

Creativity and Creative Innovation: Evidences of Cognitive Functions During Creativity with Reference to Machine Cognition*

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Abstract

Creativity is considered as the human ability of generating novel thoughts or ideas, it is a mental journey between ideas or concepts which includes the novel route and results as novel outcome. Human creativity is based on high-level (convergent/conscious) as well as low-level (divergent/unconscious) cognitive processes, these processes are determined by complex information processing systems and are influenced by emotional and motivational regulatory subsystems. Current research on creativity in agency shows that both conscious and unconscious idea generation plays vital role to artificially develop the creative behavior. This paper highlights cognitive processes and their involvement in development of a novel outcome, which provides support to the remarks on creativity with reference to machine cognition. It will also help us to throw light on importance and power of idea generation in agency and its usefulness to boost up the process of creativity.

Keywords:

Cognitive Science, Creativity, Consciousness, Unconscious.

1. Introduction

Scientifically, cognition represents all mental abilities and processes related to knowledge, memories, attention, decision making, problem solving and computations. From human's perspective, human cognition could be conscious and unconscious, abstract or concrete, intuitive (like having knowledge of something) or conceptual (conceptual models). Cognitive processes evolve and generate new knowledge from the existing one, these processes can be analyzed in different perspectives like in the field of philosophy, psychology, neurosciences, biologically and computer sciences [1]. Psychology and Philosophy explains cognition in terms of mind intellect, which involves the mental processes (unit of thoughts), mental functions and states of intelligent entities which includes, human, collaborative groups, artificial intelligence and highly autonomous machines [2].

Cognitive architectures are inspired by the functional mechanism of human brain, and various proposed models tries to define necessary modules to elaborate the complex interaction among memories, learning modules and perception, and action execution [3]. Psychologists have been puzzling over the working of human mind and its

modeling from centuries. They are trying to find out best suitable method for modeling the human cognition, from which they find computers to simulate human cognition and behavior by writing the software code, by using the programming languages they can develop procedures and functions which perform as human does [4].

It is a great challenge to be able to integrate all complex cognitive processes in a single architecture like language processing, emotions, abstract thoughts and creativity. The major difficulty that one faces in the representation of these cognitive process is to manage the inner representation of the outer world, and ability to continuously update these module by interacting with the external world. So, in this context it must be taken in to consideration that new upcoming models on neuro-biological mechanism of human mind must be able to represent the highest level of cognitive functions and vice versa [5]. As Yoshua proposed that new models of classification and learning such as deep learning could solve these issues in future, and their contribution in cognitive architectures can reduce the gap between high level and low level modules [6].

From machine perspective, machine consciousness is broader and almost a new research area and highly cross disciplinary, which takes elements from computer science, psychology, philosophy and neuroscience. The basic hurdle in the research of consciousness is that there is not a single point of view of researchers and practitioners on consciousness. For systematically analyzing about the machine consciousness, philosophical aspects about consciousness must be taken into consideration to clarify the concept of machine consciousness [7]. The major question in the study of philosophy is that either the physical or the phenomenal objects are same or they are different? For the explanation of this question some metaphysical theories and philosophical aspects must be taken into consideration.

2. Philosophical Perspective of Mind

In philosophy, philosophers deals with the study about the nature of human mind, according to them human's mental

phenomenon (mind) are different from its physical (body) aspects. Two major schools of thoughts in mind body problem are Dualism and Monism. Human beings have both physical and mental properties, physical properties are considered as tangible properties whereas mental properties which are not credited with physical object include, perception, emotions, intentions and motivations and these properties are possessed by self or subjectivity. Materialist belief that there are only physical states, physicalists argues that mental processes are expressed in term of single reality substance i.e. through physical theory. In contrast to this dualism sets point of view regarding the relationship between mind and matter (body) and explains that mental phenomenon's are non-physical. Still the best recognized version of dualism was proposed by Ron Descartes according to which mind is a non-physical, non-extended substance, also to distinguish mind from brain Descartes clearly identify that human mind possessed with consciousness and self-awareness [8]. So there are various ways to divide dualism into its different kinds so as to make the clear distinction between both schools of thoughts.

2.1. Interactionist Dualism

This branch of dualism considered the phenomenal world as entirely different thinking substance and states that it is totally different from the physical world [9]. It argues that our physical brain takes data through senses, pass it to the thinking substance (mind), where it becomes conscious, this thinking substance decided upon what action has to be taken on the given data and gives result back to the physical substance that will generate the motor response. This theory makes the clear distinction between conscious and unconscious representations [7].

