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Understanding action in neurological and psychological framework

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Abstract
Realizing that a plethora of procedures go into the production of what is termed as action, the current endeavour seeks to bring in all the constituents involved in the production of action yet discovered in one fold, showing holistically what action is. As found by many who seek to understand action, one needs a combination of both reductionism and synthesis to understand the phenomenon of action. Forcing us to take a multidisciplinary approach, reductionism allows us to understand the multifaceted nature of human voluntary action. For instance, this exercise of ours goes in to psychology, a subject designed to study human action, to understand some facets of action. Similar facets are studied then from the point of view of neurobiology, a subject that studies nervous system to understand human action. Having found and understood the various components of action, the current paper tries to bring all the components in to one fold under general systems theory, an approach of synthesis. Taking a lead from the foregoing, that is, a holistic understanding of action, the whole exercise moves towards to understand the knowledge framework in which one could fit the understanding of action – a knowledge framework built by causation, reason and purpose.

Keywords: action, reason, causation, purpose, perception, mental states

1. Introduction

Nothing in the nature can capture the essence of its own march through the sinuous paths of evolution but humans endowed with the spirit of enquiry. Scrutinizing every bit of its own action, human race has come to amass enormous information depicting what could arguably be claimed as the true nature of human action.

Various organized areas of knowledge, if they could be called so, have managed to unravel many facets of action which were earlier regarded as mysterious in nature. If Ludwig von Bertalanffy, the originator of the general systems theory in biology, is to be believed, one should see things in its entirety- a set of interconnected elements gelling together so well to conjure up a whole. (Bertalanffy, 1974) [8] Going by the same rule, one ought to be able to figure out and fathom all the elements of action in order to understand it in its wholeness. In other words, action is an edifice built on the foundation of many stepping stones, the omission of any one of which may lead to the collapse of the whole pack of cards.

Having considered the foregoing assertions, one could easily argue that it leaves many questions unanswered. However, more significantly, for a curious mind it generates enough questions that can guide him/her in the maze of confused thinking. As ought to be the case, a whole gamut of questions is already on the plate waiting to be tasted.

Firstly, the most obvious one: what are the elements of action if it can be seen as a system?

Secondly, how does each one of those elements participates in the overall process, and what is the relationship that each one of these elements has with the action and also among each other?

Thirdly, are there any organized studies being conducted in the area which can conclusively establish the relationship, if any, between the aforesaid elements?

Fourthly, psychology has been able to discover many of the elements; viz., Will, intention, motivation, perceptions, emotions, feelings, mental states to name a few. Now, is there a neurophysiological underpinning behind these elements?

Finally, how is the why question answered, does the answer include causation, reason, purpose or some other elusive explanation not discovered yet?

Answering these areas seems to be an uphill task; however, convergence of studies in areas such as pharmacology, neurobiology, psychology, psychiatry, application of behavioral sciences in other areas such as sociology, economy, polity, and management can provide great insight in the study of action, and much to everybody's satisfaction, the results emanating from such studies might withstand all sorts of scrutiny. Let's proceed with some of the research conducted in psychology, economics, management, and sociology, and analyze it using the concepts developed in neurobiology so as to get a holistic picture of the human voluntary action.

Perception: the guide to voluntary action

It seems a story wouldn't do any bad to explain some of the elements that psychology has found long ago to be a part of the aforesaid system. Smita, a diligent student who always looked forward to studies, cannot resist the temptation of going to the school and attend mathematics classes, a class otherwise detested by the most. Of her same age is Richa, who studies in the same standard and is a national player in badminton. She is someone who doesn't want to miss a single practice session. When it comes to Smita she would do anything but play, and quite contrary to it, Richa would do anything but study. These seemingly different acts come from

two people, who, being identical twins, have mostly everything in common in terms of socio-cultural environment.

