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The Self-Simulation Theory: A Computational Theory of Consciousness

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ABSTRACT

The current theories of consciousness do not address the two major problems: What is the solution to the hard problem of consciousness or What is the experience of self-existence? and how is conscious perception computed? We address these questions using our hypothesized theory: The Self Simulation theory and propose a model of computation of consciousness. The components of the model are an interconnected network of auxiliary processors or Auxiliary Neural Networks(AN) which receives input from the external sensory modalities, computes a representation of the information and relays it to the NCC(Neural Correlates of Consciousness), the NCC – a processing unit which can be neuro anatomically distributed in location but computationally connected to each other and to the Auxiliary Networks, and a working memory which the NCC references for further computation of information. Computation of conscious perception is achieved via the decoding of the content of the memory by the NCC. The self-simulation theory accounts not only for the various phenomenal experiences but also experimentation paradigms conducted in the past.

Introduction

Consciousness as stated by Chalmers [1] is anything that we experience, from perceiving the color of red, the depth of thought, smell of a flower, sound of a guitar, pleasure of orgasms to the agony of pain. Over the years many people have tried to explain the phenomenon of consciousness. Descartes gave the homunculus concept, a homunculus viewing contents in a tiny theater in brain [2]. Dennet disapproves of the casting of analyzed data in the "Cartesian theater" in brain and gives the multiple drafts theory [3]. Crick and Koch gave the neurobiological theory of consciousness [4] and also proposed a framework of consciousness [5]. Other theories proposed are the global workspace theory [6], global neuronal workspace theory [7], and recurrent processing theory [8] suggesting the neural correlates of consciousness to be a global neuronal workspace and a local recurrent processing network respectively .Giulio Tononi proposed the Integrated Information Theory [9-10], where a sufficiently complex and integrated information processing network is deemed to be conscious. However, the current theories of consciousness fail to explain the hard problem of consciousness- "How do we perceive an experience? How do we perceive self-existence?" [1] Also they fail to explain the computation behind a conscious experience- "What is the exact mechanism by which an external sensory modality is perceived as a conscious experience?" We resolve to solve the problems stated above by directly targeting the notion of perception.

Marr [11] argued that there are three levels of analysis for every information processing system: Computational: stating the problem to be solved, Algorithmic: giving the algorithm to solve the problem and Implementational: how the algorithm is implemented in the physical hardware of the system. In this paper we aim to address the computational aspect of the information processing required to generate a conscious perception. We propose the existence of a processing unit which can be neuro anatomically distributed in location but computationally connected, which we call the neural correlate of consciousness (NCC).This processing unit will be bidirectionally connected to a working memory, thus giving NCC access to its past state. To tackle the hard problem of consciousness we propose that there is no real perception or experience, rather it's just the format information is stored and processed by NCC. Hence, the perception of self-existence is just a simulation generated by the computation between the NCC and its memory, giving the name: The Self Simulation Theory.

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Presentation of the Hypothesis

Consider that you are deprived of our vision, you will experience a feeling of lack of vision. Similarly if you are deprived of your other sensory modalities one by one, you will experience a feeling of lack of smell, taste, touch, so on and so forth. It has been reported that patients with akinetc mutism, in spite of loss of emotional and goal directed behavior, have an intact level of consciousness [12]. Thus, this suggests that the neural network generating the feeling of consciousness should function independent of the external sensory, emotional and behavioral modalities. Thus, we categorize the existence of the various sensory, emotional, behavioral, attention and cognitive networks to be auxiliary networks to the the network producing sensation of consciousness, also called NCC (Neural Correlates of Consciousness) [13].

Auxiliary Network (AN)

An auxiliary network acts as a bridge between the environment and the NCC. It computes information relayed by various modalities like peripheral sensory receptors, eyes, ears, taste buds and form a representation of the modality for input to the NCC ('f' in (Figure 1). The auxiliary network also comprises of the motor system, which receives input from the NCC and converts it to an executable form ('e' in (Figure 1).

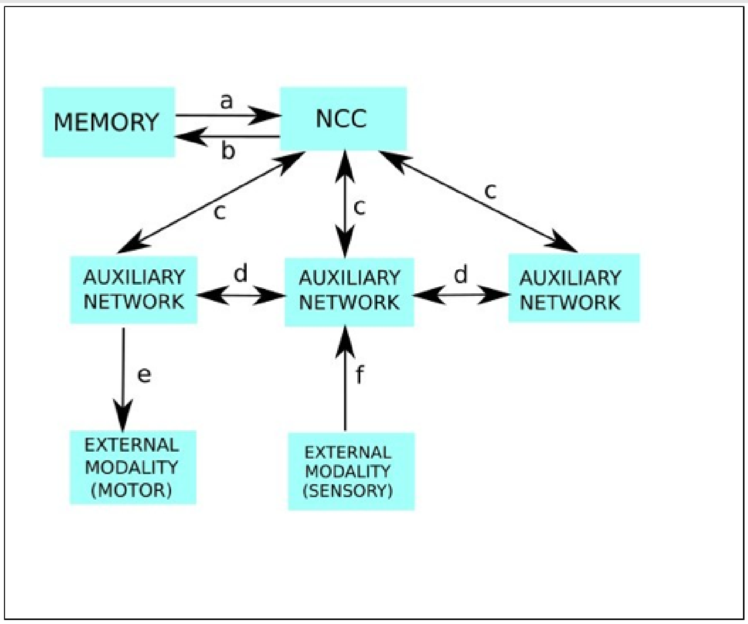

Figure 1: This Figure Demonstrates the Computational Architecture we Hypothesize.

- 'a': Referencing of the stored information by the NCC for further computation and generation of conscious perception.,
- 'b': NCC stores relevant information needed for its next cycle of computation,i e the content of
- consciousness,in its working memory.,
- 'c': Bi-directional information relay between the auxiliary networks and the NCC.,
- d': Information transfer between the various auxiliary networks causing computational integration in a distributed system of auxiliary networks.,
- 'e': Motor response relayed from auxiliary network to the external motor modalities.,
- 'f': Information input from external sensory modality to the auxiliary network layer.

