INFERENCE : HEURISTIC VS. NATURALISTIC MODEL

RINITA MAZUMDAR

My aim in this article is to explore the question, "What is reasoning or inference?" In the course of this article I explain and criticize a theory of reasoning or inference which I call the 'Heuristic theory of reasoning (or inference)' that views reasoning as making rational connections among propositions. The main problems with this view are that, as I show here, (1) this type of so-called 'reasoning' can be simulated in a machine, and as I show here, machines, at least in the present state of technology, cannot be said to be 'reasoning'; (2) this theory does not accurately reflect human concept acquisition and conceptual ability; (3) it ignores the *biololgical component* of reasoning; (4) it has no *scientific framework* to support itself. In the course of this article I develop a *naturalistic theory* of reasoning or inference.

This article is divided into two main sections. In section 1, I critically survey the *Heuristic Theory of Reasoning* which I develop primarily from Schank's program.[1] According to this view, to reason is to know some implicit and explicit set of 'rationally connected' propositions; one who 'reasons', according to this view, manipulates some propositions. This view of reasoning excludes how we *as biological* beings actually reason. In section 2, I discuss the 'naturalistic view of reasoning.' The scientific framework from which I draw my theory is G. Edelman's theory of Neuronal Group Selection.[2] In the course of this section, I discuss this theory briefly. I conclude this article with a brief note on why we have to import propositions into our ontology.

1. The Heuristic Theory of Inference or Reasoning

'Heuristic Theory of Reasoning', I contend, has its origin in ancient Greece. Starting with the Greek invention of logic and geometry, Dreyfus observes, it was believed that all reasoning might be reduced to some kind of calculations.[3] Dreyfus says that for Plato all knowledge must be stated in explicit definitions - 'knowing how' must be reduced to 'knowing that' Although, as

Dreyfus says, Plato was more concerned with *semantics* than with *syntax*, the Galelian tendency to formalize physics set a trend to reduce all semantic considerations to formal manipulations.[4] As Hobbes said, "When a man *reasons*, he does nothing but conceive a sum,-total from the addition of parcels,"....."for REASON is nothing but reckoning."[5] Further, for Descartes, all understanding "Consists in forming and using appropriate symbolic representations. For Descartes, these representations were complex descriptions built out of primitive ideas or elements, and Frege showed that rules could be formalized so that they could be manipulated without intuition or interpretation."[6]

In recent times workers in Artificial Intelligence (around 1950's in the U. S) have echoed similar sentiments regarding reasoning; to reason, according to them, is to make some connection among propositions. One of the goals of some workers is to reproduce reasoning in machines. Among these workers, to name a few, are Roger Schank and Terry Winograd for whom reasoning is some kind of 'formal symbolic manipulation'. Schank's program was to simulate human congnition in a machine. He wanted to do this by showing that a machine can be said to be reasoning in the way a human does if it is able to answer questions concerning facts not explicitly contained in a piece of information.[7] Suppose individual *S* imparts to individual *P* the following information : *A* is the mother in law of *B* and *A* has a tendency to resent *B*. Now, after *P* has this information, individual *T* asks *P*, "Is it true that an offspring of *A* is the spouse of *B*?", *P* will answer "Yes". Again, if *T* asks, "Is it true that the offspring of *A* is not the spouse of *B*?" Then *P* will answer "No". "Schankians" would argue that *P* can be said to be reasoning by being able to answer the questions that *T* posed. Such reasoning, Schank contends, can be simulated into a machine. To do this, according to Schank, machines must have a sort of "representation" that humans beings have about "mother-in-law" which enables them to answer questions of the above sort. When machines are given the above information and asked questions not explicitly contained in the information, they will give a printout corresponding to the answers that humans give. This shows, "Schankians" would argue, that the machine, by virtue of some representation, can make rational connections among implicit and explicit rationally connected propositions. I call this the 'Heuristic Theory or Reasoning'. This type of reasoning accurately models, according to these AI researchers, human reasoning. I show in the next few pages that *Heuristic Reasoning cannot be taken as accurately reflecting how humans reason or make inferences.*

Searle has shown by his thought experiment (known as the Chinese Room argument) that it is false to assume that the machine is reasoning because it can answer the above question.[8] Depicting the heuristic model as *the* model for explaining reasoning or inference, according to Searle, is therefore wrong. I present here Searle's thought experiment in a nut-shell. Take the case of an individual, *S*, who is a native English speaker and is illiterate in Chinese; Chinese script for *S* are, in Searle's language, "meaningless squiggles."[9] Now suppose *S* is locked up in a room and at three different stages he is given three different batches of Chinese scripts. At first he is given simply a batch of Chinese writings. At the second stage *S* is given a second batch of Chinese scripts with a set of rules in English by which *S* can correlate the scripts in the first batch to that in the second. Now, being a native English speaker, *S* has no problems understanding the rules.[10] These rules enable *S* to correlate one set of formal symbols with another set; as Searle says, 'formal' here means that *S* can "identify the symbols entirely by their shapes".[11] At the third stage, *S* is given further scripts and some instructions in English to correlate the scripts of the third batch to the scripts of the first two batches. Also, these rules instruct *S* how to give back certain Chinese symbols of certain shapes in response to certain sorts of shapes given to *S* in the third batch. After a lot of trial and error, *S* becomes an expert at manipulating and matching the Chinese symbols. Now *S* can give back answers *in Chinese* as well as a native Chinese speaker. Further, *S* is given a set of English letters and is asked some questions and he has to answer back in English which he does efficiently as he is a native English speaker. From the poing of view of someone *outside the room, S's* answers in Chinese are indistinguishable from a native Chinese speaker; they are as good as his answers in English. In the Chinese case, there is a series of input and output. The followers of Schank and Turing claim that such series of input and output and symolic manipulations accurately model how humans reason, and such reasoning can be perfectly simulated in a machine.