A possible explanation for the difference in the choice of activities under similar situations is offered in psychology. It is the perception regarding the action to be performed that holds the key. Leaving aside the question of how these perceptions are formed initially, one would find that both the girls have different perceptions regarding their own chosen field of interest. Smita associates joy and happiness or pleasure with studies whereas richa does the same for badminton. Similarly, feeling of displeasure is what they associate with the tasks they do not like.

As psychology upholds, Perception, one of the key elements of action, when repeated in one's mind, leads to the creation of a mental state also called as mood in layman language. Apparently, a perception, with repeated reinforcements, leads to the creation of particular mood. To illustrate, a person repeatedly thinking about some negative event of his life eventually enters into a mental state of depression. This is a classic case in which a particular perception takes hold of the mind and creates a mental state. Finally, as has been witnessed, any mental state thus formed culminates in some form of behaviour showing the true colour of a person's mental state and perception. Having followed the foregoing argument, one can conclude that the elements; videlicet, perception and the corresponding mental states have definite links with behavior or action.

Components of Human Action

However, is this psychological picture able to present a view regarding how perceptions are formed in the brain? Is there a neurobiological foundation of the whole process?

Neurobiological explanation of perception and its impact on action

As it should be, to perceive the external world body requires a system that could take the information to the brain. According to the known knowledge, our senses, viz., visual, olfactory, auditory, tactual, gustatory and visceral are collectors of sensual data. They themselves, however, are not good enough to take the information to the various regions of the brain- a work that could only be performed by our specialized parts of nervous system. Stimulus energy generated in the environment gets received by various receptors that are situated at the terminal end of axons of various afferent nerve cells – a part of peripheral nervous system. It is witnessed with the peripheral nervous system that particular types of receptors are designed to receive only a particular kind of stimulus. Having received the stimulus, these afferent nerve cells perform the function of stimulus transduction, a process of converting the environmental stimulus into an electrical response that could be sensed by the brain. Taking the ascending pathways, the electrical impulse, also called the sensory information, gets relayed to the central nervous system – a combination of brain and spinal cord. Here the synapse between the afferent neuron and interneuron allows the sensory information to pass in to the axon of interneuron. Not stopped by any lateral inhibition, the sensory information reaches reticular formation in the brain stem region of central nervous system. An insight of this region could be gained by the fact that this region acts as convergence zone for all the reciprocal pathways. Also, brain stem, also called as the old brain is responsible for the regulation of all those functions which are common between us and the animals with a considerably developed brain. Depending on the nature of sensory information, reticular formation sends information to thalamus where various thalamic nuclei receive sensory information directed at them. From here the sensory information gets relayed to the designated primary cortical sensory or motor areas of cerebral cortex. Although processing of information is done here to an extent, it is in the cortical association areas lying adjacent to primary cortical sensory area where real processing takes place. Barring the exception of olfactory nerve pathways which go through limbic system and terminate there, all other pathways finally end up in cerebral cortex which decides what to do with the sensory information. When cerebral cortex becomes conscious of any particular sensory information, that particular information is called sensation. Finally, a person's understanding of the meaning of a sensation is called perception. Once processed, the information in the form of instructions is relayed back to thalamus, reaching where it is further relayed back to reticular formation of brain stem via descending pathways. There are, however, a few exceptions to it, such as, certain pathways going to limbic system before converging at reticular formation or certain pathways particularly performing motor functions reaching reticular formation through cerebellum. Not to forget the role played by hypothalamus, which often receives processed information from cerebral cortex and produces hormones or relay further instructions to brain stem via descending pathways. From central nervous system, efferent nerve pathways of peripheral nervous system take the information to the target areas of the body. Receiving the information from the axon terminal of efferent neuron, effecter cells of the region instruct the body to react in a desirable manner, which we perceive as a conscious human action. Process of processing in the cerebral cortex being a complex one, it'll be discussed later on when sufficient matter necessary for its understanding would have been already discussed.