An Auxiliary Network Will Have the Following Properties

The Network Consists of Functionally and Computationally Connected Neural Networks: Consider the topography of the brain to consist of a complex interconnected network of neurons. Over the years there have been a large number of studies in the field of network analysis and cognitive computational neuroscience [14-24] to explore and model various cognitive domains, like attention: visuospatial attention [25-26] endogenous attention network [27] ventral and dorsal attention networks [28], emotion [29], language [30], memory [31], audition [32], sensory motor [33], thought generation [34], so on and so forth. These approaches prove that cognitive neural architecture is a distributed neural network processing that are computationally connected to generate a representation of a cognitive domain. We call these neural architectures as auxiliary networks. These do not generate perception of cognition. They are merely auxiliary to the neural correlates of consciousness (NCC).

The Network Should be Computationally and Neuronally Connected to the NCC: As we have already discussed, the auxiliary networks do not compute conscious perception of cognition. They merely compute a representation of the cognitive domain. Thus, these auxiliary networks are unconscious in nature. The computation of conscious perception is done by NCC. Thus, in order to relay information for integration the auxiliary networks have to be connected both computationally and neuronally to the NCC ('c' in (Figure 1).

The Connection Between AN and NCC Should Be Functionally Bi-Directional: Consider the following thought experiment: You are in a room where there is a table with an apple on top of it. You are seeing the entire scene, including the table, the apple and the room. When you are asked," Do you see an apple?" You will search for it in the room and probably reply that you can see an apple on the table. This is because of visual attention. Here the information of the scenic representation will be integrated by the NCC along with other information inputs from the memory network, language network, attention network, etc. The NCC will direct the visual attention network to shift attention to that of the apple. Then instead of the entire scenic representation, representation of the apple will reach the NCC. Similarly other phenomenological experiences like recursive thought generation, imagination and others consider that there must be bi-directional computation and functionality between the various auxiliary networks and NCC ('c' in (Figure 1).

There can be Multiple ANs, Interconnected with Each Other: Studies have shown that damage to white matter can cause damage to multiple cognitive domains [35]. According to network analysis studies the cognitive domains are interconnected via network architecture [34]. Thus, the various auxiliary networks like visual, auditory, motor and others can be interconnected to compute the various cognitive processes ('d' in (Figure 1).

Neural Correlates of Consciousness (NCC)

The term NCC or Neural correlates of consciousness was introduced by Koch and Crick [4] to explain the specific mechanism or system responsible for the state of consciousness.

Properties of NCC

Performs Information Integration Across Various Auxiliary Networks: NCC helps to answer the binding problem introduced by Damasio [36]. Information relayed by various auxiliary networks will be integrated by the NCC. ('c' in (Figure 1) Then a output command is computed by the NCC to direct the auxiliary network for further computation. ('c' in (Figure 1)).

Performs Discrete Information Processing: NCC integrates information from auxiliary networks in discrete time intervals. In one cycle of computation, NCC takes in information from auxiliary networks and then processes the information for a fixed time period. During this time period the NCC cannot integrate further information from the auxiliary networks.

Possesses an Intrinsic Memory Network: NCC possesses an intrinsic memory network. This memory is a type of working memory. NCC stores information being processed in a single cycle of computation which it deems to be important for integration in the next cycle of computation, in its memory ('b' in (Figure 1)). Due to this property of referencing of previous memory ('a' in (Figure 1)), the connection between the NCC and the memory network is bidirectional in nature. This cycle of computation and referencing the working memory continues infinitely across the temporal dimension.

Computation of Consciousness

Chalmers states that the hard problem of consciousness is to find out why a conscious organism experiences a feeling of self-existence [1]. According to our hypothesis when the NCC performs information integration from various auxiliary inputs, it stores certain important information in its working memory, which needs to be integrated in its next cycle of computation. Now the information being stored is dependent upon the type, content and importance of each auxiliary network which will input the information of the peripheral modalities or external worlds to the NCC. While storing the information in the memory it is stored in the format of self-perception of the information. In other words, the NCC will compute the solution to the problem "If the organism is perceiving the following auxiliary information, what will be the relevant information to be stored in its memory and what will be the response to the perceived information?" To this question, the memory stores the relevant information and response in the format of "The organism is perceiving the information and an action was taken in lieu of it." The NCC, when referencing the working memory for its next cycle of computation can decode the type and content of information stored in the memory due to a predefined notion of what a particular type of information can entail. This decoding of the content of the working memory is what gives rise to the feeling of consciousness. The NCC thus computes a sense of perception of self-existence. There is no predefined area of the brain dedicated to perception of self-existence. Similarly, there is no particular area of brain dedicated to perceive what is to be in a particular cognitive state, I e perception of touch, vision, audition, so on and so forth.

Consider the Following Thought Experiments

1. You are pricked with a thorn in your hand. You will report that you are feeling pain and will move your hand away. The feeling of pain is the feeling of self-existence. Now how is this generated. When you are pricked, the peripheral pain receptors and neurons will relay the information to the auxiliary pain networks ('f1', 'e1' in (Figure 2). The auxiliary networks form a representation of the pain modality. This information is relayed to the NCC ('c1', 'c2', 'c3' in (Figure 2). The NCC computes the solution to the problem "If you are perceiving the information regarding representation of pain what is the most relevant information to be stored in the memory and what is the appropriate response?"

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The memory stores information in the form of "I am feeling the representation of pain and my hand should be withdrawn." ('b' in (Figure 2). Further the NCC directs the auxiliary motor network to withdraw the hand from the site of pain('c4' in (Figure 2).The auxiliary motor network in turn directs the peripheral motor apparatus to withdraw the hand.('e2', 'f2' in (Figure 2). NCC references its memory in the next cycle of computation and decodes the information stored in it.('a' in (Figure 2) Information is interpreted as "I felt a sense of pain and I withdrew my hand in response". Thus, the perception of pain is a result of the computation of the NCC and its memory.

