



Exaptation Theory of Mind

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Theory of mind is the ability to understand situations and achieve reality in the past, present, and future in himself and others.

(Meysam Iranpanah - 2020)

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Introduction

Exaptation was first proposed by Elisabeth Vrba and her colleague Stephen Jay Gould based on Charles Darwin's research on genetic characters resulted from evolutionary adaptability. Their work indicated that the origin of a genetic character does not always reflect the contemporary functions. Evolutionary adaptability might lead to acquiring new functions and may probably help the species to achieve a different goal during evolution process. Exaptation represents a function shift of either an organ or behavior which differs from the initial and original reason of its existence. Bird wings are an example, what do you think the function of feathers is?

The initial functions are maintaining balance and regulating temperature but later were adapted for flight in some birds as an exaptation which might carry higher values and efficiency than balance maintenance and temperature regulation in my point of view. Exaptation is one of the most controversial terms and it is difficult or sometimes next to impossible to determine whether a particular function is due to evolutionary adaptability or exaptation especially in more complex systems of life like human beings but crucially affects interpreting, predicting and mind engineering of a subject.

Accordingly, and considering my major and personal interest in exploring research, I have undertaken a project under the title of "HEP" standing for Human Exaptation Project and this book is the first attempt of HEP to take first steps of defining exaptation in realm of Cognitive Science. To begin, I selected Theory of Mind which is a matter of great importance in designing smart systems, changing/alerting attitudes in education, and defining the concept of human. I do believe that social function of Theory of Mind has undergone exaptation and its function adaptability lasts in our genetic coding system which is a more beneficial function than the social one.

The first chapter is a brief review of available data called "Present Reality" and the outcomes of the research are concisely presented. The second chapter named "Pretend" explores the causes and other functions and finally the third chapter called "Desired Reality" studies its effects on different fields of mind and brain.

HEP project will reveal potentials of interpreting, predicting and mind engineering particularly for human subjects by hopefully being globally sponsored.

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2020

Present Reality

Understanding present reality of Theory of Mind and what we have gone through is a matter of great importance particularly in understanding the goal we are pursuing. The term "Theory of Mind" first appeared in research in 1978 by Premack and Woodruff's question of "Does the chimpanzee have a theory of mind?". These two primatologists defined theory of mind as one's ability to impute mental state to himself and others. The term was later applied by child psychologist like Alan M. Leslie to evaluate development of Perspective-taking in 1987.

Since then, the term has been used in psychological pathology as schizophrenia, in cognitive neuroscience as social cognition, and in autism disorders, as mind-blindness and confusion theory.

So far, theory of mind has been the most effective ability of a human being to establish social interactions, and has caused cognitive neuroscience to create new and fascinating fields for neuroscientists under the title of social brain. theory of mind is also referred to by other terms, such as mentalizing, mind reading, social cognition, and etc.

This field has been studied through various sciences and attitudes by different point of views. For example, in cognitive neuroscience and mind philosophy in which mental state is hypothetical, it is compatible with thinking and feeling, and consist of mental representations and propositional attitudes. Explanation theory of mind function is usually examined by desires, emotions, intentions, beliefs, knowledge and so on, as mental states.

There are three approaches regarding explanation of theory of mind function: module theories, theory- theories, and simulation theories. Module theories explains that mind is consist of separate systems such as Linguistic talent, visual system, facial recognition measure and each one has its own especial features. On the other hand, the theory-theories assume human understanding of mind is based on "folk psychology". This theory consists of appropriate concept for everyday interactions (Churchland 1991.) In other words, our knowledge about mind forms daily structural theory. (Gopnik & Cary 1993 quoted by Tirassa, Bosco and Colle 2006.) Simulation theory states that children are aware of their own mental state through

introspection and therefore they can use this awareness to infer the mental states of others. They do this by doing some kind of role-playing or simulation, in other words, the theory of mind capabilities can only be correctly understood if it is considered as role-taking.

Researchers of all three approaches believe that theory of mind appear after the age of four. All of them also associate this ability with the ability to explain, predict, and manipulate other people, and as afore mentioned are accordingly related to human social behaviors (Longdon and Coltheart 2001.)

