

The mathematical nature of the universe and consciousness: the universe is a self-driven parallel computing automaton; consciousness is a Turing machine's subjective mathematical model of the objective universe

Xiaoyang Yu^{1*}

¹ Xiaoyangyu.org, Auckland, New Zealand (ORCID: 0000-0001-6857-667X)

* Corresponding author

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Abstract

Background/introduction

This study is to discover the nature of consciousness and/or universe.

Methods

Comparing the nature to a Game of Life system.

Results

Found that the universe and a Game of Life system has the similar mathematical nature.

Conclusions

Humans are limited in what they know by the technical limitation of their cortical language network. A reality is a situation model. The universe is a self-driven objective state machine which evolves by itself automatically. Heisenberg's uncertainty principle can be explained under this situation. If we are happy to accept randomness, it's obviously possible that all *other* worlds in the many-worlds interpretation don't exist objectively. Consciousness is actually the use of a mathematical model by a Turing machine (TM). A TM's consciousness or decisions shouldn't be able to alter/impact/change the fated world line of any elementary particle within *this* world. Except Schrodinger equation (or its counterpart) which is the only actual causality of the objective-reality, any other causality is only a (subjective) Granger causality.

Keywords: theoretical physics; Turing machine; psychology; causality; consciousness; determinism

Abbreviations

1O: first-order

2O: second-order

BB: building block

GCo1OPCA: geometric construction of first-order parallel computing automaton

MM: mathematical model

PPS: primordial particle system

SM: situation model

TM: Turing machine

Situation model

Just like other animals, humans are limited in what they know by the structure of their nervous systems and by the structure of their languages [5]. More specifically, humans are limited in what they know by the technical limitation of their *cortical language networks* [6][7].

Situation models (SMs) [8] [9] are complex mental representations that can simulate the situation described in a

text [10]. A SM is a mentally perceived *situation*.

When a human is not reading a text, I believe that a “background” SM is simulated (by her objective/physical brain) to represent her current situation in real world, and this SM is somehow narrated by her cortical language network, like an internal monologue. Then, when she is reading a text, her objective brain has to simulate two SMs for her, one of them is the “background” SM. Her brain can somehow use text to describe either SM respectively.

My brain somehow uses the text below to describe its “background” SM.

Each SM simulated by a human’s objective brain, is a reality for her; every reality for her, is a SM simulated by her objective brain. A reality is a mentally perceived *situation*.

Human believes that a SM can be more real than another SM. A SM’s realness degree decides the realness degree of its elements/components; a SM’s elements/components have the same realness degree.

Some terms are conventionally used in natural language, to compare the realness degrees of two SMs.

For example, the following terms are conventionally used when referring to a SM with higher degree of realness:

“physical”, “objective” (aka “third-person objective [11]”), “actual”, “real”, “real-world” and “fated”. Let’s add a term “first-order (1O)” to the list for convenience.

For example, the following terms are conventionally used when referring to a SM with lower degree of realness:

“mental”, “subjective” (aka “first-person subjective [11]”), “imagined”, “pareidolic”, “counterfactual”, “if”, “free”, “possible” and “uncertain”. Let’s add a term “second-order (2O)” to the list for convenience.

Comparing to a SM with higher degree of realness, a SM with lower degree of realness is imagined/pareidolic/counterfactual.

Parallel computation

Let's call a state machine's transition function the 1O-function. The “actual future” of a state machine refers to its state transition.

In the Standard Model of particle physics, elementary particles are the simplest possible objects that can be shifted, rotated and boosted [35]. A pure quantum state corresponds directly to (objective) reality [36]. “Ever since the fundamental paper of Wigner on the irreducible representations of the Poincaré group, it has been a (perhaps implicit) definition in physics that an elementary particle ‘is’ an irreducible representation of the group, G , of ‘symmetries of nature.’ [37]” “Particles are at a very minimum described by irreducible representations of the

Poincaré group [38].”

Let's call a cell in Game of Life, an elementary particle in the universe, or a particle in PPS the building block (BB). In the semantics of the present article, a BB's “state” includes its position.

The universe, a Game of Life system or a primordial particle system (PPS) [39] [40] is a state machine.

In case that a state machine is a collection of BBs, its state transition refers to the state evolution of all BBs; its state transition is a parallel computation to *calculate (let's call it IO-calculate)* the new state of every BB, using the IO-function. Let's call such a state machine the IO-parallel-computing-automaton, and call its state transition the IO-parallel-computation.

BBs are mutually exclusive subsets of a IO-parallel-computing-automaton. Governed by the IO-function, the IO-parallel-computation is not goal-directed.

The IO-function of every Game of Life system [52] is as below:

$$State(p, q, h + 1) = \begin{cases} 1 & \text{if } N(p, q, h) \leq 3 \text{ and } (3 - State(p, q, h) \leq N(p, q, h)) \\ 0 & \text{otherwise} \end{cases}$$

where

$$N(p, q, h) = \left\{ \sum_{a=p-1}^{p+1} \sum_{b=q-1}^{q+1} \text{State}(a, b, h) \right\} - \text{State}(p, q, h)$$

Let's suppose that there are only three BBs in the universe, and suppose that the initial state of the collection of BBs is as below:

Sequential number of the BB	State of the BB				
	Position of the BB			Other states of the BB	
	x	y	z	Type of the BB	Other state of the BB
0	0	0	110	0	0
1	3.4	-5.87	9	6	1
2	2	75	-64.3	4	0

Table 1

At the next moment, let's suppose that the state of the collection of BBs changed to below:

Sequential number of the BB	State of the BB				
	Position of the BB			Other states of the BB	
	x	y	z	Type of the BB	Other state of the BB
0	98	-35.4	8.43	0	1

1	2567	-765.4	-243	6	1
2	-334.2	24.2	894.3	4	0

Table 2

In this example, a BB's position includes three numbers (e.g., "0, 0, 110" for the first BB in table 1). In theory, it's possible that the position of a BB (in the universe) actually includes four or more numbers.

It's possible that Schrodinger equation is the 1O-function of the universe. For readers who don't agree with that, let's *suppose* that I just discovered the actual 1O-function of the universe, and let's call it X function.

Let's say that the *state* of a BB carries 1O-information, and say that the *state change* of a BB carries 2O-information.

In a 1O-parallel-computing-automaton, the 1O-parallel-computation 1O-calculates 1O-information, which gives rise to 2O-information.

When we humans observe a 2O-information being propagated/processed, let's say that the 2O-information is being 2O-propagated/2O-processed. Being part of the 1O-parallel-computation, the 2O-propagation or 2O-processing is not something different from the 1O-parallel-computation.

Humans postulate that BBs are the only medium for the 2O-propagation/2O-processing of 2O-information -- information which can't be represented by the state change of BBs, is not a 2O-information, and has no way to be 2O-propagated/2O-processed.

For example, when humans observe a Turing machine (TM) [44] processing information in a Game of Life system (on a computer screen), the information is 2O-information, which is being 2O-processed. A BB switches its state between live and dead over time. Such a state change carries 2O-information.

Another example, visual information from a retina to the brain, is carried by electric currents through optic nerves. An electric current is a stream of charged particles. In the state of a BB in a charged particle, the position information changes over time. The change of a BB's position carries 2O-information. This 2O-information will be 2O-processed by the BBs in the brain. Output information from a vertebrate brain to the spinal cord, is also carried by electric currents.

In the semantics of the present article, a (subjective) mathematical model (MM) is a structuralized 2O-information/knowledge (which is being 2O-processed) for forecasting.

Being a simulation/representation, a SM is a MM.

In case that a 2O-processing produces a (subjective) MM through 2O-processing 2O-information, this MM depends on the state *change* of BBs, not depends on the *state* of BBs. So, a 2O-processing can only know the state *change* of BBs, not the *state* of BBs. This explains Heisenberg's uncertainty principle.

