying algebra (and “forgetting” to explicitly mention the list of the four strands) that would support their approach for some other time. Also, in order to make themselves happy at this stage with their own work, they suggest additional explanations (Deutsch and Marletto, 2015) in order to make their suggested list of principles to go anywhere. On the other hand, Table 1 resembles symmetry and symmetry-breaking (Zee, 1986; Stewart and Golubitsky, 1992) and already existing group theory (Zee, 2016) and quantum field theory (Auyang, 1995; Zee, 2003) and Noether's (1918) work on symmetry and conservation laws. Nature is already known to use tables and matrices in group theory. If the search for the physical principles, the hard problem of consciousness (Chalmers 1996), the right interpretation of quantum mechanics, and/or some other holistic theory must use something beyond equations and laws (see also Lanza and Berman (2009), Wurzman and Giordano (2009), McNamara and Troncale (2012), Simeonov et al. (2012), Metcalf and Edson (2015), and Rousseau (2017)), perhaps hints of that "toolkit" can be found in quantum field theory and group theory, especially because they are already used for explanations of fundamental interactions and particles. See also Bohm (2005) on the implicate order and Tegmark (1998) on the ultimate ensemble.

CONCLUSION

Consciousness is bizarre (Seager, 2016), but perhaps that should be a challenge rather than a problem and a way to reveal something about other less bizarre aspects of reality. The sooner constructor theory (Deutsch, 2012) of eigenbehavior (Pangaro, 2011) addresses consciousness, the less it will deviate from relevant insights. The author refuses to be "reasonable" and takes the leap (and thinks dangerously (Malone, 2007)) assumed by Pauli (Zeilinger, 1996), but still insists on physicality (even if some aspects of physicality are emergent and sub-empirical (Kastner 2013; 2015) and implicate (Bohm, 2005)) of phenomena. The article is an attempt to take a walk across disciplines and ideas and in a manner suggested by Ladyman and Ross (2007) see metaphysics as unification of scientific disciplines and concepts (Ladyman, 2016). Circularity (Füllsack, 2016) is treated as real instead of metaphorical. It agrees with ideas of Jung (synchronicity – a controversial concept, but relevant because it questions determinism and efficient as the only form of causation), Kastner (the transactional interpretation of quantum mechanics and symmetry breaking), Rosen (anticipatory systems), Prigogine (thermodynamics, irreversibility, the arrow of time) and sees them as compatible facets of what constructor theory of eigenbehavior should be about. The author is open for criticism and discussion.

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