According to researchers, forming theory of mind in humans commences from birth to the end of the 18 months, with the ability of purposeful understanding. In this very first phase which continues to 18 months' perspective-taking and purposefulness are proceeded by imitation (Gopnik and Meltzoff 1993) and joint attention starts developing (Simon Baron-Cohen 1995) which are groundwork and initial functions of theory of mind. Later from 18 months to three years, understanding intentions and pretend play continue developing. Leslie 1987 stated that 1.5 to 2-year-old children start understanding intentions and pretend play and after being 3 years old they are being enabled to discriminate the real and imaginary events, differentiate a fake object from the original one despite of their similarities, and seeing is knowing. In this phase 3-year-old children are acquiring a mental approach which is "thinking about thinking and beliefs".

As mentioned, the age of four is emerging point of Theory of mind and at this stage, the child begins to understand the false and paradoxical reality (Woolman 2002). At this age, children are able to understand that others may have false beliefs and can correctly explain their behavior accordingly.

After the age of five children gradually acquire the ability of second level belief to point out deep beliefs and third level belief to suggest nonchalant comments. Having second level belief means people have different beliefs from what others believe which might be true or false (Astington,2002) Acquiring this ability may take up to the age of 11.

It has also been demonstrated that there are different models and situations for the forming theory of mind. Children at the age of 4 have a visual understanding of mind (Perner 1991,1995.) Children consider mental status as propositional attitudes. Most

researchers doubt the existence of theory of mind before the age four. But the existence of it is accepted in a sort of way.

Infants from birth to 18 months apply single updating model interacting with the world to visualize the object in their surroundings. Considering the stability of the object it is rather difficult. 4 to 8-month-old infants wait for the objects to return but after the age of 8 months they seek the hidden objects.

At about 12 months' toddlers become more skilled in visualizing their surroundings and location of objects. But they still have problems in recognizing removing stuff in their absence (Flavell, Miller & Miller 1993.) Proceeding this, human is being able to draw his present reality and after being 18 months old visualizing the absent reality begins. At the same age despite of single updating model other models are beginning to function. These models enable one to represent past situations, possible future situations, desired situation and even situations with mere possibility which is called secondary representation. The first sign of the implementation of these models is the child's ability to understand the displacement, which is not done in her presence.

After the age of 3 to 4 years' children acquire an ability named meta-representation which was first defined by Zenon W. Pylyshyn (1978) and means "representing a visual relation". Prenner believes that in order to understand beliefs it is essential for a child to represent that all representations are representations.

In the multiple models of evolution, children might have mental models of present reality, past situations, and hypothetical situations. From the point of view of psychologists, these mental models are called presentation. The simple model embodies the present reality. Past situation models visualize the situations in the past, and pretend models represent hypothetical situations. This is widely accepted from psychologists' viewpoints. After reaching at the age of 2, the simple model, is related to present reality, the past situation models attribute the past, and the pretend models, the possible future situations and the desired reality models are connected to future.

Humans do not know that the available information is mental models. What they are aware of is the content of the models, as well as the content evaluation and the most important part of this evaluation is determining whether it is real or false.

Real or false assessment causes the ability to pretend. Pretending usually leads to determining whether an issue is true or false through creating an especial assessing process. It is worth noting that it is not expected to be applied in prediction of other's behavior who have false presentation of reality such as people with false-beliefs. (A false belief occurs when one believes a cause or an affair is true which is not really true like false riddle. (Prenner 19978))

Various realities in the theory of mind create desires and beliefs which are part of the mental status. Philosophers believe that understanding these desires and beliefs enable human beings to explain and predict behaviors of others. They also declare that people consider the beliefs and desires as propositional attitudes. Propositions are modes of subjects or situations, which may be real or unreal. A key feature is the representation of the difference between the proposition and (2000) content of that proposition. Representations always represent objects in certain ways, as Perner calls it point of view.

All the above described functions and processes about theory of mind require neural structures. Generally speaking, studies on the brain images and brain damage show that theory of mind has a broad structure which includes a variety of skills and knowledge.