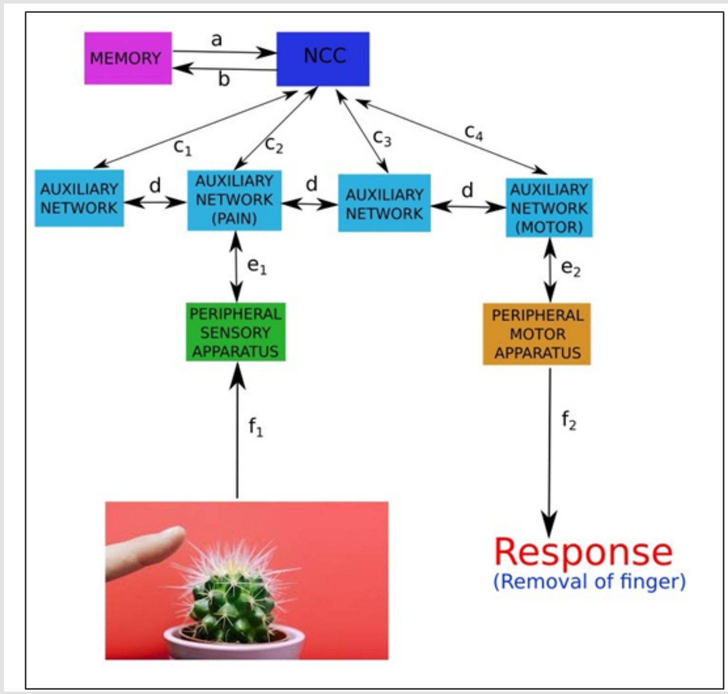

Figure 2: This figure Demonstrates the Computational Framework of a Thought Experiment of Getting Pricked by a Thorn and Withdrawing Hand in Response.

- 'A': The Memory Is Referenced By The NCC In The Subsequent Cycle Of Computation Giving Rise To Conscious Perception,
- 'B': NCC Computes The Content Of Conscious Perception Of Pain And A Response In Lieu Of It And Stores The Content In Its Memory,
- ('C_1','C_2', 'C_3'): Information Regarding Representation Of Pain Is Relayed to the NCC from the Auxiliary Network Layer,
- 'C_4': Information Regarding Response to the Perception of Pain is Relayed From The NCC To The Auxiliary Motor Network,
- 'D': Intercommunication Between The Auxiliary Networks,
- 'E_1': The Information Sent to the Peripheral Pain Apparatus Is Relayed To The Auxiliary Pain Network ,
- 'E_2': Motor Information Is Relayed From The Auxiliary Motor Network To The External Motor Apparatus,
- 'F_1': The Information Conveyed By Prick of Thorn is Relayed to Peripheral Pain Apparatus,
- 'F_2': The External Motor Apparatus Carries Out the Response.

2. There is a rose in front of you. The modal information reaches the visual cortex, where a representation of the rose is computed('f', 'e' in (Figure 3).This information is relayed by the visual auxiliary network to the NCC ('c1','c2', 'c3', 'c4').The NCC computes the solution to the problem, "If you are perceiving the information regarding representation of a rose what is the most relevant information to be stored in the memory and what is the appropriate response?" The memory will store information in the form of "Iam seeing a rose." ('b' in (Figure 3) This information will be decoded by the NCC in the next cycle of computation, giving you the perception of seeing the rose. ('a' in (Figure 3) Thus the perception of seeing the rose or the perception of any other cognitive state is merely a decoding of the content of the working memory by the NCC.

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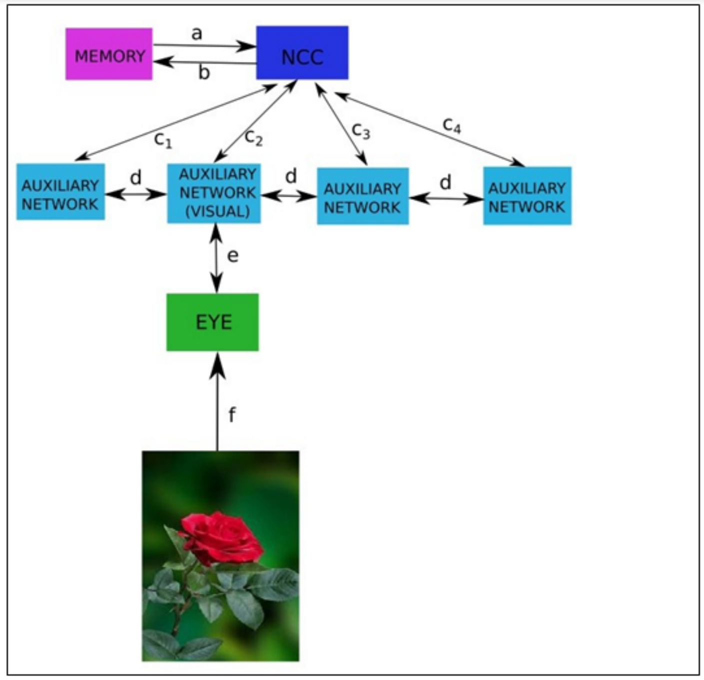

Figure 3: This Figure Demonstrates the Computational Framework of a Thought Experiment of Seeing a rose.

- 'a': The Memory is Referenced by the NCC in the Subsequent Cycle of Computation Giving Rise to Conscious Perception,
- 'b': NCC Computes the Content of Conscious Perception of Pain and a Response in Lieu of it and Stores the Content in its Memory,
- ('c_1', 'c_2', 'c_3', 'c_4'): Information Regarding. Representation of the rose is relayed to the NCC from the auxiliary network layer,
- 'd': Intercommunication Between the Auxiliary Networks,
- 'e': the Information from the eye is Relayed to the Auxiliary Visual Network,
- 'f': the Information Conveyed by the Rose is Relayed to the Eye.

Testing the Hypothesis

In this section we will report studied phenomenal experiences and experimentation paradigms andexplain their causation using our proposed theory. We also report the proposed experimentation and simulations that can be performed to test our hypothesized model.