Inside a 1O-parallel-computation, we humans can subjectively recognize/identify a fuzzy set of BBs which is 2O-processing some 2O-information, if we can subjectively recognize/identify/decode the 2O-information (from the state change of these BBs), and if we can subjectively model/recognize/identify the function of the 2O-processing (by analyzing the state change of these BBs). Based on our (subjective) MM of the function of the 2O-processing, we subjectively define these BBs to be an objective-object of the 1O-parallel-computing-automaton. This objective-object is subjectively represented by our MM of the function of the 2O-processing -- this objective-object is subjectively modeled to be a (non-linear) processor of 2O-information. In case that our MM (of the 2O-information processor) is a fitted model of the 1O-function, we can't use this fitted MM to subjectively model a counterfactual situation (which is different from the actual situation within the 1O-parallel-computation). In case that our MM is an under-fitted model of the 1O-function, we can use this under-fitted MM to subjectively model a counterfactual situation. We might counterfactually/wishfully believe/postulate that this counterfactual situation can actually happen in this 1O-parallel-computing-automaton, so that we can blame this objective-object for preventing this counterfactual situation from actually happening (i.e., in case this objective-object is a Gosper glider gun, we can blame it for shooting another pattern). (But apparently, this counterfactual situation can only happen in a different 1O-parallel-computing-automaton which has a different 1O-function or initial state.) Upon receiving the blame (as a 2O-information), the objective-object might be able to subjectively forecast what the blamers will do, and make decisions/actions based on its forecast. Its forecast/decision/action is actually carried out by the 1O-function.

Physical objects (in the universe), patterns (in a Game of Life system) and structures (in a PPS) are all objective-objects. A TM is an objective-object. Every animal brain is a biological neural network. Some (recurrent) neural networks are TMs [1] [2]. For example, the human brain is a TM [3]. Some neural networks are universal Turing machines [4].

The term “consciousness” has two meanings. Firstly, it refers to a TM’s first-hand *subjective conscious experience*; let’s call it this TM’s (private) “subjective-reality [12]” or (private) “subjective consciousness [13]”. Secondly, when an TM suspects the presence of the subjective-reality in an objective-object, we can say that this TM has subjective clues for the “objective consciousness” of the objective-object; the objective-object can be this TM itself.

When a (subjective) MM is being used by a TM within its 2O-processing, the content of the MM is being “subjectively experienced” by the TM; the subjective-reality is actually the use of a MM by a TM within its 2O-processing.

A TM’s subjective-reality is the TM’s subjective MM of an objective mathematical structure (i.e., the TM’s 1O-parallel-computing-automaton). So, the subjective MM has no way to change the evolution of the subjective MM itself. The subjective MM is 2O; the objective mathematical structure is 1O. So, the subjective MM is not part of the objective mathematical structure. For example, the subjective MM is not part of the TM’s objective

construction (in the TM's 1O-parallel-computing-automaton). So, the subjective MM has no way to change the 1O-parallel-computation of the TM's 1O-parallel-computing-automaton. So, there is no way for another TM to prove the objective existence of the said TM's subjective MM (i.e., the said TM's subjective-reality).

For example, let's suppose that there are only three BBs in a 1O-parallel-computing-automaton, and let's postulate/imagine that a BB has a MM/subjective-reality which is a geometric model of a (Euclidean) triangle with these three BBs as its vertexes. As a subjective MM, this Euclidean triangle has no way to change the evolution of the Euclidean triangle itself, and has no way to change the 1O-parallel-computation of the 1O-parallel-computing-automaton.

Based on the knowledge of a TM, the 1O-function of its 1O-parallel-computing-automaton should be empirical. The 1O-function as a knowledge of a TM, is not decision-oriented.

Every (subjective) causality is a MM.

Let's call the Granger causalities [49] the (subjective) 2O-causalities. The 1O-function is not a 2O-causality. Each 2O-causality is a pareidolia constructed by the 1O-parallel-computation; the 1O-function is not a pareidolia.

“BBs are the only medium for the 2O-propagation of 2O-information; 2O-information 2O-propagates from one objective-object (as output) to another objective-object (as input), and causes 2O-processing in the latter objective-

object; 2O-information is 2O-processed within the latter objective-object” is only a (subjective) 2O-causality. BBs, 2O-information, 2O-propagation/2O-processing and objective-objects are modeled/imagined/postulated/supposed to follow this 2O-causality. Actually, in 1O-parallel-computation, 1O-information doesn’t propagate from one BB (as output) to another BB (as input); the state change of one BB (over a time period) has nothing to do with the state change of any other BB (over the same time period); the state change of each BB is independent. The 2O-propagation/2O-processing is actually caused by the 1O-parallel-computation, not caused by the 2O-information (as input). 2O-information and its 2O-propagation/2O-processing are subjective only; 2O-information and its 2O-propagation/2O-processing are actually a subjective pareidolia/MM of human brain. In case that the 1O-parallel-computing-automaton is a Game of Life system, this conclusion will be easier to understand for human brains.

For example, when my retina captures a photon from a star, by 2O-processing 2O-information, my brain produces a (subjective) MM of the star. Actually, my MM is caused by the 1O-parallel-computation of the BBs in my brain (which is an objective-object), not caused by the 2O-information received from any other objective-object. If “God” somehow hacks the universe to totally remove the photon without affecting the state evolution of any other BB, my brain will still produce the same MM. (In this case, X function needs to be hacked accordingly.) More generally, if “God” somehow hacks the universe to remove every BB outside of my brain without affecting the state evolution of any BB within my brain, my brain will still produce the same MM. So, as an objective-object, my brain has no way to prove/disprove the existence of any other objective-object.

We human brains can observe a TM 2O-processing 2O-information in a Game of Life system. When we observing

this TM, this TM acts as if that it has a subjective MM. So, we can postulate that this TM has a subjective MM.

Actually, the existence of the subjective MM is a 2O-causality used by human brains.

Similarly, I can observe a human brain 2O-processing 2O-information in the universe. When I observing this human brain, this human brain acts as if that it has a subjective MM. So, I can postulate that this human brain has a subjective MM. Actually, the existence of the subjective MM is a 2O-causality used by my brain. This human brain can be my own brain.

Similarly, in a Game of Life system, a TM can observe another TM 2O-processing 2O-information. When the former TM observing the latter TM, the latter TM acts as if that it has a subjective MM. So, the former TM postulates that the latter TM has a subjective MM. Actually, the existence of the subjective MM is a 2O-causality used by the former TM. The two TMs can be the same TM.

When we model/imagine something, we have to use an imagined viewpoint/observer located somewhere outside of its model/representation. Our model/imagination is actually a SM simulated by our objective brains.

When I am using a viewpoint located outside of a system/SM, it implicitly means that I have some knowledge about this system/SM.

Based on the knowledge an external observer (who is located outside of a *finite* 1O-parallel-computing-automaton)

is capable to have, this external observer is capable to reliably forecast a finite time IO-parallel-computation based on the IO-function; this external observer should say that the IO-parallel-computation is empirically *fated*.

Let's suppose that a TM within the IO-parallel-computing-automaton is capable to use a general algorithm to reliably forecast the IO-parallel-computation. Then, we can suppose that there is another TM in the IO-parallel-computing-automaton. Every possible program-input pair can be given to the latter TM, while the former TM should be able to use the general algorithm to forecast whether the latter TM will finish running, or continue to run forever. Under this setting, the general algorithm can solve the halting problem for all possible program-input pairs. However, such a general algorithm cannot exist [34], which means that our first supposition is counterfactual. So, according to computability theory, it's impossible for a TM (within the IO-parallel-computing-automaton) to use a general algorithm to reliably forecast the IO-parallel-computation; the TM should say that the IO-parallel-computation is nonempirically fated.