Helen et al (2003) indicated that theory of mind, like language, has a distinct neural mechanism ranging from the basic skills and groundworks to comprehensive understanding mental status and behavioral interactions. These basic skills may consist of the ability to differentiate coming data, the ability to pay attention to another person by tracing eye contact, the ability to represent purposeful activities, and the ability to differentiate between his own activity from others'. Therefore, theory of mind's neural mechanism includes a network of functionally related domains, which form the social brain. It seems that anterior paracingulate cortex (32.9 area of Brodmann), the upper temporal sulcus, the bilateral temporal lobe, the amygdala, and the region of the orbitofrontal cortex, each one individually is performing during different levels of theory of mind's tasks.)

So far research has explicitly shown the role of mirror neurons and von Economo neurons in theory of mind, and studies of brain structures involved in representing mental states have provided us with three categorized groups, including regions of the brain engaged in representing one's mental states, regions of the brain engaged

in representing the mental states of others and the common brain region in both representations.

The outcome of studies on involved brain regions in representing mental states outline that regions in the posterior parietal of the right hemisphere of the brain, especially inferior parietal lobule (IPL) are responsible for representing individual mental states. The evidence has been found by studying the basics of neurophysiology while imputing his mental states and doing self-motivated actions.

Research from brain regions involved in representing the mental states of others in primates and humans suggests that superior temporal sulcus (STS) is responsible for representing the mental states of others. Evidence suggests that cells in this area are only responsible for stimuli of others (for example, the sound and hands and face motions of others) and not in response to his own stimuli. (Oram, Perrett 1997) Also, the outcomes of some investigations (for example, Puce et al. 1997 quoted by 2003 Abu-Akel) demonstrate that superior temporal sulcus activates in perceiving mouth movement and eye gaze. They mentioned that function wise these regions are correlated with superior temporal sulcus which also involve in perceiving body and hand motions of others. Despite that these regions selectively response to object-oriented behavior like intentional grasping motions (such as reaching, scratching, holding and tearing) but will not respond against unintentional actions (Perrett et al 1989). Generally, it can be concluded that these features and abilities are prominent particularly in inferring others' mental states and generally in social interactions.

To 2003 Abu-Akel, common specific parts of human brain which associate with both one's and others' representation are amygdala, anterior cingulate gyrus (ACG), orbitofrontal cortex (ofc), ventral and dorsal medial prefrontal cortex (v/d mPFC), and inferolateral frontal cortex (ILFC) which fall into two main categories: first one consist of structures in limbic-paralimbic system such as amygdala, ACG, VMPFC, OFC and second one includes structures in prefrontal cortex like DMPFC and ILFC.

Accordingly, a neurobiological network model of brain regions engaged in theory of mind has been provided by Abu-Akel 2003 which is illustrated in figure below:

Figure1-2: Functional neuroanatomy of representation and imputing to self and others.

In this model, the anterior and posterior lateral groove areas are bilaterally related, and there are also connections between the limbic and paralimbic structures and the anterior and posterior lateral groove areas. The roles of the above-mentioned regions are demonstrated as following:

- 1) Representing individual mental states are made by inferior parietal lobule
- 2) Representing others' mental states are associated with superior temporal sulcus
- 3) Represented mental states in these areas are imported to limbic and paralimbic system for emotional and social interpretation and regulation.
- 4) Finally processed data are sent to the areas of Prefrontal cortex applicably.

So far, present reality of theory of mind has been elaborated according to the conducted investigations in order to briefly decipher adaptability and exaptation. This is worth mentioning that many debates in this field such as various definitions of theory of mind and mental states are not scrutinized not to unreasonably prolong the subject. Readers are also referred to the available sources in case they are keen to know more details.

Pretending

The question which brought “theory of mind” into the research literature is based on social functioning. All investigations have probably undergone many changes and social expectation of researchers regarding theory of mind appeared due to this question. It is controversial that scientific development of theory of mind come to a halt at the age of 4 and like the first stage of Doodles-themed games only the unrecognizable part of theory of mind is provided to us. Although the doodle part is complete, yet the riddle part is unsolved.