One won't be off the mark if one claims that everything psychological is biological, Glimpse of neurobiology in the foregoing passages support this fact. However, a question looms around. Is our psychological understanding of action complete without mentioning the role of motivation, one of the most important elements of action, in the production of action? Further, what could be the neurobiological underpinnings of such a psychology? Finally, do social elements such as society, culture, polity and economy have any role in the creation of motivation?

Motivation: an inalienable component of action

Motivation is an area that has been researched about both intensively and extensively. Motivation, in psychology, is regarded as the prime mover of any human voluntary action. Further, all the psychological theories point towards the

necessity of a goal for any voluntary action to be performed. To put it simply, action is always goal directed, and if observed keenly one would appreciate the fact that motivation or one's needs help in deciding one's goals. Let's understand how it works and find out the relationship that is emerging.

Of all the people, it was Abraham H. Maslow, the proponent of need hierarchy theory, who showed us the significance of motivation in any human endeavour. Theory claims that people have many wants and desires influencing their behavior. Moreover, it goes on to claim that there exists a hierarchy of needs of which only unsatisfied ones have the tendency to influence the human action. (Maslow, 1970) [5].

Hierarchy of needs, as envisioned by Maslow, starts with the physiological needs such as hunger, sleep, thirst etc. This is the most basic need and is directly linked to our survival. Apparently, scanning the whole nature, we can be rest assured that this is one need that is common to all the living beings, be it a unicellular organism like bacteria or a multicellular organism like us humans. Although physical needs are an inalienable part of Maslow's need hierarchy, for our scheme of things, they are not as important as other needs are, for other needs are the ones that separate us from rest of the animal community. Next in the hierarchy are the safety and security needs, to fulfill which people look for shelter, health and other facilities. To amplify its importance, one just needs to imagine the state of nature conjured up by the Contractual theorists like Thomas Hobbes, and one may understand the basic motive behind the formation of state itself, a colossal human action. The next level fosters in people a need for belongingness that is normally quenched by finding love and friendship in their relations. This is one need that gives us some clue regarding the formation of the institution of family and to some extent society itself. As one moves up the ladder, one would find oneself inching towards the need for self-esteem or recognition. People, under the influence of this need, strive to achieve all those goals that they think may lead to gain them social reverence. Social perception plays a great role in the activity of setting goals that can fulfill this need. Finally, the need for self-actualization, the need, the motivation very intrinsic in nature, forces one to realize the maximum potential one embodies. It is thirst to achieve excellence in one's chosen area of endeavour. The goal seems to be finding pleasure in the activity itself. Whether this chain works in an exact hierarchical manner or not is a matter of speculation. However, there is no denying the fact that the theory goes on to a great extent in making us appreciate the role played by motivation in one's life to choose any goal and the appropriate action that could achieve it. Following the tenets of need hierarchy theory, many theories have come into the picture, viz. two factor theory of Fredrick Herzberg, Alderfer's ERG theory or Chris Argyris's participative management theory, strengthening the claim that motivation and goal play a very important role in shaping action.

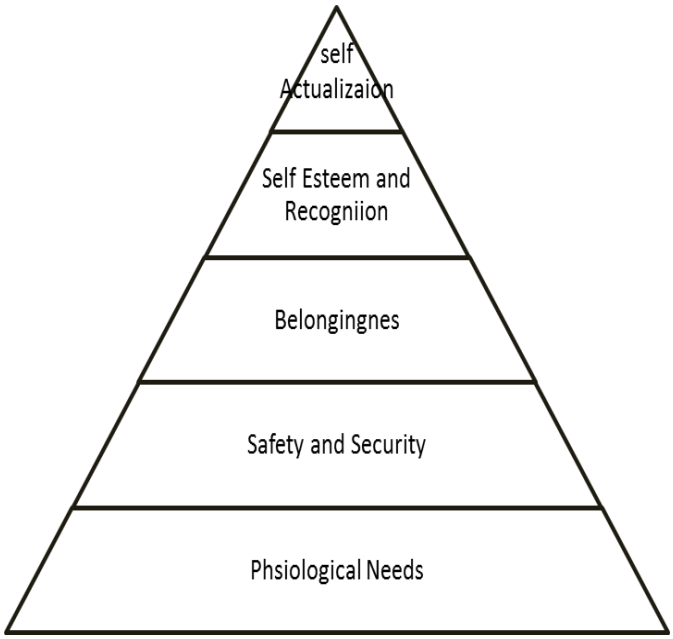

Fig 1: Maslow's Need Hierarchy

Let's now build a new edifice of action using the new element that we have just understood i.e. motivation.