2.2. Epiphenomenalism

According to this theory, physical events play role in the causation of mental events, but both do not causal influence on each other [10]. For example, if a person hurts or got some injury (burn) then physical realm generates stream of events one after the other until the movement of the muscle, due to this activities in the mental realm will be triggered as a result of some events in the physical brain

2.3. Parallelism

Parallelists considered that both realms (conscious/unconscious) works parallel although these have distinct ontological status, and it seems like both influence each other but these two realms don't have causal influence on each other, i.e. mind events causally influence only mind events whereas brain events only causally influence brain events [10].

3. Existing Cognitive Architectures

Above mentioned metaphysical theories clearly give evidences for the existence of unconscious regime and its interaction with the conscious mind. Machine consciousness is a related field of artificial intelligence and cognitive robotics, aim of this artificial consciousness concept is to find out cognitive correlates of consciousness (like memories, learning and experience) which have to be engaged in an artificially developed artifact. In same way we can find numerous cognitive architectures from the literature that gives support to these metaphysical theories about dualism and to machine cognition [11][7].

3.1. IDA (Intelligent Distributed Agent)

IDA is basically a conceptual and computational cognitive model designed by Stan Franklin which is implemented as a software agent. It was developed for US Navy, and it completely automates the working of Navy's personal agents (detailers). IDA is conscious software agents, which includes the modules like perception, action selection, working memory, associative memory, emotions, Meta cognition system and learning mechanisms. The idea of author was twofold: due to which author replicates human cognition and additionally includes modules of human consciousness according to global work space theory [12]. In global work space theory the author Bars hypothesizes that human cognitive processes are implemented by small processes, which are always unconscious [13].

3.2. Learning Intelligent Distributed Agent (LIDA)

Every AGI agent aiming to have human level intelligence must be capable of following the theory of mind. Cognitive model LIDA is derived from the Global work space theory, based on theories of psychology, neurosciences and cognitive sciences. This model explains that how theory of mind is accomplished in both human and animals and how it could be implemented computationally. Its architectural design implements sensory memory, sensory memory, declarative memory, perceptual associative memory and workspace as cognitive component, which ensures that LIDA has cognitive association with consciousness [14].

3.3. DUAL:

DUAL is a hybrid general purpose cognitive architecture gives the description of mental representation, memory management and processing mechanism. This architecture was designed by taking inspiration from idea given by Marvin Minsky on Society of Mind. Dual is hybrid in two ways from one aspect it makes the distinction between connectionist/symbolic and integration between them,

whereas on the other hand it makes distinction between procedural/declarative and integration between them. The basic functional unit of DUAL is DUAL agent. The architectural principle of DUAL is that larger structures develop from the interaction of smaller structures [15].

3.4. CLARION (Connectionist Learning with Adaptive Rule Induction Online)

This architecture was proposed by Ron Sun [16], it is also a dual mode architecture that handles both implicit and explicit type of knowledge and makes a clear distinction between implicit and explicit set of processes. By focusing on these processes this architecture could be used to simulate many tasks in cognitive and social psychology. This architecture clearly follows the concept of phenomenal consciousness.

4. Creativity And Intelligence

Creativity is the component of human intelligence, it is a complex high level cognitive mechanism of associative analogy, and its composition strongly dependent on some evaluation processes, if this component get introduce in cognitive architectures then it may provide the way to investigate new solutions or improvements.

In past decades, the main focus of artificial intelligence is toward learning, action selection and knowledge management but the part of dynamic interaction with the outer world got ignored specially in case of social interaction. Agnese Augello proposes the framework and its evaluation processes for the development of computational creative agent, the agent is embodied in the PSI cognitive architecture, and its creative processes are triggered and planned by a motivation parameter, depending by the desires of the agent. The system exploits an internal and an external evaluation. The internal evaluation depends on the technical ability of the agent in realizing the artwork, and it influences its Competence. The external evaluation is carried on a natural language interaction between the artist and the users. The aim is to find out how to maintain a motivation high enough, to enable the creative processes [17].