Theory of mind might possibly be at the stage of pretend play. The stage that required concepts and skills are being built in order to complete and receive the bigger picture of the question “what is theory of mind?” under domination of three unreal pretend play components, the Object substitution, Attribution of pretend properties and Invention of nonpresent objects

In order to survive, human beings need to predict and understand their inner and outer environments in present and future situations. This prediction enables him to visualize the circumstances of a balance, and once the balance is disturbed in the present or the future, he starts to act to obtain the balance again. Now this argument pops up that what functions make human beings able to predict and understand their inner and outer environments in present and future situations.

As afore mentioned, scientists believe that the theory of mind generally equip human beings with explanations, predictions, and manipulations. On the other hand, forming theory of mind in humans demonstrates that representing situations at various time in the present is only possible by the help of structures and functions engaging in theory of mind. However, malfunctioning of theory of mind in people suffering from autism and schizophrenia who are disconnected with the real world and are not able to plan to survive due to their impairments, indicates the importance of theory of mind functions which outweigh our expectations.

To clarify and understand the theory of mind functions and its importance in human survival, it is essential to understand situations and models and forming each model during the development makes the potentials of survival possible in present and future.

The theory of mind mechanisms' models applies as energy savor for brain and as behavioral guidelines in order to survive and slow down the response to stimuli. Present reality of situations, time, true or false and models were explained in the previous chapter, therefore and regarding the present reality of what we know about theory of mind, its potentials are being discussed from different attitude. To illustrate the theory of mind functions, apart from understanding other people's desires and beliefs and social functions, situations such as present situations, past situations, future situations (including desired situations), , absent/nonpresent, hypothetical situations and the ones with less likelihood are being evaluated and along with them real or non-real (false) functions of the situation are assessed in order to measure how actual or illusive the output of a situation model might be.

Every system or organism must have an understanding of its present reality in order to survive, so that it can predict the future, interpret the past and the present, and maintain its survival with what it does now. Single updating model is explicitly associated with the time and present reality. To understand it better, suppose you are a grain. To accomplish the primary goal of survival, growing roots, stems and leaves are required, but not any time is plausible for the nature to provide the circumstances to grow. The seed receives environmental information including moisture and temperature, at which point the seed will have an understanding of its present reality. This understanding ultimately determines the seed's decision to germinate, considering its given resources for survival. This means that the seed, through perceiving the present reality, anticipates that it will be able to absorb the required resources from the environment in the next few days due to sprouting when it no longer has any resources left. But if the environment changes for any reason, that plant will not survive. The same scenario goes for human too. We are supposed to understand the present reality, one example of theory of the mind regarding children is understanding objects permanence, this perception is part of the single updating model. Human beings also need to understand the present reality to set goals, plan to achieve and subsequently act. We as living systems which receive signs of balance and imbalance from internal and external environment based on homeostasis require to understand the balance or imbalance in the decision-making process to spend the remained resources in order to act or not. As it is clarified about single updating model and its presence of this model from birth, it is clear that this task is the responsibility of theory of mind and single updating model.

The next model is the pretend model, which is related to all situations and strongly influence them. Human babies take their survival granted due to the presence of caregivers who are able to understand the present and predict the future and this is because of single updating model. Getting reassured about survival in the present allows the brain to provide babies with the time and resources needed to practice and develop other models of prediction. That is why they engage in pretend play from infancy to childhood as a special exercise to expand their understanding of the past, present and future. This continues mentally in adulthood if it is fully formed. In pretend models that later make the theory of mind's simulation possible, one interprets, predicts, and manipulates himself and the environment with role-playing. I believe that conduct disorder which later leads to anti-social disorders can be presumably rooted in this field. A child who is unable to play and pretend to be normal will have a distinct simulation of theory of mind compared to other people. In this case, he can never place himself in the position of the victim and feel the pain he endures, and therefore he does not feel sympathy. Besides, the lack of emotional memory in these people increases the desire to repeat the crime in them, this can be rooted in their inability to simulate emotional situations in their memory, and therefore the need for external stimuli such as trophy increases. This is also seen in people with damage to the engaging regions in emotional memory. Therefore, this model provides the brain with the result and output of each stimulus and the response to it by the possibility of simulating situations.