Slowing Down of Events During Traumatic Incidents

Studies over the years have reported that there is a subjective experience of slowing down of events in traumatic incidents, also known as "bullet time," [37-38]. During a traumatic event there is a state of panic in the brain. There is heightened alertness or attention in the sensory, emotional, motor and other cognitive networks, causing increased computation of the auxiliary networks. Due to this there is an increased influx of information to the NCC for being computed. To compensate for the increased requirements of computational power, the NCC increases its cycle number per unit time. The duration of one computational cycle decreases. Thus, the computation time for an event registered by the memory of NCC will be of much smaller duration than the actual timing of the event in the external reality. In other words, the external environment gets slower relative to NCC. Thus, the external reality will be perceived as a delayed or slowed down event with respect to the internal state of NCC's computation.

Subjective Experience of Time Dilation

Studies have reported incidents of subjective experience of time dilation in boredom and time contraction in cases of having fun [39]. According to various psychological models of time perception like the pacemaker - accumulator model [40] and the attention gate model [41], attention will dictate the number of pulses being transferred from the pacemaker to the accumulator. Greater the the count of pulses stored by the accumulator, the greater will be the perception of time dilation and vice versa [42]. The model we propose is in agreement with the attention gate model. The amount of attention being allocated to time will dictate the computation of the "time" variable by the NCC. The time count will be stored by the NCC in its functional working memory after every cycle of computation, in the form of "I am perceiving the passage of n number of counts." This is decoded by the NCC in its next cycle of computation, giving rise to the perception of passage of time. Normally there is no significant attention being paid to time or its passage in day-to-day life. However, during boredom, there is increased attention being paid to time, due to decreased attention to external cues. This will cause a greater time count to be stored in the working memory of NCC, leading to a perception of time dilation. Thus, There is no real time dilation here, only increased awareness of passage of time. Similarly in cases of having fun, there is decreased attention being paid to time, because of increased attention being paid to the external cue. This will cause decreased time computation by NCC, causing a reduced time count to be stored in its memory and thus leading to a perception of time contraction or "flying" of time. Thus, there is no real time contraction here, only decreased awareness of passage of time.

Working Awareness

Crick and Koch [4] have used "fleeting awareness" to describe a type of transient awareness or attention with a large one time capacity and ability to focus on certain relevant items or features, bound epigenetically or over learned, for further processing. This means that you are not attending to all the things in your visual field. Consider two objects-A and B in your visual field. Information regarding both the objects will be relayed by the peripheral sensory modalities to the auxiliary networks. Information about both object A and B being relayed to the NCC. NCC decides whether object A or Bis important depending upon various auxiliary network inputs-memory, sensory, thought generation, and others. In subsequent cycles of computation, NCC will order the ANs to send more information about the attended object, giving rise to working awareness. The duration of awareness will depend upon the extent of computation of NCC and the incoming information from the auxiliary networks.

Split Brain Phenomenon

Split brain refers to patients in whom the corpus callosum is cut for relieving medically untreatable epilepsy. Studies by Gazzaniga, Sperry and colleagues [43-45] have shown using contra lateral domains like vision and touch, that in a split-brain person, after presentation of an external cue in their left visual field, can point to the cue with their left hand but reports to seeing nothing when asked. There is no known fixed neuro anatomical location of the NCC. NCC may be distributed computationally or neuro anatomically between the two cerebral hemispheres. The visual information from the external cue in the left visual field is processed by the auxiliary visual networks of the right visual cortex (Left visual field to 'c' in (Figure 4). This information is relayed to the NCC in the right cerebral hemisphere. The NCC will compute the response for relaying to the right motor cortex and direct it to point towards the cue('c' to 'b' in (Figure 4)). Since the mortex cortices control contralateral body parts mostly, the left hand will point towards the cue ('b' to Left side response in (Figure 4). However, since the verbal auxiliary network is concentrated in the left hemisphere resulting in no communication between the NCC in the right hemisphere and the verbal network ('c' to 'a' in (Figure 4)). Thus, even though the perception of vision occurs in the right NCC, the verbal network does not receive any information. We propose that both hemispheres have independent NCCs. When they are connected by corpus callosum, they function as a single unit and give rise to a unified consciousness [46-48]. When corpus callosum is cut, they become separated and form two independent conscious entities. In other words, give rise to split consciousness [43-44].

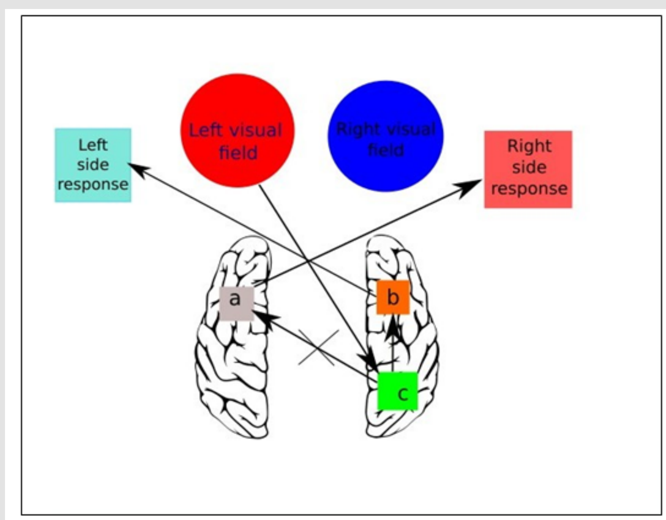

Figure 4: This Figure Demonstrates the Computational Architecture of the Phenomenon of Split Brain.

- 'a': Verbal Auxiliary Network,
- 'b': Right Motor Auxiliary Network,
- 'c': Right Visual Auxiliary Network.