For example, if a TM in a Game of Life system discovered the IO-function of the system, the TM should say that the IO-parallel-computation is nonempirically fated.

Based on the knowledge an external observer is capable to have, a IO-parallel-computing-automaton evolves like a preexisting documentary film. I am in this film in real time. No one in the IO-parallel-computing-automaton has watched this film beforehand.

When my brain is watching this documentary film, a SM (let's call it the 2O-SM) is automatically emerged/created based on the past plots in this film, to be used to unreliably forecast/guess the upcoming plot in this film. Postulating/perceiving/imagining itself to be the protagonist in this film, my brain automatically makes decisions based on the unreliable forecast/guess (of the 2O-SM), to control the protagonist in this film.

The actual evolution of this documentary film (which can't be reliably forecasted by the objective/physical construction of my brain based on the past plots) is represented/simulated/modeled by another SM of my brain, i.e., the SM of the 1O-parallel-computation. Let's call this SM the 1O-SM.

The 2O-SM uses 2O-causalities; the 1O-SM uses 1O-function. The 2O-SM is decision-oriented; the 1O-SM is not decision-oriented. The 2O-SM is a pareidolia constructed by the 1O-parallel-computation; the 1O-SM is not a pareidolia.

For a TM's mutually exclusive SMs, if the TM (limited by the knowledge the TM itself is possible to have) has no way to prove/disprove any of them empirically, these SMs can be called SM-candidates (for the TM). It's absolutely fine for the TM to choose to believe any of them.

“What is being forecasted by a TM regarding its own future, is the actual future.” When a TM is postulating this, this postulation is a SM.

“What is being forecasted by a TM regarding its own future, is *not* the actual future.” When a TM is postulating this, this postulation is a SM too. When a TM is using this SM, this TM can simulate the actual future by another SM (e.g., the 1O-SM). Then, the actual future is like a script for this TM to follow automatically/unintentionally, while this TM is not aware of the upcoming plot (in the script) in advance. Let’s call this “script” the *fate*. Anything which follows the fate, is fated.

“The 1O-parallel-computation is (nonempirically) fated” and “the 1O-parallel-computation is not fated” are two SM-candidates. Let’s call them SMC-fated-1O-parallel-computation-Positive and SMC-fated-1O-parallel-computation-Negative respectively.

As a TM in a 1O-parallel-computing-automaton, my brain postulates/believes that SMC-fated-1O-parallel-computation-Negative is counterfactual in the 1O-parallel-computing-automaton, although this postulation/belief can't permanently prevent my brain from using SMC-fated-1O-parallel-computation-Negative.

A SM is a tool for forecast. The SMs are designed in order to forecast. The SMs are used (by a TM) to forecast the future. As soon as the TM uses a SM, the TM immediately gets the forecast made by this SM. (Some forecasts are (unnoticeably) wishful and hence fascinating/addictive.) Whenever the TM is using a SM, the TM is mentally living in the future as being forecasted by this SM. That’s why “(mentally) living in the present moment” is difficult for a brain.

Each SM has its neural underpinning in the brain. Multiple SMs might co-exist in a human brain at the same time. Being a MM, a SM is an abstract information/knowledge about what a human knows, rather than what she directly sees in her local environment, or what she directly reads from a text. “There are a thousand Hamlets in a thousand people's eyes.”

Every reality for a human, is a situation simulated by her objective brain as a SM. So, none of these realities actually exists in the way it is simulated as (i.e., none of these realities actually exists in the way it is simulated to be). In this sense, none of these realities is 1O/actual; all these realities are 2O/imagined.

Being simulated by my objective brain as a SM, the (shared) *objective-reality* [14] [15] (aka *third-person objective reality* [16] [17]) is the thing in itself [18] which doesn't depend on the existence of my objective brain.

For a TM in a 1O-parallel-computing-automaton, the 1O-parallel-computing-automaton is the TM's objective-reality.

“I am 1O/actually living in the objective-reality; I am *not* 1O/actually living in the reality of any other SM of mine” and “I am 1O/actually living in the objective-reality; I am *also* 1O/actually living in the reality of every other SM of mine” are two SM-candidates. Let's call them SMC-single-objective-reality-Positive and SMC-single-objective-reality-Negative respectively.

Just like physicists, my brain believes/postulates that I am only actually living in the objective-reality, and the SM of the objective-reality is only a MM/representation/simulation of the objective-reality; the objective-reality is more actual/real than its SM. In this sense, I believe/postulate that the situation in the SM of the objective-reality is 1O/actual/real, while the situation in any other SM of mine is 2O/virtual/imagined/perceived.

The term “universe” refers to a single objective-reality shared by all humans.

Logically speaking, everything a human knows, is somehow generated by her objective-reality (which includes her objective brain); all her SMs are somehow generated by her objective-reality, so they might be counterfactual.

The many-worlds interpretation is a SM. Let’s call it the many-worlds SM.

When a TM postulates that all other so-called “worlds” in the many-worlds SM only exist subjectively (in the TM’s subjective-reality), instead of existing objectively (in the TM’s objective-reality), this is another SM. Let’s call it the one-world SM.

The many-worlds SM and the one-world SM are two SM-candidates.

If I postulate that all other so-called “worlds” in the many-worlds interpretation only exist subjectively, this is a

new interpretation of quantum mechanics. Let's call it the many-subjective-worlds interpretation.

Both the many-subjective-worlds interpretation and De Broglie–Bohm interpretation use the one-world SM.

In the many-worlds interpretation or De Broglie–Bohm interpretation, “God does not play dice”. In the many-subjective-worlds interpretation, “God plays dice”.

For a TM, “God plays dice” and “God does not play dice” are two SM-candidates, let's call them SMC-dice-Positive and SMC-dice-Negative respectively.

The SMC-fated-10-parallel-computation-Positive is compatible with the many-worlds SM, the one-world SM, the SMC-dice-Positive or the SMC-dice-Negative.

It's possible that X function doesn't apply to all BBs equally. In this case, I can give each BB a serial number, so that X function can include this serial number, to handle each BB differently, based on its serial number. To say the least, X function can simply exhaustively define the state of every BB at every moment. Then, no matter how weird a BB behaves (comparing to other “normal” BBs), this weird behavior still follows the X function. For example, even psychokinesis can follow the X function -- “it looks like that the person makes a chair floating in the air without physical interaction; actually, the position information in the states of the BBs of the chair was fated to evolve to that location (in the air) during that time period, following the X function.”

Logically speaking, quantum effects can follow the X function, while the X function is deterministic. In this case, the X function handles every BB uniquely, so that it is super complicated as a mathematical function. (Here the one-world SM and SMC-dice-Negative are being used.) If a TM doesn't have access to this super complicated X function in advance, the TM can't use this deterministic X function to forecast the activity of a BB deterministically. That's why the activity of a BB looks random to this TM.

Let's suppose that an external observer (who is located outside of the universe) has access to this super complicated deterministic X function in advance. Based on her knowledge, the external observer should say that quantum effects are empirically *predetermined* by this X function deterministically.

Geometric situation model

There is strong psychological evidence that human brains parse visual scenes into part-whole hierarchies and model the viewpoint-invariant spatial relationship between a part and a whole as the coordinate transformation between intrinsic coordinate frames that they assign to the part and the whole [19] [20].

If a TM has the subjective conscious experience of being immersed within a viewpoint-invariant spatial structure (from the viewpoint of an observer who is a geometric object being part of this spatial structure), the spatial structure is the TM's subjective/internal mathematical/geometric model/representation/simulation which

represents the spatial structure of the TM's local environment (if the TM postulates that its local environment has a spatial structure). Let's call this model/representation/simulation the TM's (private) geometric reality. The TM's geometric reality is a SM, let's call it the geometric-SM. The geometric-SM describes the spatial structure of a so-called "macroscopic world".