Other models of past situation models are related to the past. These models make it possible to access storing information about stimuli, responses, and its outcomes. These models are more closely linked to the brain's economy, making it easier to simulate the present and the future in the brain when dealing with situations that are similar to the past situations. This model is based on theory-theory and simulation theory.

And the last model is related to desired and probable future. These models are the most effective output for planning, Acting and balancing the future that our brain has hands-on. Accessing the natural output of these models, means accessing Required energy in the future. Having no target and ability to plan is based on not being able to implement the models.

How can one trust the outcome of these models? In people suffering from schizophrenia, the difference between the outcome and the reality, is going to hurt patient's survival.

As mentioned earlier in "the growth of theory of mind" that the ability to pretend makes the evaluation of reality and pseudo-reality Possible, but this evaluation is wrong in people whose reality Formation is wrong. It means pretending can't be used in model outputs of others and the person himself. For that reason, we should be looking for a function to make this evaluation possible.

Let's start by recognizing why a situation is pseudo- real. I believe people can be in three modes of reality or pseudo-reality Depending on the situation. These three modes are rooted in a person's evaluation of themselves. 2 modes are pseudo-real and one is real. In the real mode evaluation of personal potentials are totally compatible with the real situation in which models provide the brain with real situations. In the first mode of pseudo _ reality the evaluation of personal potential is greater than reality, in this mode the models provide pseudo-reality to the brain these situations are based on prodigious or self-centeredness. In the second mode of pseudo-reality the evaluation of personal potential is lower than reality. in this mode models provide the brain with pseudo-real situations; these situations are rooted in lack of self-confidence. For a better understanding please pay attention to the following question. Imagine you are asked to lift a 100 kg load. If your answer is yes however your ability is only to lift 50 kg, this is a response of pseudo real situation Brought about by delusion of grandeur. But if you have the ability to lift it and your response is no, this is a response of pseudo real situation brought about by inferiority complex.

The real and pseudo real modes show us that the base of the real or pseudo real evaluation is rooted in understanding the present time potentials of the system. In other words, a person definition of their own potentials which is a kind of updating plain model, reality or pseudo reality is not about the outputs but it's before model starts and the evaluation is after receiving responses from inner and outer environments. Moreover, the change in responses and the actions result of in the environmental causes the updating plain model to change the definition of someone's self constantly which changes the predictability of identical situation if a proper response isn't received.

I believe researching models and situations indicate that theory of mind plays an undeniable role in human beings' survival, definition of oneself in mind, decision making and executing. That's how it defines a human being.

Human beings are creatures who have made decisions, planned and executed to survive according to models of past situations and understanding the present time which enables them to predict the distance between the plain reality and the desired mental picture. But is this new definition and perspective real or pseudo real? Can this approach bring about new desired situations in the study of brain and mind?

Desired Reality

This chapter, covers the functions of the new attitude toward the theory of mind during growth, which in my view is rooted in adaptability, and its social function is an exaptation and figure out whether this attitude is true or false?

Infants need to have a real understanding and representation of their inner and outer environment in order to survive. The dearth of understanding the environments fosters infants to fail responding properly which leads to jeopardizing the marathon of life. Infants find enough time to expand and enhance the potentials for these functions, considering that they have care-givers who are able to understand the past, present, and future of the environment.

From birth to 18 months is the examining period for acquiring and developing capabilities of understanding the present through genetic factors. This understanding provides the primary possibility of predicting based on resources and acts for the child. At this time, the demands are based on the representation of the balanced circumstance in present. The baby begins to cry generally facing with hunger stress and in case his need is not met, normal crying turns into anger crying. In this case, crying is not based on social communication, but a sign that the infant uses to express his present understanding. This is due to the fact that the infant is unable to achieve his demands. This applies the same in case of smiles too. John Bowlby (1969) proposed as following regarding infants' smile:

“It is the absolute privilege for infants that the smile is well designed to provide their survival by manipulating and enslaving their mothers.” From this viewpoint smile is more of a tool for achieving output, which understanding present brings to the baby. Gradually, as the infant grows up and gains more abilities to move through the environment and achieve desires without help of others, the reason for crying and smiling changes. However, at this point, the response of caregivers to the baby's present perceptual outputs influence shaping and changing infants' desires. Infants who have to experience day care environment because of their parents' or their caregivers' occupations try to achieve their desires by crying in the first few days. But because of the inability to achieve the desire, he might perform other behaviors, but finally, as a result of not being able to achieve the present desire and experiencing

the deprivation, as many infant researchers report, the infant enters a depression phase.