Afferent Signals Do Not Directly Contribute to Conscious Perception of External Modalities

Charles Bonnet syndrome is a syndrome of having visual hallucinations with impairment of vision due to macular degeneration or diabetic retinopathy with old age [49]. Studies have reported auditory hallucinations in deaf individuals [50]. Similarly there have

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been studies reporting retaining of conscious perceptions in setting of stroke or lesion of certain cortices. When sensory afferents do not relay information to the auxiliary networks, these networks can either perform random or erroneous computation of information. Thus, NCC will receive random or erroneous input from the auxiliary networks. Depending upon the type of auxiliary network giving input, the NCC will compute a perception of that cognitive domain. Subjects have reported to see hallucinations of their past memories in Charles Bonnet syndrome. This indicates that the visual auxiliary networks can relay information from the long-term memory networks and perform erroneous or random computation to render information to the NCC. The NCC will perceive the information as an input from the visual auxiliary network and thus compute the perception of vision. In stroke patients, after destruction of some portion of the cortex, they loss some aspect of a sensory modalities or completely loss the modality, yet they remain conscious. Thus, external sensory modalities or even a particular single auxiliary network do not contribute to consciousness. There may be loss of perception of a particular sensation but that does not result in the loss of consciousness.

Efferent Signals Do Not Directly Contribute to Conscious Perception

The locked-in syndrome is a type of disorder in which a person is aware and conscious but are devoid of various efferent systems-speech, facial, limb movements, except for vertical eye movements and blinking [51]. Similarly sleep paralysis is a state of REM paralysis when the person is still conscious and aware of his surroundings [52]. Many patients get paralyzed after stroke in the motor cortex,yet retain their consciousness. The NCC computes the information stream from the auxiliary network to generate a response and the content of conscious perception to be stored in its memory for the next cycle of computation. If the motor auxiliary network is inhibited or compromised, the response computed by the NCC will not get an external representation. But the inability of the motor auxiliary networks cannot affect the computation of NCC. Thus, there is a conscious perception of the external environment in spite of having no efferent connections or motor response.

Blindsight

Blindsight is defined as the ability to possess goal directed behavior towards an external cue in a person with damage to primary visual cortex [53-55]. Information about the external environment is transferred to NCC via various ANs. Studies have reported that the visual pathway mediated by the superior colliculus, the pulvinar and the extra striate visual areas is involved in blindsight circuitry [56]. These neuro anatomical regions may house certain auxiliary networks that can transfer the information to the NCC. Since in these conditions, there is no intact visual auxiliary network to transfer external information to the NCC, there is no perception of vision. However, the incoming information can go to other interconnected networks like thought generation network, memory network, and so forth. The computed information can then go into NCC and can influence the decision by the NCC through an indirect pathway, causing the action of pointing towards the external cue.

Masked Priming Experiments

Studies have presented visual words(prime) masked by nonsense letters for a very brief duration(43ms) so that it cannot be seen but nevertheless facilitates the subsequent processing of shown related words(target). This phenomenon is called masked priming [57]. We can attribute this phenomenon to the impaired information transfer between NCC and the auxiliary networks. Upon seeing the prime, the information is relayed to the visual auxiliary networks, however due to such small duration of presence, the information is considered unimportant for further. processing by the visual AN. Thus, this information is not sent to the NCC. However, the information of prime is still being stored among the auxiliary networks and can influence subsequent information processing of the visual and other ANs. Thus, in the subsequent processing, information about the target thus gets increased importance and is sent to the NCC for conscious perception by the auxiliary networks. So, the prime helps in the subsequent processing of the target though it is not consciously perceived.

Proposed Experimentation Paradigm

We propose certain experimentation paradigms that we deem will be useful in testing our hypothesized theory.

Testing the Discreteness of Information Processing of NCC: In order to determine the discreteness of NCC's information processing we need to conduct simple psychological experiments to estimate the interval of computation of NCC. Information regarding further experimentation will be provided in later papers.

Simulation of the Model: Computer simulations of the proposed model need to be created to estimate its efficacy in reproducing the perception of consciousness and to execute cognitive functions. Once we can simulate the functioning of NCC and its working memory, we will be able to know the content of the memory, I e the content of conscious perception. Monitoring the evolution of conscious perceptions by administering external stimulus to the simulation and simultaneously the actual person will allow us to evaluate the effectiveness of our model and ultimately decode the exact computational algorithm.

Implication of Theory

It is important to mention the various implications or conclusions that we derive about consciousness, its computation and its perception using the self-simulation theory.

Consciousness is the Ability to Perceive Self-Existence

Consciousness as stated by Nagel [58] is to have the experience of being a conscious organism, in other words the perception of self-existence. Even after removal of all external sensory and motor

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modalities there is still a feeling of self-existence and the perception of the lack there of.

Conscious Perception is a Simulation Generated by NCC's Computation

We have already stated that the conscious perception is a result of decoding of the memory's content by the NCC and that there is no such experience of cognitive domains rather the perception is due to the format of information stored in the memory of NCC.

Content of Consciousness is the Content of the Working Memory of NCC

The NCC computes the information incoming from the auxiliary networks and stores relevant information in the memory, for use in its next cycle of computation. This information being stored in the memory of NCC is the content of conscious experience and is decoded by the NCC to generate the perception of consciousness.

Consciousness is Self-Referential and Self-Sustainable

We have already established that conscious perception does not need any afferent or efferent signals to exist. It is a computational product of NCC and its working memory and is thus self-sustainable. Memory is referenced by the NCC for its next cycle of computation to compute a response for the incoming stream of information and is thus self-referential in nature.

Consciousness is Discreetly Computed but Has a Continuous Temporal Distribution

The NCC performs computation in a discrete manner, which means there is a particular time interval for which NCC computes and does not admit further information input from the auxiliary networks. The memory of NCC is updated every cycle of computation resulting in a discrete computation of the contents of consciousness, continuing infinitely across the temporal dimension.

For a System to Be Conscious It Must Have Access to Its Immediate Past State

We propose a basic theory of computation needed to generate consciousness. According to our theory any system which has access to its immediate past state i.e., information about its existence in the past is conscious. The NCC stores information in its working memory in the form of "the organism is perceiving the incoming information". The NCC in its next cycle of computation, decodes the memory content and simulates a conscious perception of the event.

Consciousness is an all or none phenomenon, but its contents can be graded.

We consider consciousness to be a state which either exists or not. However, the content of consciousness is decided by the computation of NCC and the amount of external input it gets. The computation of NCC again depends on the level of activation or complexity of the integrated networks. Thus, simpler systems fulfilling the criteria of consciousness, with lesser integration with other auxiliary networks and lesser network activation, will have a perception that has lesser dimensions in terms of experience.