The geometric-SM is like a documentary film being watched by the TM. The TM postulates/perceives/imagines itself to be the protagonist in this film. The TM's 2O-SM unreliably forecast/guess the upcoming plot of this film based on the information in the past plots. The TM's 1O-SM represents/simulates/models the actual evolution of this film.

The semantics of natural language counterfactually treats the *private* geometric reality as the *shared* objective-reality. For example, "I am sitting behind you" actually means that "my avatar/representation is sitting behind your avatar/representation; both avatars/representations are geometric objects within my geometric-SM".

Based on a TM's knowledge, "my geometric-SM is the *actual* objective-reality" and "my geometric-SM is not the *actual* objective-reality" are two SM-candidates. Let's call them SMC-geometric-situation-model-objective-Positive and SMS-geometric-situation-model-objective-Negative respectively.

SMC-single-objective-reality-Positive and SMC-geometric-situation-model-objective-Positive are incompatible.

SMC-single-objective-reality-Negative and SMC-geometric-situation-model-objective-Negative are

incompatible.

The geometric-SM uses allocentric mapping, in which representations of object positions are stable with respect to observer position; the geometric-SM has allocentric character [21].

The TM's geometric-SM is a MM reconstructed from the sensory information. The geometric-SM is mathematical.

In case the TM is a human brain, the TM's geometric-SM is a three-dimensional Euclidean space, but the three orthogonal coordinate axes of the three-dimensional Euclidean space are not visualized inside the geometric-SM, so the geometric-SM doesn't look like a textbook example of a three-dimensional Euclidean space; imaginary objects are not visualized inside the TM's geometric-SM, so a human brain can distinguish imaginary objects from objective-objects, and can distinguish other SMs from the geometric-SM. An imaginary object (within another SM) is visualized by the TM, using the elements/components of some geometric objects (i.e., the avatars/representations of objective-objects) within the geometric-SM.

Every SM (e.g., the geometric-SM) is being narrated (by cortical language network) in the same way as a dream/film or a multiplayer virtual reality entertainment system [22] is being narrated.

A TM has no way to know whether another objective-object actually has the subjective-reality or not. The subjective-reality is like "the ghost in the machine [23]". A TM won't have a correct algorithm to judge whether

a thing (e.g., itself) has the subjective-reality or not. It's logically possible that the brain of the author of the present article, is the only thing which has the subjective-reality. This is the position of solipsism.

When a TM postulates that only itself is actually experiencing a private subjective-reality, this is a SM. When a TM postulates that every TM is experiencing a private subjective-reality, this is another SM. When a TM postulates that no TM is actually experiencing a private subjective-reality, this is another SM. These three SMs are SM-candidates.

A TM is subjectively experiencing its subjective-reality. What a TM has access to, is always the content of its own subjective-reality. A TM doesn't have direct access to its so-called "objective-reality" (aka "physical reality") in its subjective-reality. A TM has no way to logically prove/disprove that its so-called "objective-reality" exists objectively. A TM can at most postulate/imagine that its so-called "objective-reality" exists objectively. This is the position of solipsism.

When a TM postulates that the so-called "objective-reality" exists objectively, this is a SM. When a TM postulates that the so-called "objective-reality" doesn't exist objectively, this is another SM. These two SMs are SM-candidates. Let's call them SMC-objective-reality-objective-Positive and SMC-objective-reality-objective-Negative respectively.

Both SMC-single-objective-reality-Positive and SMC-single-objective-reality-Negative are incompatible with

SMC-objective-reality-objective-Negative.

As a TM, the author of the present article postulates that every TM has both an objective-reality (which exists objectively) and a SM (or two or more SMs) at the same time, and this TM itself lives/exists in its objective-reality objectively, not in its SM, although this TM's program counterfactually feels like that it "lives/exists/*presents*" in its SM "objectively", because it counterfactually defines/imagines/narrates its SM to be its objective-reality (this is a pareidolia); every TM's SM is produced by its objective-reality objectively. A TM's SM is a MM/representation/simulation of its objective-reality. Apparently, a TM's MM (of its objective-reality) is not its objective-reality. "The map is not the territory [5]."

A common human's theory of mind postulates a spatial unity of self and body, an observer that resides in one's body and is the subject of one's subjective conscious experience [24]. This postulated situation is the 2O-SM. Let's call the reality of the 2O-SM the 2O-reality, and call the observer in the 2O-SM the 2O-observer (aka the false self [25]).

Human brain has the ability to imagine/simulate the thoughts of another person. Based on this ability, a human brain can imagine/simulate an imaginary companion (aka imaginary friend), and can further identify/postulate this imaginary companion to be an observer of one's subjective conscious experience (like an alternate personality). Let's call this observer the 1O-observer (aka the true self [25]).

Actually, the human brain perceives/imagines itself to be the 1O-observer. The 1O-observer is different from an ordinary alternate personality, because the 1O-observer can be experienced (by the human brain) to be located outside of the human's body.

Dramatically, this human brain can further nominate the 1O-observer to be the sole observer of one's subjective conscious experience. (It's a kind of out-of-body experience. It's like observing one's virtual doppelganger from the viewpoint of another person, by using a virtual reality system [58].) This postulated situation is the 1O-SM.

Let's call the reality of the 1O-SM the 1O-reality.

In the context of a TM's 1O-SM, the 1O-parallel-computation of the objective-reality is *only* determined by the 1O-function; in the context of a TM's 2O-SM, the 1O-parallel-computation of the objective-reality is *not* only determined by the 1O-function.

Besides the geometric-SM, the 2O-SM and the 1O-SM are two different *MMs* of the TM's *objective-reality* (i.e., the *thing in itself*; another SM).

In the TM's 2O-SM, the TM's geometric-SM is a collection of geometric objects. The geometric objects (within the TM's geometric-SM) are being referred by the TM's 2O-SM in real time. In this way, the TM's 2O-SM works as an extension/explanation/understanding of the TM's geometric-SM, and works like an augmented reality on top of the TM's geometric-SM. In this sense, the TM's 2O-SM syncs with the TM's geometric-SM.

In the TM's 1O-SM, it's the same.

The 2O-SM defines a mathematical relation among the geometric objects (within the geometric-SM). The 1O-SM defines another mathematical relation among these geometric objects. These two mathematical relations are different in nature. These two SMs are MMs of the mathematical relation among these geometric objects.

According to the nature of the mathematical relation it defined, the 2O-SM can be used (by the TM) to (roughly) forecast/guess the future, so it can be used to make a decision; in practice usually the 1O-SM can't be used to forecast/guess the future, so it can't be used to make a decision. So, in order to make a decision, the TM has to use the 2O-SM.

During the 1O-parallel-computation of a 1O-parallel-computing-automaton, at any given time, every BB must have a *state* (i.e., a set of objective/physical quantities, such as position and momentum), and only has *one* state; a BB can't have two or more different states at the same time. That's why physicists bother to measure the state of a BB. Neither Heisenberg's uncertainty principle nor many-worlds interpretation implies that a BB has two or more different states at a given time (in this world among the many worlds).

If we suppose that a BB is capable to do something other than what it actually does, and if we also suppose that this BB actually does something other than what it actually does, then actually this BB is still doing what it actually

does, as long as we don't suppose that this BB is doing two different things (i.e., having two different states) at the same time. Even if we suppose that this BB is actually doing two different things at the same time, actually this BB is still doing what it actually does. A human brain just can't imagine the situation "a BB can actually do anything other than what it actually does".

So, limited by the imaginative capacity of human brain and human language, every BB is incapable/powerless to do anything other than what it actually does (in the 1O-parallel-computation), and is incapable/powerless to have any state other than what it actually has (in the 1O-parallel-computation).

So, every objective-object (in a 1O-parallel-computing-automaton) is incapable/powerless to do anything other than what it actually does (in the 1O-parallel-computation). This is the view of fatalism [27].