Numerous researchers have used creativity in their work either explicitly or implicitly as a significant component of intelligence, there are also theories which elaborate creativity as a subcategory of intelligence, as Multiple Theory of Intelligence (MIT) is represented by Gardner includes creativity implicitly as a set of intelligence, in his theory Gardner cited different example of famous creators like Einstein (logical-mathematical), Picasso (spatial intellect) and Freud (inter-personal) [18]. Sternberg proposed a theory named as Theory of multiple

Intelligence is encompasses of three sub theories Analytic, Contextual (Practical) and Creative (Experiential) which include creativity as a main component. Experiential sub theory is directly related to creativity and using the notion of using the existing knowledge and skill for solving the new problem [19]. The Dual Process Theory of intelligence consists of two types: Type 1 is related to conscious regime and is concerned with goal directed thoughts (also known as convergent thoughts), whereas Type 2 is related to unconscious process and is concerned with daydreaming, implicit learning and spontaneous cognitive ability, Kaufman argues that both Types of processes work together to attain creativity [20].

5. Psychological, Neuroscientist And Computational Perspective Of Creativity

Thoughtful neuroscientists are investigating what actually happens in human brain during the creative process, their findings overturn the conventional ways. Latest neuroscientific findings suggest that only distinction between left right brain doesn't elaborate the whole picture of creative process in human brain, as creativity doesn't involve the single brain region, the entire process consists of interactive cognitive processes (of both conscious and unconscious) and emotions, work together to perform the creative task. Three large scale networks of human brain are difficult to understand the neuroscience of creativity. These are

5.1. Attention Network

This network is engaged when the task to be performed requires focused attention, and attention mechanism become active when brain is trying to concentrate on complex problem solving and decision making. This neural network involves efficient and reliable communication between outer and internal regions of prefrontal cortex.

5.2. Imagination Network

According to Randy Buckner, imagination network involves in constructing dynamic mental simulations on the basis of past experiences, it also involves social cognition, and e.g. when we are imagining about someone that what he/she is thinking at times then this network becomes active. Imagination network includes deep areas inside the prefrontal cortex and temporal lobe, also have communication among internal and external regions of parietal cortex.

5.3. Saliency Network

This network continuously monitors both external and internal stream of consciousness and flexibly passing the salient information from one brain region to another to solve the problem at hand [21].

6. Creative Innovation

Creativity is a phenomenon in which something new and valuable is being into existence, this created outcome could be tangible or intangible too, like it could be in the form of any idea, musical composition, artwork and invention. Scholarly interest in creativity has defined it in many ways according to different concepts and correlates of varied domains like, psychology, physiology, economics, sociology, cognition, and according to technology, in order to elaborate its application and to improve the effectiveness of learning, as there is not a single aspect of creativity as different researchers gave their point of view from Convergent and Divergent perspective of creativity in their respective work. The presence of two stages of creativity revealed a widely accepted point of view that there are two forms of thoughts, first one is intuitive mode (divergent idea generation) which shows that there are remote association between cognitive correlates but not necessarily casually related to one another, this provides the solution to the problem though this idea generation is vague, spontaneous and in unpolished form. Second form of idea generation is more focused and advantageous to analyze the cause and effect relation, one could work out in this mode on logistics of solution with existing knowledge and artifacts and convert it into more presentable form [22]. Knowledge and skill is required to a person to be creative, many psychologists assume that intelligence is the measure of individual's capability to gain knowledge and skill which permit them to adapt according to the environment. The ability to understand express and develop orderly new relations in a systematic way is said to be creativity, thus for this purpose there must be the communication between different brain modules. The strongest proof about brain modules is hemispheric specialization, left hemisphere is dominant for language processing, motor skill movement and categorical processing, whereas right hemisphere is important for spatial cognition (including spatial imagery, coordinates coding and face recognition) not only this, right hemisphere plays important role in emotional communication and might be dominant for mediation of primary emotions. Left hemisphere has focused attentional perspective whereas right hemisphere has global attentional perspective, similarly there are many left-right brain dichotomies have been described by researchers [6].



7. Conclusion

From the above discussion and evidences from literature about creativity, on basis of some existing cognitive architectures and metaphysical theories, it is concluded that these indications not only provide the basis for the existence of conscious and unconscious regime (phenomenal and physical) also plays an important role for the development of scientific theory, therefore a working metaphysical theory as a part of cognitive domain is required for the development of conscious machine. Also, the review on existing cognitive architectures suggests that machines could only be conscious, so most of the these models caters the part of consciousness and tries to completely address the correlates of consciousness, from implementation point of view most of these architectures follow neural, functional and cognitive correlates of consciousness. In spite of all of this discussion it is worth mentioning that these architectures play a distinct role to expand the research in the field of cybernetics, cognitive science and machine cognition and provides the road towards the computational creativity.

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