Neurobiological underpinnings of motivation and consequent action

As we have been doing heretofore, we ought to see the neurobiological and physiological picture of motivation and its relationship with the goal and the action to get an understanding that is testable empirically. Neurobiology perceives motivation in a different way than what has just been mentioned about it in the foregoing paragraphs. Primary and secondary motivators are the class in which neuroscience classifies motivation into. (Vander's, 2001) [7]. Apparently, it seems significant to understand primary motives and its

working to do some justice to the understanding of secondary motives. Primary motivation, as has been found, is the result of homeostatic imbalance. Homeostasis, an autonomous nervous system controlled condition, is a state of metabolic equilibrium that body ought to be in in order to sustain the process of life. Owing to wide variety of reasons, body constantly faces homeostatic imbalance, correcting which suddenly becomes an urgent need for the body. As it happens, internal environment of the body sends the stimulus that gets received by the receptors of afferent nerves of peripheral nervous system, which relays it to the cerebral cortex region of brain through the ascending specific or non specific pathways via spinal cord, reticular formation of brain stem and thalamus. Cerebral cortex ultimately decides whether the conscious involvement is required or not. As it happens, in abovementioned cases, controlling of behavior are left to the autonomous nervous system, meaning processed information is relayed back to thalamus, which finally sends it to hypothalamus. Receiving the sensory information, hypothalamus either sends output stimulus through descending nerve pathways or it activates the endocrine system by stimulating pituitary gland, thus regulating the whole homeostatic process. Controlling breathing rate, heart rate, blood pressure, the process of digestion, sensation for hunger and thirst are some of the vital functions performed by it. Although consciousness and perception do not seem to play any part in the overall system, the overall process goes on to explain some of our activities which are directed specifically to fulfill the physical needs. To illustrate, any reduction in the amount of water in the body makes us thirsty, which culminates in us taking water. Thus, we can now affirm to have understood the foundation of some of the physical needs and the reciprocal actions mentioned under Maslow's need hierarchy theory. However, we cannot make the same claim for the other needs mentioned in the Maslow's theory, for its explanation requires understanding of conscious brain doing higher order cognitive functions. Moreover, instances of hunger strike or fasting, in which one is going against one's physical needs cannot be explained by the concept of primary motives. Here, neurology has managed to come up with the concept of secondary motives, which strives to explain other needs delineated by Maslow.

Secondary motivation emanates from a need that our brain is able to perceive; that is, the cerebral cortex has a specific meaning for the sensory information that it received in terms of the feeling of pleasure and pain. It is worth noticing that the feeling of pleasure and pain plays a great role in incentivizing the action. In other words, motivation is all about perceiving incentives associated with action. Neurobiological research tells us that the feeling of pain and pleasure are an inalienable consequence of emotions. Deducing from the foregoing, one can easily say that apart from cerebral cortex, amygdala, a part of limbic system that plays a primary role in producing emotions, also plays a very important role in motivating a person to pursue a particular course of action. Now the key questions badgering our minds are: what is the role of emotion in evoking action? How does emotion create a particular kind of feeling, seeking which actions are produced? Before answering these questions, there is no harm in asking why do we have emotions in the first place and what are they after all? And does perception has any role in creating emotions.