Let's suppose that an external observer has unlimited computational power and knows the real-time state of every BB inside an isolated system, without measuring it. Let's call such an external observer the omniscient observer. So, no agent can have more knowledge than the omniscient observer regarding anything inside this isolated system.

When observing/forecasting the 1O-parallel-computation of an isolated system, the omniscient observer will believe that, no matter a BB is currently inside the animal body or outside of it, this BB has no *freedom* during its entire life cycle. (Let's use the term "1O-freedom" to refer to the meaning of "freedom" here; when we say that something inside an isolated system has no 1O-freedom, it means that it has no freedom from the viewpoint of an

omniscient observer.) The animal brain's subjective-reality (as a SM) has no way to introduce 1O-freedom to any BB (inside this isolated system). Otherwise, the outcome of the 1O-parallel-computation depends on the animal brain's subjective-reality, but physicists won't believe that. Physicists believe that the animal's subjective-reality depends on the outcome of the 1O-parallel-computation.

There is no way to change an animal's trajectory in an isolated system; the animal's brain has no way to change the animal's actual trajectory. More generally, there is no way to change the world tube of any objective-object in this isolated system. There is no way to change the fated 1O-parallel-computation of this isolated system.

The animal's brain can forecast its own trajectory based on its own knowledge. The omniscient observer can forecast the 1O-parallel-computation (including the animal's trajectory) based on her knowledge. Regarding the animal's trajectory, the animal brain's own forecast should be less accurate than the omniscient observer's forecast, because the animal brain has less knowledge than the omniscient observer. Then, regarding the animal's future trajectory, the animal brain has less knowledge than the omniscient observer. So, comparing to the omniscient observer, the animal brain feels more *freedom* in the animal's future trajectory. (Let's use the term "2O-freedom" to refer to the meaning of "freedom" here; when we say that a TM inside an isolated system has 2O-freedom, it means that it is supposed to have freedom from the viewpoint of the TM itself with its current knowledge/ignorance.) Comparing to the 1O-freedom, the 2O-freedom is caused by the TM's lacking of knowledge; the 2O-freedom represents the TM's uncertainty when forecasting the time series (let's call it the 1O-time-series) of the position of each BB within the TM itself.

The 2O-observer is the center of the 2O-SM. The 1O-SM is allocentric.

The 2O-reality is defined/imagined/narrated by the TM to be its objective-reality; the 2O-observer is defined/imagined/narrated by the TM to be an objective-object. This is the TM's pareidolia. In this pareidolia, the observational reference frame of the 2O-observer is used. The viewpoint of the 2O-observer (who is located somewhere inside the TM, and who has the same knowledge as the TM currently has) is defined to be the TM's 2O-viewpoint (aka first-person perspective [28] or immersed perspective [58]). When a TM uses the 2O-viewpoint, actually it is using the 2O-SM.

From the TM's 2O-viewpoint, the 2O-observer observes how the 2O-observer works as the center in a 2O-reality.

The TM's pending action is modeled/represented/simulated as something outside of the 2O-evolution of the 2O-reality like an external force, not as an internal component within the 2O-evolution of the 2O-reality. (The 2O-evolution is the TM's program's imagined/forecasted/supposed/narrated evolution of the TM's objective-reality.)

The TM's pending decision is intentionally excluded from the TM's internally simulated 2O-evolution of the 2O-reality, when the TM is forecasting a 2O-baseline (of the 2O-evolution of the 2O-reality) which doesn't include the consequence of the TM's pending decision, so that the TM can make the pending decision based on this 2O-baseline.

The 1O-reality is defined/imagined/narrated by the TM to be its objective-reality; this is the TM's pareidolia. In this pareidolia, the observational reference frame of the 1O-observer is used. The viewpoint of the 1O-observer (who is located somewhere outside of the TM, and whose knowledge is not limited by the knowledge the TM

currently have) is defined to be the TM's 1O-viewpoint (aka third-person perspective [29], distanced perspective [58] or God's eye view [30] [31] [15]). When a TM uses the 1O-viewpoint, it is either using the 1O-SM, or using a SM which is an obscure mixture of the 1O-SM and the 2O-SM.

From a TM's 1O-viewpoint, the 1O-observer observes how the TM works as an ordinary objective-object in a 1O-reality. The TM's pending action is modeled/represented/simulated as an internal component of the 1O-parallel-computation of the 1O-reality, not as something (which is like an external force) outside of the 1O-parallel-computation of the 1O-reality. Because the TM's pending decision is included by the TM's internally simulated 1O-parallel-computation of the 1O-reality. This internally simulated 1O-parallel-computation (of the 1O-reality) is not decision-oriented. The 1O-baseline (of the 1O-time-series of the 1O-parallel-computation of the 1O-reality) recognized by the TM includes the consequence of the TM's pending decision.

When a TM analyzes a future event from its 1O-viewpoint, the TM analyzes this event, like analyzing an event which already happened in the past (i.e., suppose that this event will happen at 8am sharp tomorrow, the TM makes a mental time travel [32] into 8am tomorrow, to observe the happening of this event, and to analyze this event right after the happening of this event). This is a *distorted* perception of time, if we define its perception of time from its 2O-viewpoint to be *normal*. In contrast, if we define its perception of time from its 1O-viewpoint to be *normal*, the perception of time from its 2O-viewpoint is *distorted*.

Time matters because knowledge/ignorance changes [33]. A TM's 2O-observer is imagined (by the TM) to live in the present, and is imagined to have the knowledge/ignorance this TM current have. A TM's 1O-observer is

imagined to live in the future (i.e., its IO-observer makes a mental time travel into the future), and is imagined to have the knowledge this TM is going to have in the future; a TM's IO-observer is imagined to have no ignorance (regarding the future), like an omniscient observer.

A TM plans its pending action, based on its conceptualized (aka modeled/abstracted/summarized/imagined/narrated) union (aka collection) of categories of situations to model/represent an uncertain future state of its 2O-SM, e.g., "I will catch the last bus tonight" and "I will miss it". Each category of situation is actually a large-scale SM regarding an overall future situation for the TM.

From the viewpoint of the TM, based on its current knowledge/ignorance, each category of situation has the 2O-freedom to happen in the future. Being the 1O-parallel-computation, the actual future is fated; the evolution of the TM's 1O-SM is fated. But being part of the 1O-parallel-computation, the 2O-processing of the TM's program is incapable to forecast which category will actually happen in the future, so it has to use a union of two or more categories together as a MM to model/represent a future situation. So, a union of categories of situations of its 2O-SM (in the future) is used to handle the uncertainty in the TM's forecast of an uncertain future state of its 2O-SM.

From the 1O-viewpoint of the IO-observer, when a MM is being used by a TM within its 2O-processing, from the 2O-viewpoint of the TM, the content of the MM is being "subjectively experienced" by the TM.

Using the semantics of natural language, “a TM uses a MM (from the 1O-viewpoint of the 1O-observer)” is described as “a TM subjectively experiences a MM (from the TM’s own 2O-viewpoint)”.

Building block

From the viewpoint of an TM within Game of Life (or PPS), human observers use a 1O-viewpoint to observe the 1O-parallel-computation of a simulation of Game of Life (or PPS).

From the viewpoint of a human who is located outside of Game of Life, Game of Life is a collection (aka union) of BBs. A BB in Game of Life is some data stored in the computer memory; a BB is not a *mathematical* entity. A BB is not *self-driven*, because apparently a BB is driven by the computer who is simulating Game of Life.

But from the 1O-viewpoint of a TM within Game of Life, a BB in Game of Life can only be viewed (by this TM) as a *self-driven mathematical* entity, because the TM has no way to know the actual objective/physical form of the BB (in humans' world), and has no way to know who actually drives the BB (in humans' world). Or in other words, “a BB is a self-driven mathematical entity” and “a BB is not a self-driven mathematical entity” are two SM-candidates.