Conscious Perception cannot be Subjectively Verified or Falsified

The NCC is involved in storing the content of a conscious experience and decoding it to generate the respective conscious perception. We are all having an illusion of the simulation computed by the NCC. We cannot subjectively verify or falsify the claim of having conscious perception, as any conscious perception is a result of NCC's simulation, and we have no way to go around it.

Discussion

We propose in this paper the self-simulation theory, a model that performs cognitive processing and simulates conscious perception of self-existence. The basic architecture of our model is the existence of auxiliary networks, the NCC and working memory for NCC. The auxiliary networks perform computation about information received from the external modalities and relay a representation of it to the NCC. The NCC in turn computes the answer to the question "If the organism is perceiving the representation of the external modality, then what is the necessary information to be stored in its memory and what is the response to the incoming information?" The memory stores information in the format "the organism is perceiving the information computed by NCC." The memory's content is referenced and decoded in the next cycle of NCC's computation, generating the perception of consciousness. Thus, we conclude that conscious perception is a simulation carried out by the computation between NCC and its memory. The Global Workspace Theory of Consciousness [6] (GWT) states that conscious perception involves a wide distribution of focal information to recruit other neural resources for information processing. We refer to this distribution of information processors as a distribution of auxiliary networks, integrated together to perform information processing. GWT suggests the existence of attention codelets, which capture important features from the incoming information and compete for access to global workspace.

This information is stored in a "fleeting" global workspace memory and is broadcast [59]. This broadcasted information is ultimately processed by the distributed network of information processors, giving a cognitive basis to the conscious experience. The Global Neuronal Workspace theory [7] also supports the existence of a global neuronal workspace, which gives rise to conscious perception via broadcasting to certain specialized processors. However, these theories do not answer the questions of "How is the existences of self-perceived?" "What is the NCC?" or "When is an organism conscious?" We suggest the existence of the NCC as a processing unit which can be neuro anatomically distributed in location but computationally connected. The NCC has a working memory referenced as "Global Workspace Memory", which stores the information needed for the next cycle of NCC's computation. The content of NCC's memory is the content of conscious experience and is perceived via decoding of the memory's content in the next cycle of NCC's computation. The Integrated Information Theory [9-10] states that the neural substrates of consciousness is the main complex of neural networks with well-integrated information processing and high Φ value. This conscious experience cannot be altered by altering the external complex of neural networks. However, it does not explain how the conscious perception of self is generated. The NCC is defined as the minimum neural system which directly correlates with states of consciousness [13].

Thus, if we were to keep the NCC in any other state, there would be no conscious state. However if we were to change the network architecture in the main complex or as mentioned by Tononi et al. [6], removing the red sensitive network within the color sensitive network of the main complex, according to IIT there will be an altered state of consciousness, a weaker perception of blue. Thus, IIT proposes that consciousness is graded and that greater the information integration or Φ more conscious it is. We propose consciousness to be a perception of self and the content of consciousness as a product of information computation. If a system does not have the proposed computationally connected network, the NCC, there will be no state of self-existence, thus there will be no state of consciousness. IIT proposes that any system, natural or artificial, with a high level of information integration can be conscious. However, it does not specify a cut off value of Φ, the measure of information integration. We propose that for a system to be conscious it should have access to its immediate past state, thus must have a functional bi-directionally connected memory. The Recurrent Processing Theory [8] proposes the presence of feed forward processing under attentional influence, a localized recurrent processing unit and a widespread recurrent processing unit of information. The localized recurrent processing of information is proposed to be the Neural Correlate of Consciousness (NCC). However, this theory fails to answer the questions of origin of the perception of self-existence and also the respective response generated to the incoming information from the external modalities.

There is no mention of any memory of NCC also. Our model holds that there will be recurrent connections between the NCC and the auxiliary networks, as well as between the auxiliary networks. However, we also provide the existence of a memory of the NCC, which transiently stores the content of a conscious perception, and is referenced and decoded by the NCC to generate the perception of consciousness or self-existence. Response is computed by the NCC to the respective information received from the ANs and sent downstream to the other auxiliary networks for further processing. Crick and Koch have given a neurobiological theory of consciousness [4]. They suggested that a "working awareness" or conscious percept is formed by binding relevant neurons, selected by attentional mechanism, together by synchronization of their activity in 40 Hz oscillations. They also introduce a "binding problem" consisting of neurons that are computationally connected with an unlimited, maybe time limited, capacity to store information for a short period of time. The elements required for binding are proposed to be stored into a short-term working memory. In their paper "A framework for consciousness" [5], they mention the existence of "penumbra", which they define as an unconscious seat consisting of past states of NCC's neurons, expected consequences and movements computed by NCC. Also, the penumbra neurons may project back to the NCC to support it. This short-term working memory and penumbra referenced directly correlates with our proposed model of the working memory of the NCC.

The working memory is bi-directionally connected to the NCC and stores the information computed by the NCC in each cycle of its computation. The content of the memory is also the content of the conscious perception. Even though the memory is unconscious in nature, the decoding and referencing of the contents of memory by the NCC gives rise to conscious perceptions. Finally, we come to the discussion of the hard problem of consciousness. 1. Have we solved it? Not entirely. Do we think it is relevant? Not entirely. We provide a basic model of how consciousness can be computed, how conscious perception is nothing, but a simulation generated by the NCC and when we can call a system conscious. We propose that information computed by the NCC is stored in the memory in the format of "the organism is perceiving a particular cognitive domain". Thus we do not think that someone or something is experiencing any self-existence, it's just the way the memory stores the information and the NCC decodes it to generate an illusion of self-existence or conscious perception, giving the name of the proposed theory: The Self Simulation Theory. There have been efforts in the domain of neuro imaging and cognitive science to find out which neuroanatomical regions or circuits are responsible for being the NCC. Studies have studied cortical activation patterns under altered states of consciousness-anesthesia [60], sleep [61] and others. Network analysis studies have suggested the existence of cortical hubs, which are areas of highest network connectivity.