Let's venture an era when we were as primitive as our other primate brothers are now. We were in a situation constantly marred by threats of predators, constant search of food and prey etc. An automated program of action was necessary for our survival especially in situations such as fight and flight. As the famous neuroscientist Damasio (2010) [3] would agree, this automated program of action is called emotion. What it means to say is that the moment we perceive a situation such as the one mentioned above, the amygdala, hippocampus (a part of limbic system associated with learning and memory) and prefrontal lobe of cerebral cortex produce an automated program of reaction which we call emotions. Furthermore, in the process of emoting, that is, when we follow the automated program of action, our internal afferent system gets stimulated and relays sensory information to the cerebral cortex region of brain where it gets registered as feelings. To illustrate, if a person perceives a threat and situation demands him/her to run, the stimulation of amygdala, prefrontal region of cerebral cortex and hippocampus will run an automated program of action in which hypothalamus, brainstem, and medulla oblongata will function in such a way that it will raise one's breathing rate and blood pressure. Complementing the foregoing process, his/her endocrine system will pump adrenaline in the blood vessels. Finally, person will be in such a heightened state that he will run. However, more importantly, our internal receptors will be able to sense the homeostatic change that has occurred in the body and accordingly send ascending pathways to the cerebral cortex, where, the overall sensation will be registered as a feeling of stress. Natural reaction for a man is to avoid a situation like this which may trigger a feeling like one now mentioned. Now it is amply clear that certain perceptions trigger certain emotions which in turn trigger certain feelings, some of which are wanted and the others unwanted. Any activity giving a feeling of pleasure is desirable whereas the one generating displeasure will be resisted. This explanation, it seems, is doing some justice in explaining secondary motives, and we have, if not wrong, a sound explanation of need hierarchy theory mentioned earlier.

Role of decision making process in voluntary action

However, emotions and feelings alone cannot produce voluntary action. There is ample evidence to suggest that higher order thinking, emanating from cerebral cortex also plays a gargantuan role in producing human voluntary action. Rational decision making process is one such element, without which any explanation of action is impossible.

There have been many theories on decision making but none could claim to have made a contribution that Nobel laureate Herbert Simon's theory made. However, before getting a glimpse of his theory, it would be sensible to get a grip of what the common perception was regarding rational decision making process before his ground breaking research came into the forefront.

Rational decision making process

As it happens in economics, an economically rational man was the central point of all the economic theories. It goes without saying that it was true in the case of theory of decision

making too. The emphasis was on optimality in decision making. Going by the postulates of the theory, the first step in the overall decision making process is to find a situation where in a decision has to be made, and then choose a goal according to the need of the hour. Once the step is accomplished and a worthy goal is in sight, the decision maker strives to collect all the information regarding the alternative course of action one can take to achieve that goal. Having accomplished the previous step, one has to predict the consequences of all the action one could take to achieve the goal. Final part was to choose the most efficient option, meaning the act taking least number of resources to achieve maximum, thus offering maximum satisfaction.

Bounded rationality and decision making

However, for a real life scenario, the theory was grossly inadequate. Not everybody is expected to be economically rational. Consequently, Herbert Simon came up with his own theory of decision making. It will be an ardent task, he contended, even for a man with all kind of resources to get all the information to choose the most ideal goal for him. He asserts that even if someone is able to manage that feat, it looks seemingly unlikely that somebody will be able to muster all the information regarding all the alternative course of action one can take to achieve the predetermined goal. Similarly, it is highly improbable that somebody can predict the outcome of all the actions one can take precisely. Finally, people, he argues, very rarely go for the most efficient course of action. Sometimes they are just content with a good enough alternative, not paying much attention on the process itself. He coined the word 'satisficing' joining the words 'satisfaction' and 'suffice'. Thus, his parameter for a good action was satisfaction and sufficiency. Considering the constraints involved in the process of optimal decision making, he also coined a phrase called 'bounded rationality'. The whole purpose of his work was to improve the situation of bounded rationality, particularly in administration and management (Simon, 1976). Rest of his work doesn't seem to be significant for this paper.