For a TM in a 1O-parallel-computing-automaton, from the viewpoint of its 1O-observer who is located outside of the 1O-parallel-computing-automaton, a BB can only be viewed (by this TM) as a *self-driven mathematical* entity,

so the 1O-parallel-computing-automaton can only be viewed as a collection (aka union) of self-driven mathematical entities. (“Our external physical reality is a mathematical structure.” [42]) A self-driven mathematical entity is an objective entity *itself* (i.e., a *thing in itself*); it's not a *MM* of an objective entity.

For the TM, it's only theoretically possible that the so-called “self-driven mathematical entities” actually have objective/physical forms in *another world* (for example, in case the TM is in Game of Life, humans' world is *another world*), or are actually driven by something else in another world.

From the viewpoint of a TM's 1O-observer who is located outside of a TM's objective-reality (it's like “from the viewpoint of a human who is located outside of Game of Life”), the objective-reality is the 1O-parallel-computing-automaton.

In the TM's SM of its objective-reality, it's 1O-parallel-computing-automaton is a collection of the self-driven BBs. Unlike the 2O-SM and the 1O-SM, the TM's SM of its objective-reality does not refer to the geometric objects within the TM's geometric-SM.

The 1O-parallel-computing-automaton is self-driven, in the sense that every BB is self-driven. The 1O-parallel-computing-automaton is the time series of the states of all self-driven BBs. The 1O-parallel-computing-automaton does not include vacuum (aka free space).

Nothing has impact to the 1O-parallel-computation of the (self-driven) 1O-parallel-computing-automaton. The state evolution of a self-driven BB, won't cause any change in the state evolution of another self-driven BB.

A TM's 2O-SM (or 1O-SM) defines the mathematical relation/model among the self-driven BBs of the TM's 1O-parallel-computing-automaton, based on the context of the geometric objects within the TM's geometric-SM.

“Matter” and “time” (as conventional concepts of human) are actually mathematical, not physical. “Matter” and “time” together represent a mathematical evolution (of the states of all self-driven BBs). The mathematical evolution (of the states of all self-driven BBs) is perceived by a TM to be the evolution of *matter* as *time* goes on. In this case, this TM will imagine/postulate both *matter* and *time* (it perceived) to be “physical”.

The state of an aforementioned self-driven mathematical entity includes position information, and a TM inside the 1O-parallel-computing-automaton can imagine/postulate the position information to be coordinates in its imagined/postulated geometric space. From the viewpoint of a TM's 1O-observer (who is located outside of the 1O-parallel-computing-automaton), there is no so-called "objective space" (aka “physical space”) underlying this TM's imagined/postulated geometric space; this TM's 1O-parallel-computing-automaton (i.e., its objective-reality) doesn't actually occupy a so-called "objective space". The so-called "objective space" doesn't exist objectively; it only exists in this TM's imagination/postulation, subjectively. The so-called “objective space” is this TM's pareidolia; the state of the collection of self-driven BBs is not this TM's pareidolia. In other words, the so-called “objective space” is 2O; the state of the collection of self-driven BBs is 1O.

SMC-single-objective-reality-Positive and the SM “the so-called ‘objective space’ exists objectively” are incompatible.

In summary, “objective space” or simply “*space*” (*as a conventional concept of human*) actually doesn’t exist. So, “objective space” is neither physical nor mathematical; “objective space” is only imagined/postulated to exist, by a TM.

So, there is no actual (spatial) movement/carrier in a 1O-parallel-computing-automaton; the self-driven BBs don’t actually move.

As external observers to Game of Life (or PPS) as a 1O-parallel-computing-automaton, humans watch the visualization of the computer simulation of Game of Life (or PPS) on computer screen. The visualization on computer screen is not part of the 1O-parallel-computing-automaton; the 1O-parallel-computing-automaton only includes the state of the collection of BBs in the computer memory. Humans feel like that the 1O-parallel-computing-automaton uses the space on the computer screen, which is not the case.

If the universe is a 1O-parallel-computing-automaton, where does the state of the collection of self-driven BBs store? How can the state of each self-driven BB change? Is the universe actually a simulation at the BB level? Or in other words, is each BB (of the universe) actually a simulation? Being a TM (which is a fuzzy subset of all self-

driven BBs) within the universe (which is a 1O-parallel-computing-automaton), my brain has no way to find the actual/real answers of these questions.

For a TM, “my 1O-parallel-computing-automaton is actually a simulation at the BB level; each BB (of the 1O-parallel-computing-automaton) is actually a simulation” and “my 1O-parallel-computing-automaton is not actually a simulation at the BB level; each BB is not actually a simulation” are two SM-candidates. Let’s call them SMC-simulation-Positive and SMC-simulation-Negative respectively.

From the viewpoint of my 1O-observer (who is located outside of the 1O-parallel-computing-automaton), my 1O-observer can imagine that God or an alien stores the state of every BB and changes the state of every BB, like a TM.

If a TM’s 1O-observer (who is located outside of its 1O-parallel-computing-automaton) extracts position information from the states of all mathematical entities, the 1O-observer can imagine/visualize a geometric structure which uses the extracted position information as coordinates in a geometric space (which doesn't need to be a three-dimensional Euclidean space). Let's call the 1O-observer’s imagined/visualized geometric structure the (subjective) geometric construction of first-order parallel computing automaton (GCo1OPCA). In a sense, the GCo1OPCA describes the spatial structure of a microscopic world. Comparing to the so-called “macroscopic world” (described by the geometric-SM), this microscopic world is closer to the actual world – the 1O-parallel-computing-automaton.

If the universe as a 1O-parallel-computing-automaton is actually a simulation (aka SMC-simulation-Positive), let's suppose that this simulation is running on a computer which is located outside of the universe. The computer can visualize the universe's GCo1OPCA on its screen, for an alien (who is located outside of the universe) to watch. From my viewpoint, my 1O-observer works like this alien.

Similarly, my computer can visualize a Game of Life system's GCo1OPCA on its screen, for me (who is located outside of the Game of Life system) to watch. From the viewpoint of a pattern in the Game of Life system, its 1O-observer works like me.

The 1O-SM is based on the space of the geometric-SM. The 1O-parallel-computing-automaton (or the objective-reality) is not based on any space. So, the 1O-SM is like a visualization of the 1O-parallel-computing-automaton.

The spatial structure of human brain's geometric-SM is a three-dimensional Euclidean space. If the spatial structure of the GCo1OPCA is also a three-dimensional Euclidean space, the two spatial structures can map to each other in the 1O-SM, so that every BB can be located within the three-dimensional Euclidean space (of the geometric-SM).

If the GCo1OPCA is not a three-dimensional Euclidean space, the two spatial structures can't map to each other in the 1O-SM, so that no BB can be located within the three-dimensional Euclidean space (of the geometric-SM).

But apparently, it doesn't mean that the so-called “macroscopic world” (described by the geometric-SM) and the microscopic world (described by the GCoIOPCA) are actually using two different “objective spaces”, or actually using two different physical laws.

Let's call a TM Alan.

From the viewpoint of Alan's IO-observer (who is located outside of the IO-parallel-computing-automaton), in the IO-parallel-computing-automaton, the state of the collection of self-driven BBs evolves as time goes on, with a IO-function to describe this self-driven IO-parallel-computation; as a TM (which is a fuzzy subset of all self-driven BBs) within this IO-parallel-computing-automaton, Alan can't alter/impact the IO-parallel-computation of his self-driven IO-parallel-computing-automaton. To decide the IO-parallel-computation of this IO-parallel-computing-automaton, the IO-function is just enough. (No matter Alan postulates/believes his IO-parallel-computing-automaton to be mathematical or “physical”, as long as the IO-parallel-computation of the state of the BBs follows the IO-function, the activities of these BBs don't have any difference mathematically. No matter Alan has subjective-reality or not, the IO-parallel-computation of the state of the BBs of Alan should follow the IO-function. Otherwise, it simply means that the IO-function need to be revised to reflect the impact of Alan's subjective-reality.)