After reaching 18 months old, the theory of mind enables the drawing of human desires and needs by understanding the present in order to preserve survival. After passing 18 months, as mentioned earlier representation of absent situations begins. The representation of absent situations demonstrates the child's ability to measure the distance between what he has experienced in the past and present. This ability requires memory functions, storing the situations, recalling the past situations, and recognizing the differences between the present and past representations make representing the past situations possible and also valuable. Therefore, in order to implement this process, the child cannot be sure of survival only with a single updating model. That is why the initial functioning of representing the past situations are being observed. Past situation models provide Prototype to reduce brain energy consumption facing any stimuli. A child who has achieved his desires by crying in the past, considers crying as an obvious example of reaching desires and uses that in similar situations. But if this obvious example does not make it possible to achieve the desired response, again the single updating model seeks different responses to reach the resources. Besides, representing the past situations brings about retrospective prediction for human. At this point, apart from single updating model and representing the past situations other models gradually appear. These models enable the ability to predict in hypothetical or possible future situations, desired situations, and even situations with seldom probability. These models are called secondary representation. The first sign of the implementation of these models is the child's ability to understand the displacement of object, which is not done in his presence. The child's prediction models at this time enhance the ability of planning and decision making. If the surviving environment is reassuring so these models will change from targeting basic needs like food providing to secondary needs. To better understand how the past, present, and future function in theory of mind, consider the following example: suppose a child whose parents provided him with some orange juice for the first time. After drinking orange juice, the child builds an obvious example of orange liquid by single updating model and evaluating the amount of sugar and associating that with survival depending how much sweet the juice tastes. Now, if the orange juice is sweet, single updating model stores a positive residual value for any liquid look like orange juice in the brain and attributes a negative point

for the reverse. After some time, what the child experiences becomes the past and a past situation is formed. From then on, whenever the child sees the orange-colored liquid, the representation of the past situation retrieves leads to the child's prediction and this continues to his adulthood.

As stated before, children begin to pretend from 18 months to 3 years despite of models and time situations. Pretending makes it possible to simulate and attribute experienced situations, hereinafter referred to as the obvious examples. In this case, the child is able to experiment and create predictions of situations he has not experienced yet. This type of prediction develops at the age of 3 to 4 years old and obtaining the ability of metarepresentation and self-awareness expands too. The ability to be self-aware tend to appear in the late second half of life and there is evidence of self-conscious emotions. Infants experience emotions such as joy and fear. But children need to be well aware of attributing self-conscious emotional experiences to themselves and differentiating them from others. (Lewis ,2002,2007) Pride, shame, and guilt are examples of self-conscious emotions. Self-conscious emotions do not appear during growth until one is aware of himself which is reached by the late half of second year of life. As it is discussed this enables him of recognizing true or false situations. During one's life span, theory of life makes survival possible by understanding situations in the right time, prediction and self- awareness. But what problems are brought about due to the lack of theory of mind?

I call the lack of functionality and recognizing the situation, "Time Turmoil". In this case, the person loses communication with reality due to confusion and disconnection or incorrect response of the output of an obvious example and his self-perception, and considering to the volume and type of confusion, his survival is endangered. The behavior of people suffering autism, schizophrenia, or drug abuse confirms this. These people are struggling not only because of their inability to communicate socially but their inability to associate the situations and the Prototype or lack of prediction or false prediction.

That is the reason I believe that theory of mind is survival adaptability and social interactions, understanding others' beliefs and intentions are its exaptation. The reevaluation to the theory of mind is required and I propose the following definition:

Theory of mind is the ability to understand situations and achieve reality in the past, present, and future in himself and others.

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