Emerging Picture of Action

Neurobiological picture of the foregoing theory too is no less interesting. one could claim that a combination of frontal lobe of cerebral cortex -- a region known for the processing of higher order thinking, problem solving and decision making; and hippocampus -- a region situated in limbic system known for memory and learning -- process the sensory information received by it as already explained earlier and produce what may be called as rational act.

Having followed the research carefully, one could claim that some kind of information is always required to make the decision. Further, the brain's ability to receive so much of information, and the ability to process the information to create a perception, and finally to choose one course of action out of many alternatives is commendable. However, with lot many things happening simultaneously, brain is a complete mishmash. It is not always the case that brain participates in an informed rational decision. Sometimes decisions are impulsive based on emotions. Sometimes, on the other hand decisions are taken subconsciously, where previous learning and long term memory plays a huge part.

Hitherto, we have managed to present a picture in which cognitive processes of perception creation, motivation, mental states, decision making and goal formation are playing their part to create human action.

Systems theory explaining action as a whole comprising all the elements discussed heretofore

Once again, general systems theory of Bertalanffy, mentioned in the beginning, can help us in putting things into their rightful place to give us a grand view of action. Systems theory takes everything as a system, in which a set of elements forming the system are interconnected in such a way that it forms a relationship among elements to give us a proper understanding of the overall phenomena. Besides, system itself forms a reciprocal relationship with its environment, shaping it and getting shaped by it in a continuous process.

Getting a stimulus from the environment -- biosphere (a combination of lithosphere, atmosphere, and hydrosphere) in our case, human nervous system reacts in a manner that is already explained in this work. Having converted the stimulus into sensation, a process called as processing of the sensory information, brain instructs the various parts human body to act, thus giving stimulus back to the environment that shapes it. This interaction of ours has led to the creation of a new kind of environment called cultural environment, which thus far has been able to create a civilized world controlled by a new ever dynamic social, political and economic environment.

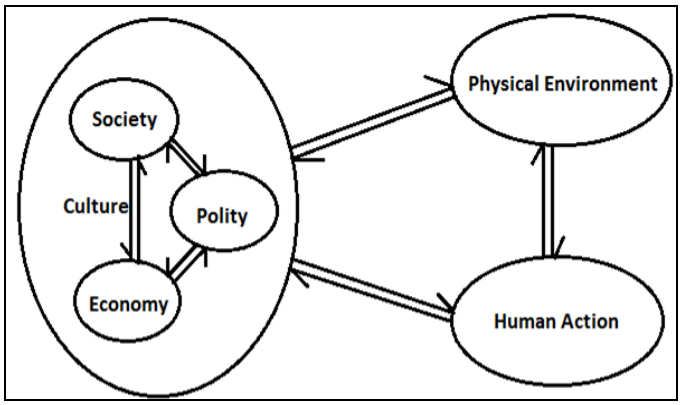

Fig 2: System's view of human Action

Thus, it is not difficult to understand that every moment we are bombarded by various stimuli from the so called cultural environment and its products, which shape our perceptions, motivations, decision making, and therefore our action finally. However, it is not the end as we too with our actions are shaping every aspect of the environment, be it physical, cultural or its various components in society, polity and economy.

Framework of causation, purpose, and reason to understand action

Throughout our civilized past, we had always some lack of consensus regarding the working of action. Repeated dissections of human voluntary action have always been performed using the lenses of causation, purpose, and reason. However, if we dig more deeply, we can appreciate the fact that controversy mostly doesn't emanate from the working of action rather it emanates from our interpretation of its working. Causation, purpose and reason – the tools interwoven in a subtle relationship and indispensible for human intellect to enhance its understanding of the nature – reveal no lesser a picture when the area of enquiry is action.

The question is how causation, purpose and reason present a different picture of the same action. Causation is a framework that allows us to understand the relationship between events, meaning that it focuses on the relationship between two events in such a way that one event leads to the other. Fundamental assumption is that events do not happen in vacuum. There has got to be an event that should cause another event.