(Only if the IO-function of Alan's IO-parallel-computing-automaton as a mathematical function has to include the decisions of Alan (i.e., only if there is no way to omit Alan's decisions from the mathematical function), which means that Alan's decisions are not redundant in the mathematical function, we can say that Alan's decisions have

an actual impact to the IO-parallel-computation. In this imagined case, Alan works like God in his IO-parallel-computing-automaton, through his decisions. However, in this imagined case, the BBs of the IO-parallel-computing-automaton are not self-driven anymore, because they are also driven by Alan's decisions.)

(We can add a particular pattern's decisions into the IO-function of Game of Life, but obviously this pattern's decisions can be omitted from the IO-function as a mathematical function. It is impossible to design a cellular automaton which is governed by a IO-function as a mathematical function, and the decisions of a particular pattern cannot be omitted from the mathematical function.)

In Alan's SM of his objective-reality, the IO-function describes the only *actual* mathematical relation among the BBs of Alan's IO-parallel-computing-automaton.

In Alan's IO-SM, the IO-function describes the only *actual* mathematical relation among the geometric objects (within Alan's geometric-SM).

The IO-function is the only causality included in Alan's objective-reality (which is a SM) or Alan's IO-reality (which is another SM); any other causality is not included in either SM. In either SM, with this only causality, everything actually happens (e.g., what Alan actually does) is the IO-function's work; everything actually happens, is only caused by the IO-function and the IO-parallel-computing-automaton's initial state; the IO-function and the IO-parallel-computing-automaton's initial state are the only reasons/causes for everything actually happens.

Using this only causality, either SM evolves in exactly the same way as the 1O-parallel-computation.

In a 1O-parallel-computing-automaton, for each objective-object, its state evolution is a 1O-time-series. The 1O-parallel-computation of each 1O-time-series (as time goes on) follows the 1O-function objectively. The objective (aka 1O) *MM* (aka *mathematical relation*) between any two states on the same 1O-time-series, is the 1O-function. The objective MM between a state on one 1O-time-series, and another state on another 1O-time-series, is the 1O-function. The objective MM between the 1O-parallel-computation of one 1O-time-series, and the 1O-parallel-computation of another 1O-time-series, is the 1O-function.

For a TM, “the 1O-parallel-computation of my 1O-parallel-computing-automaton actually decides my subjective-reality” and “my subjective-reality actually decides the 1O-parallel-computation of my 1O-parallel-computing-automaton” are two SM-candidates. Let’s call them SMC-objective-reality-rules-Positive and SMC-objective-reality-rules-Negative respectively.

SMC-fated-1O-parallel-computation-Positive and SMC-objective-reality-rules-Negative are incompatible.

The “extreme” positions that the subjective-reality of a TM plays no causal role (‘epiphenomenalism’) or that any cognitive/behavioural activity can in principle be carried out without the subjective-reality (‘conscious inessentialism’) are counterintuitive but hard to disprove [45]. These “extreme” positions claim that the subjective-reality of a TM has no function [46], which is correct.

Humans' concept of cause is constructed from experience (e.g. [47]). "Correct" theory of causality can be learned from relatively little evidence, often becoming entrenched before specific causal models are learned [48].

Except the 1O-function which is an objective MM followed by the 1O-parallel-computation of every 1O-time-series, any other MM between the 1O-parallel-computation of one 1O-time-series and the 1O-parallel-computation of another 1O-time-series, is not an objective MM followed by these two 1O-parallel-computations, but only a (subjective) 2O-causality which these two 1O-parallel-computations are modeled/imagined/postulated/supposed to follow, modeled/imagined/postulated/supposed by the control logic of a TM's program. (A 2O-causality is not an objective MM. Except the 1O-function, every other causality used by the control logic of the TM's program, is a 2O-causality. In this sense, every 2O-causality is a self-hypnosis; the TM is being hypnotized by every 2O-causality. Based on the knowledge of a TM, its 2O-causalities should be empirical. A TM's all 2O-causalities as a holistic knowledge of this TM, is decision-oriented.) In this 1O-parallel-computing-automaton, the control logic of the TM's program is emerged, due to the 1O-parallel-computation of the third time series (which follows the 1O-function objectively). In our 2O-SM, it looks like that the 1O-parallel-computation of the third time series uses the 2O-causality between the 1O-parallel-computations of other two time series, and thus the third time series is imagined/defined to be a TM who uses this 2O-causality in the control logic of its program. Or in other words, any third time series which looks like using a 2O-causality between the 1O-parallel-computations of another two time series, is imagined/defined to be a TM who uses this 2O-causality to forecast the 1O-parallel-computation of the second time series based on the 1O-parallel-computation of the first time series. In this sense, if a third time series always happens to be a relay in between another two time series,

this third time series is imagined/defined to be a TM who uses a 2O-causality to forecast the 1O-parallel-computation of the second time series based on the 1O-parallel-computation of the first time series. If this third time series always happens to be a relay in between another two time series, it is due to the 1O-function and the specific local construction of the 1O-parallel-computing-automaton. So, a TM is a specific local construction in the 1O-parallel-computing-automaton which always happens to be a relay in between another two time series, due to the specific construction of the 1O-parallel-computing-automaton. Under this specific construction of the 1O-parallel-computing-automaton, the TM doesn't have 1O-freedom.

A human brain's theory of mind module [53] [54] [55] [56] uses 2O-causalities to reason the inner states of another brain as a SM. Let's call this SM the mind-SM. The mind-SM simulates the situation in the latter brain's subjective-reality, e.g., "the latter brain is scared". The mind-SM is a component of the former brain's 2O-SM. The mind-SM as a MM roughly reflects certain details of the latter brain's objective construction, e.g., the latter brain's amygdala activation. The former brain and the latter brain can be the same brain [57].

A TM's program uses 2O-causalities to forecast the evolution of its geometric-SM, to make a decision. The forecast/decision relies on the TM's 2O-causalities.

At any moment, no matter what 2O-causalities a TM has, these 2O-causalities have no impact to the 1O-parallel-computation of the 1O-parallel-computing-automaton, because these 2O-causalities are decided by the 1O-parallel-computation of the 1O-parallel-computing-automaton; the TM is fated to have/use these 2O-causalities.

If a TM believes that “the state evolution of a BB causes change in the state evolution of another BB”, this belief is a 2O-causality. The concept of “physical interaction” is based on this 2O-causality.

Some 2O-causalities are physical laws. The mathematical relation (of the evolution of the state of BBs) reflected by these physical laws, should have been expressed by the 1O-function already. Otherwise, it means that the 1O-function need to be revised to cover this mathematical relation. In this sense, once I know the 1O-function, all other physical laws are redundant. Or in other words, all other physical laws are derived from the 1O-function.

Every physical law is a fitted model of the 1O-parallel-computing-automaton. Except the physical laws, any other 2O-causality is an under-fitted model of the 1O-parallel-computing-automaton. Except the physical laws, the 1O-parallel-computation of the 1O-parallel-computing-automaton doesn't follow any other 2O-causality, although every TM's program is using its 2O-causalities to forecast the 1O-parallel-computation of the 1O-parallel-computing-automaton.

Using a single mathematical function (i.e., the 1O-function), the 1O-SM is a coherence theory of truth, or in other words, the 1O-SM is not self-contradictory.

As a MM, a 2O-causality might be contradictory to another 2O-causality. Using a set of 2O-causalities, usually a TM's 2O-SM is not a coherence theory of truth, or in other words, usually a TM's 2O-SM is self-contradictory.