These hubs have been reported to be interconnected and linked to a particular core network, which when studied revealed to have similar components to that of the default mode network of brain [62-63]. Also, the default mode network has been shown to have reduced connectivity under anesthesia [60], supporting the claim of its plausible involvement in conscious perception. However, in order to understand the computational framework of NCC, the neural architecture of the brain needs to be simulated. Brain neuronal simulations being carried out by École Polytechnique fédérale de Lausanne (EPFL), Switzerland under Blue Brain Project of the Swiss Brain Research Initiative [64], aim to simulate the human brain neural architecture to understand neural network functions and explain various neurobiological phenomenon [65-66]. Perhaps after simulation of the entire neural architecture the exact mechanism of computation of consciousness will be clear and our model can be validated.

References

1. Chalmers David (1995) Facing up to the problem of consciousness. Journal of Consciousness Studies 2(3): 200-219.
2. Donaldson IM (2009) The Treatise of man (De homine) by René Descartes. The journal of the Royal College of Physicians of Edinburgh 39(4): 375-376.
3. Dennett DC (1991) Consciousness Explained, Boston and New York: Little Brown.
4. Crick Francis, Christof Koch (1990) “Towards a Neurobiological Theory of Consciousness.” Seminars in the Neurosciences 2: 263-275.
5. Crick F, Koch C (2003) A framework for consciousness. Nature neuroscience 6(2): 119-474.
6. Baars BJ (1988) A Cognitive Theory of Consciousness, Cambridge University Press.
7. Dehaene S, Kerszberg M, Changeux JP (1998) A neuronal model of a global workspace in effortful cognitive tasks. Proceedings of the National Academy of Sciences of the United States of America 95(24): 14529-14534.
8. Lamme VA (2004) Separate neural definitions of visual consciousness and visual attention, a case for phenomenal awareness. Neural networks: the official journal of the International Neural Network Society 17(5-6): 861-872.
9. Tononi G (2004) An information integration theory of consciousness. BMC neuroscience 5: 42.
10. Oizumi M, Albantakis L, Tononi G (2014) From the phenomenology to the mechanisms of consciousness: Integrated Information Theory 3.0. PLOS computational biology 10(5): e1003588.
11. Marr D (1982) Vision: A computational investigation into the human representation and processing of visual information. San Francisco CA: WH Freeman.
12. Arnts H, van Erp WS, Lavrijsen J, van Gaal S, Groenewegen HJ, et al. (2020) On the pathophysiology and treatment of akinetic mutism. Neuroscience and biobehavioral reviews 112: 270-278.
13. Chalmers David J (2000) What is a neural correlate of consciousness? In: Thomas Metzinger (Edt.)., Neural Correlates of Consciousness. MIT Press, p. 17-39.
14. Xu L, Zhang H, Hui M, Long Z, Jin Z, et al. (2014) Dynamic reconfiguration of human brain networks during learning. Neuroscience 261: 7641-7646.
15. Nagano-Saito A, Martinu K, Monchi O (2014) Function of basal ganglia in bridging cognitive and motor modules to perform an action. Frontiers in neuroscience 8: 187.
16. Ma S, Calhoun VD, Eichele T, Du W, Adalı T (2012) Modulations of functional connectivity in the healthy and schizophrenia groups during task and rest. NeuroImage 62(3): 1694-1704.
17. Palva JM, Monto S, Kulashekhar S, Palva S (2010) Neuronal synchrony reveals working memory networks and predicts individual memory capacity. Proceedings of the National Academy of Sciences of the United States of America 107(16): 7580-7585.
18. Stevens AA, Tappon SC, Garg A, Fair DA (2012) Functional brain network modularity captures inter- and intra-individual variation in working memory capacity. PloS one 7(1): e30468.
19. Heitger MH, Ronsse R, Dhollander T, Dupont P, Caeyenberghs K, et al. (2012) Motor learning-induced changes in functional brain connectivity as revealed by means of graph-theoretical network analysis. NeuroImage 61(3): 633-650.
20. Bassett DS, Yang M, Wymbs NF, Grafton ST (2015) Learning-induced autonomy of sensorimotor systems. Nature neuroscience 18(5): 744-751.
21. Kinnison J, Padmala S, Choi JM, Pessoa L (2012) Network analysis reveals increased integration during emotional and motivational processing. The Journal of neuroscience: the official journal of the Society for Neuroscience 32(24): 8361-8372.
22. Muller AM, Meyer M (2014) Language in the brain at rest: new insights from resting state data and graph theoretical analysis. Frontiers in human neuroscience 8: 228.
23. Parks EL, Madden DJ (2013) Brain connectivity and visual attention. Brain connectivity 3(4): 317-338.
24. Kriegeskorte N, Douglas PK (2018) Cognitive computational neuroscience. Nature neuroscience 21(9): 1148-1160.
25. Thiebaut de Schotten M, Dell'Acqua F, Forkel S, Andrew Simmons, Francesco Vergani, et al. (2011) A Lateralized Brain Network for Visuo-Spatial Attention. Nat Prec.
26. Zhao J, Wang J, Huang C, Liang P (2022) Involvement of the dorsal and ventral attention networks in visual attention span. Human brain mapping 43(6): 1941-1954.
27. Sani I, Stemmann H, Caron B, Daniel Bullock, Torsten Stemmler, et al. (2021) The human endogenous attentional control network includes a ventro-temporal cortical node. Nat Commun 12: 360.
28. Vossel S, Geng JJ, Fink GR (2014) Dorsal and ventral attention systems: distinct neural circuits but collaborative roles. The Neuroscientist: a review journal bringing neurobiology neurology and psychiatry 20(2): 150-159.
29. Pessoa L (2017) A Network Model of the Emotional Brain. Trends in cognitive sciences 21(5): 357-371.
30. Friederici AD, Gierhan SM (2013) The language networks. Current opinion in neurobiology 23(2): 250-254.
31. Jeong W, Chung CK, Kim JS (2015) Episodic memory in aspects of large-scale brain networks. Frontiers in human neuroscience 9: 454.
32. Horwitz B, Braun AR (2004) Brain network interactions in auditory, visual and linguistic processing. Brain and language 89(2): 377-384.
33. Chenji S, Jha S, Lee D, Brown M, Seres P, et al. (2016) Investigating Default Mode and Sensorimotor Network Connectivity in Amyotrophic Lateral Sclerosis. PloS one 11(6): e0157443.
34. Medaglia JD, Lynall ME, Bassett DS (2015) Cognitive network neuroscience. Journal of cognitive neuroscience 27(8): 1471-1491.
35. Silver JM, McAllister TW, Arciniegas DB (2009) Depression and cognitive complaints following mild traumatic brain injury. The American journal of psychiatry 166(6): 653-661.
36. Damasio AR (1989) Time-locked multiregional retroactivation: a systems-level proposal for the neural substrates of recall and recognition. Cognition 33(1-2): 25-62.
37. Noyes R Jr, Kletti R (1976) Depersonalization in the face of life-threatening danger: a description. Psychiatry 39(1): 19-27.
38. Bedard-Gilligan M, Zoellner LA (2012) Dissociation and memory fragmentation in post-traumatic stress disorder: an evaluation of the dissociative encoding hypothesis. Memory (Hove,England) 20(3): 277-299.
39. New JJ, Scholl BJ (2009) Subjective time dilation: spatially local, object-based, or a global visual experience? Journal of vision 9(2): 1-11.
40. Gibbon J, Church RM, Meck WH (1984) Scalar timing in memory. Annals of the New York Academy of Sciences 423: 52-77.