When it comes to purpose, things change dramatically. Purpose brings in the assumption that there has to be a goal for any given event. Purpose, it seems, is an end state to attain which an action is performed.

Reason seems to be a more complex entity getting contributions from both cause and purpose to erect its edifice. Instead of establishing any relationship among events, Reason establishes relationship among thoughts. The process of reasoning tries to establish a conclusion using premises, which in themselves are statement of facts. Putting it differently, one can say that some small claims are used to arrive at a bigger claim. However, realization dawns on to us, when we understand that the statement of facts many a times depict cause and effect relationship and other times they depict purpose. Eventually, these very statements go on to support conclusions, which perform the role of opinion, beliefs, and judgments for us. Let's understand how these three entities provide us a different understanding of the same subject.

For instance, gravity is the force that makes things fall on the earth. We know it is causation that is answering why question here. If we ask why gravity exists, we are entering into the realm of purpose. Scientific procedures cannot answer this question satisfactorily, for there is no way to establish the truth value of the answer. Now, let's see what ISRO is doing. It is planning to send a new GSLV in to the orbit. They hold the opinion that rocket should be sent at a speed of more than escape velocity, that is, 11.2 km/s. well, it is a call they have taken on the basis of information telling them that gravity exists, and it pulls every object down to the earth. Thus to escape gravity one needs to move at a speed more than or equal to 11.2km/s. This is a process of deductive reasoning, where we have used previously established cause and effect relationship to arrive at a judgment. Similarly, using the process of reasoning, we can discover a new cause and effect relationship, and nature is teeming with examples which show it.

In the beginning itself we had a set of questions in our mind, of which the most fundamental was the way we seek to answer the why question. Having gone through the psychological and neurobiological theories that try to provide us some insight regarding the underpinnings of action, one can say that although both the areas address the same question, the answer that they provide take different kind of frameworks as a medium of expression. For an instance, when we ask a simple question- why does a person drink water? The answer seems to be pretty evident. For a common person the answer is- "well the person is thirsty". The answer seems to have an element of purpose in it, for the action was specifically performed to quench the thirst. Now let's understand a more refined explanation of the same action, the kind of one we can have in psychology. Any motivation theory such as 'the need hierarchy theory' mentioned earlier signifies the presence of most basic physical need as a motivating factor for a person to indulge in the activity of drinking water. However, decision making theory tells us that the need is not the only phenomenon that is applicable in the situation. Based on the information one has, a person can take various courses of action. The choice of action would be based on one's temperament. The current explanation holds the need to quench the thirst as the purpose or the primary motivator whereas the rest of the explanation gives us the reason to believe so.

Everything psychological has a biological underpinning. This is what psychology says about neurobiology. Let's understand why they make such a claim, using the same situation. Neurobiologically, it was a disturbance in the homeostatic balance that triggered the movement. Afferent neurons, receiving the stimulus generated by the body due to lack of water, send the sensory information to the cerebral cortex via thalamus. In the cerebral cortex it gets further relayed to the frontal lobe, hippocampus and few other areas. Having processed the information, the cerebral region sends instruction to the body to act in a particular way using descending pathways. This explanation, though seemingly very different, is empirically most correct if one goes by the various EEG records. This is one explanation which brings forth cause and effect and reasoning together.

On the one hand, Seen from the point of view of social sciences and psychology, purpose and reason seem to play a big part in the study of action. For example, Maslow's need hierarchy theory, Herbert Simon's decision making theory sees action from this point of view. On the other hand, neurobiological theories of action use cause and effect and reason to understand action.

Having covered all the individual elements of action, and having synthesized them together to form a whole, one would do better to appreciate that reason, cause, and purpose are different frameworks used to understand a phenomenon. Although they present a different picture, there is an intricate relationship that exists between them. Action seen in this light presents the best picture of its function, which is what this paper has tried to achieve.

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