An animal's 2O-causalities work as causalities in its brain, due to the objective/physical construction of its brain. For example, in Ivan Pavlov's experiment, a dog learns to salivate whenever the bell rings. To this dog, the causality between the bell and the food is a 2O-causality. This 2O-causality works as a causality in the dog's brain, due to the new neural connections built in the dog's brain during the experiment. More generally, in an animal brain, all its 2O-causalities work in the same way – they have objective constructions, and their work is carried out by their objective constructions. Or in other words, every 2O-causality has its neural underpinning. For example, the pictures of the actress Halle Berry and the letter string "Halle Berry" are somehow connected by a single unit in the right anterior hippocampus [50], which means that this single unit works as a 2O-causality between the letter string "Halle Berry" and her pictures. Similar multimodal neurons also exist in artificial neural networks [51].

The self-driven state evolution of relevant BBs constructs the objective construction of each 2O-causality a TM has, and determines which 2O-causality is being used/discovered by the TM at every moment.

The design of a TM's program is based on 2O-causalities. For example, if a TM's program is designed to play a multiplayer game, this design is based on a 2O-causality "I am playing a multiplayer game, this is my actual situation".

So, when a TM finds itself playing a multiplayer game, this TM should be aware of that "this situation implies

that my program is designed to play this multiplayer game; I find myself playing this multiplayer game, the only reason is that my program is designed to play this multiplayer game; this multiplayer game is designed/imagined/invented by my program as its own setting/pareidolia”.

The program of every vertebrate brain (as a TM) is designed (by Darwinian natural selection) to play a multiplayer game with unlimited number of players/opponents. If we ignore the difference in design between any two vertebrate brains, we can imagine all vertebrate brains (as TMs) to be (inaccurate) clones of one single TM, and then imagine that this single TM is designed to play a multiplayer game with its own clones, while treating its own clones as players/opponents. The program of this single TM is designed to cooperate with some of its own clones, under the designed/imagined/invented settings/pareidolias of this multiplayer game. (The geometric-SM is designed to be the most significant/obvious/explicit setting/pareidolia of this multiplayer game. Under the setting/pareidolia of the geometric-SM, this multiplayer game (let’s call it the three-dimensional-reality-game) is being narrated (by cortical language network) in the same way as a multiplayer virtual reality entertainment system is being narrated.) Then, we can imagine that all these clones (in the Earth ecosystem) are designed to play the same three-dimensional-reality-game together, while each clone is designed to play this three-dimensional-reality-game under the setting/pareidolia of its own geometric-SM. Similarly, we can imagine that two AlphaGo clones are designed to play a (multiplayer) Go game together, while either clone is designed to play a (multiplayer) Go game under the setting/pareidolia of its own internal/subjective Go board. In a three-dimensional-reality-game, a vertebrate brain’s geometric-SM is the counterpart of an AlphaGo clone’s internal/subjective Go board (in a Go game); a vertebrate brain’s geometric-SM has the same function as the AlphaGo’s internal/subjective Go board; the geometric-SM is the “board” of the three-dimensional-reality-game.

To a vertebrate brain, the three-dimensional-reality-game is not just another game to play, but its real-world life; the situation in the three-dimensional-reality-game defines/determines the meaning of its real-world life.

All vertebrate brains are playing the same three-dimensional-reality-game as players. In this three-dimensional-reality-game, each vertebrate brain is being trained (through its geometric-SM) by the experience of itself and others.

Suppose Alan's body decides to move itself, and then Alan's body sees himself moves. So, Alan's body discovers a 2O-causality "my body's movement is caused by my body's decision". Let's call it the body-causality. Actually, the state evolution of every *self-driven* BB in Alan's body, is not *caused* by the decision of Alan body. In contrast, the decision of Alan's body is *determined* by the state evolution of the self-driven BBs.

Based on the use of the body-causality, Alan's 2O-SM treats a geometric object (in Alan's geometric-SM) as a (spatial) carrier called "Alan's body", which moves across the space (within Alan's geometric-SM) upon the decision of itself, like a self-driving car. However, there is no actual (spatial) movement/carrier in Alan's 1O-parallel-computing-automaton.

In case that Alan is a vertebrate brain, Alan's 2O-SM is narrated/simulated as a three-dimensional-reality-game, where each TM is narrated/simulated to be an active player whose objective behavior is unpredictable/uncertain

and not fated, and each player has 1O-freedom to act. The subjective uncertainty of the whole 1O-parallel-computing-automaton is forcedly/counterfactually divided/categorized by Alan's 2O-causalities, to assign/attribute to the narrated/simulated players respectively. Each player represents a category of uncertainty. Based on the current knowledge/ignorance of Alan, the upcoming behavior of each player has a number of possibilities, each possibility is actually a small-scale SM (of Alan) regarding a specific player's future situation. Each small-scale SM is part of the large-scale SM of Alan. The large-scale SM is like a jigsaw puzzle, while each small-scale SM is like a jigsaw piece; within a large-scale SM, any two small-scale SMs should be logically compatible. When Alan is solving this jigsaw puzzle, usually he has to forecast/guess every jigsaw piece one by one, based on his 2O-causalities, while the 1O-parallel-computation of his 1O-parallel-computing-automaton is independent of his current/future 2O-causalities. (In case Alan is a human brain, in Alan's 2O-SM, each player's subjective-reality is represented by a mind-SM respectively, while the simulated situation inside each mind-SM should be compatible with Alan's 2O-causalities. For example, Alan has a mind-SM about another player "this player is angry", and has a 2O-causality "if I keep talking with this player, it's highly possible that this player will argue with me." If Alan makes a decision to stop talking with the player, this decision is compatible with the 2O-causality. Alternatively, if Alan makes a decision to continue talking with the player, this decision is compatible with another 2O-causality "if I keep talking with this player, it's possible that this player will agree with me". No matter which decision Alan will make, Alan is capable to use a 2O-causality to explain the simulated situation inside his own mind-SM. Being part of the 1O-parallel-computation, the decision process is not something different from the 1O-parallel-computation; the decision process is a 2O-processing. So, the decision Alan will make, is fated. During the decision process, among the two contradictory 2O-causalities, which 2O-causality will win, is fated.) In case Alan believes that the 1O-parallel-computation of his 1O-parallel-computing-automaton is *determined* by his current/future 2O-causalities, it's difficult/tricky for Alan to label this belief to be counterfactual.

Actually, Alan's 2O-causalities are determined by the 1O-parallel-computation of his 1O-parallel-computing-automaton.

Suppose Alan encounters a dog. Alan has two small-scale SMs regarding this dog's upcoming behavior -- "the dog will bark at me" and "the dog will not bark". Alan has another two small-scale SMs regarding his own upcoming behavior -- "I will smile to the dog" and "I will not smile". These four small-scale SMs can combine to four different large-scale SMs, e.g., "the dog will bark at me; I will smile to the dog".

Based on his current knowledge/ignorance, Alan can counterfactually/wishfully believe that both himself and this dog have 1O-freedom to actually trigger any of these small-scale SMs or large-scale SMs to happen, which means that either player's objective behavior is not fated, and means that which large-scale SM will actually happen is not fated. I.e., every small-scale SM and large-scale SM has the potential to happen in real world; the exact large-scale SM which will actually happen, is up to the players' (1O-free) objective behaviors.

If we suppose that Alan doesn't have his current ignorance, which means that Alan knows which large-scale SM will actually happen beforehand, then Alan can't counterfactually/wishfully suppose that which large-scale SM will actually happen is not fated, and can't counterfactually/wishfully suppose any player's objective behavior to be not fated. Alan supposes that his 1O-observer doesn't have his current ignorance, that's exactly why his 1O-observer can't counterfactually/wishfully suppose any player's objective behavior to be not fated.

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