41. Block RA, Zakay D (1997) Prospective and retrospective duration judgments: A meta- analytic review. Psychonomic bulletin & review 4(2): 184-197.
42. Polti I, Martin B, van Wassenhove V (2018) The effect of attention and working memory on the estimation of elapsed time. Sci Rep 8: 6690.
43. Gazzaniga MS, Bogen JE, Sperry RW (1963) Laterality effects in somesthesis following cerebral commissurotomy in man. Neuropsychologia 1(3): 209-215.
44. GAZZANIGA MS, BOGEN JE, SPERRY RW (1962) Some functional effects of sectioning the cerebral commissures in man. Proceedings of the National Academy of Sciences of the United States of America 48(10): 1765-1769.
45. Sperry RW (1968) Hemisphere deconnection and unity in conscious awareness. The American psychologist 23(10): 723-733.
46. Bayne T (2008) The unity of consciousness and the split-brain syndrome. The Journal of Philosophy 105(6): 277-300.
47. Bayne T (2010) The unity of consciousness. Oxford: Oxford University Press.
48. Bayne T, Chalmers DJ (2003) What is the unity of consciousness? In: Cleeremans A (Edt.)., The unity of consciousness: Binding, integration and dissociation. Oxford England: Oxford University press, p. 23-58.
49. Jackson ML, Ferencz J (2009) Cases: Charles Bonnet syndrome: visual loss and hallucinations. CMAJ: Canadian Medical Association journal=journal de l'Association medicale Canadienne 181(3-4): 175-176.
50. Atkinson JR (2006) The perceptual characteristics of voice-hallucinations in deaf people: insights into the nature of subvocal thought and sensory feedback loops. Schizophrenia bulletin 32(4): 701-708.
51. Laureys S, Pellas F, Van Eeckhout P, Ghorbel S, Schnakers C, et al. (2005) The locked-in syndrome: what is it like to be conscious but paralyzed and voiceless? Progress in brain research 150: 495-511.
52. Farooq M, Anjum F (2021) Sleep Paralysis. In Stat Pearls Stat Pearls Publishing.
53. PÖPPEL E, HELD R, FROST D (1973) Residual Visual Function after Brain Wounds involving the Central Visual Pathways in Man. Nature 243: 295-296.
54. MD Sanders, Elizabeth K Warrington, John Marshall, L Wieskrantz (1974) "BLINDSIGHT": VISION IN A FIELD DEFECT, The Lancet 303(7860): 707-708.
55. L Weiskrantz, Elizabeth k warrington, MD Sanders, J Marshall (1974) Visual capacity in the hemianopic field following a restricted occipital ablation brain. 97(1): 709-728.
56. Kinoshita M, Kato R, Isa K, Kenta Kobayashi, Kazuto Kobayashi, et al. (2019) Dissecting the circuit for blindsight to reveal the critical role of pulvinar and superior colliculus. Nat Commun 10: 135.
57. Dehaene S, Naccache L, Le Clec'H G, Koechlin E, Mueller M, et al. (1998) Imaging unconscious semantic priming. Nature 395(6702): 597-600.
58. Nagel T (1974) What is it like to be a bat? Philosophical Review 4: 435-450.
59. Baars BJ, Franklin S (2003) How conscious experience and working memory interact. Trends in cognitive sciences 7(4): 166-172.
60. Deshpande G, Kerssens C, Sebel PS, Hu X (2010) Altered local coherence in the default mode network due to sevoflurane anesthesia. Brain research 1318: 110-121.
61. Nir Y, Massimini M, Boly M, Tononi G (2013) Sleep and Consciousness. In: Cavanna A, Nani A, Blumenfeld H, Laureys S (Eds.)., Neuroimaging of Consciousness. Springer Berlin Heidelberg.
62. Buckner RL, Andrews-Hanna JR, Schacter DL (2008) The brain's default network: anatomy, function, and relevance to disease. Annals of the New York Academy of Sciences 1124: 1-38.
63. Gusnard DA, Raichle ME, Raichle ME (2001) Searching for a baseline: functional imaging and the resting human brain. Nature reviews Neuroscience 2(10): 685-694.
64. Markram H (2006) The Blue Brain Project. Nat Rev Neurosci 7: 153-160.
65. Libet B, Gleason CA, Wright EW, Pearl DK (1983) Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act. Brain: a journal of neurology 106(Pt 3): 623-642.
66. Beaty RE, Benedek M, Silvia PJ, Schacter DL (2016) Creative Cognition and Brain Network Dynamics. Trends in cognitive sciences 20(2): 87-95.

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