While agreeing with the contention that such series of input and output can be perfectly simulated in a machine, I have serious doubts regarding the reasoning or inferential powers of a machine. My contention is that machines cannot make inferential connections. It is an assumption of the followers of Schank that input-output and symbolic manipulation is enough to explain reasoning; only in case of the Chinese sentences it is more 'formal' manipulation than in the case of English sentences. The basic difference between the English and the Chinese sentence is that, as Searle says, whereas in the former case *S* *understands* the meaning of what he is saying, in the latter case, as Searle says, he does not *understanding* the meaning of what he is saying. The assumption here, as Searle says, is as follows: we can construct a program that will have the same input and output as a native speaker. Searle observes, "The computer and its program do not provide sufficient conditions of understanding since the computer and the program are functioning, and there is no understanding."[12] Searle also says,

> In the Chinese case I have everything that artificial intelligence can put into me by way of a program and I understand nothing; in the English case I understand everything, and there is so far no reason at all to suppose that my understanding has anything to do with complex program, that is, with computational operations on purely formally specifed elements. As long as the program is defined in terms of computational operations on purely formally defined elements, what the example suggests is that these by themselves have no interesting connection with understanding. They are certainly not sufficient conditions, and not the slightest reason has been given to suppose that they are necessary conditions or even that they make significant contribution to understanding. ...
>
> Well then what is it that I have in the case of the English sentences that I do not have in the case of the Chinese sentences? The obvious answer is that I know what the former mean, while I hav'nt the faintest idea what the latter mean.[13]

To summarize, what is considered reasoning by the Heuristic view can be very well simulated in a machine; nonetheless, it does not involve understanding on the part of the manipulator, the machine. It cannot model how humans really reason because humans do understand connections among facts when they are reasoning.

Searle's Chinese Room argument, however, has not been universally accepted. Following Searle, I call the first objection the *Systems or Berkeley Reply.* According to this objection, while *S* by himself does not understand Chinese, it is the sum-total of *S* plus the pencil, paper, data bank that understand the inferential pattern. In other words, the *whole system* understands the inferential pattern, The problem with this assumption is that there are two sub-systems in *S*, one understanding English and the other understanding

Chinese. While the English system, for example, knows that "mother-in-law" refers to mother in law, the Chinese system knows that "squiggle squiggle" is followed by "squaggle squaggle". Searle says, "All he knows is that various formal symbols are being introduced at one end and manipulated according to rules written in English, and the other symbols are going out the other end".[14] This clearly does not involve understanding meaning of the symbols on the part of *S* or the machine. Searle observes,

> The only motivation for saying there *must* be a subsystem in me that understands Chinese is that I have a program and I can pass the Turing test: I can fool native Chinese speakers. But precisely one of the points at issue is the adequacy of the Turing test. The example shows that there could be two "systems", both of which pass the Turing test, but only one of which understands; and it is no argument against this point to say that since they both pass the Turing test they both must understand, since this claim fails to meet the argument that the system in me that understands English has a great deal more than the system that merely processes Chinese. In short, the system reply begs the question by insisting without argument that the system must understand Chinese.[15]

A further objection, which Searle calls the *Robot or Yale reply,* contends that reasoning, as the following case shows, is not a matter of mere symbolic manipulation. Suppose scientist *S* makes an android (or a robot) *R-1* in his lab. *R-1* has a T. V. camera for vision, arms and legs for movement, and a computer for brain. Then the robot would gather information through perception, walking around, moving, etc, and cognize this information as a human being would; such cognition is not a matter of symbolic input-output. The problems with this view is that first, it implicity accepts the point that cognition is not merely a matter of symbolic manipulation. Second, as Searle observes, the same thought experiment as the Chinese Room can be applied here to show that there is no understanding. Suppose that instead of a computer in *R-1's* brain, *S* chooses to put his brother *P* there. *P* receives some Chinese symbol via the T.V. camera and gives out some other Chinese symbols to move the motors inside the robots arms and legs. All *P* is doing here is really manipulating symbols: receiving "information" from the robot's "perceptual" apparatus and giving out "instructions" to its motor apparatus *without knowing what he is doing.* The robot, says Searle, "is simply moving about as a result of its electrical wiring and its program." [16]

Moreover, another objection, which Searle calls *The Brain Simulator or Berkeley and M.I.T. Reply,* has been raised against Searle's Chinese Room. Suppose that we use a program which simulates in *S* the actual sequences of neural firings at the synapses of the brain of a native Chinese speaker when he is reasoning instead of using a heuristic input-output program. In this case, *S* takes in Chinese as inputs which stimulates the same sequence of neurons as it had done with native Chinese speakers and gives back answers in Chinese. There may be a whole set of programs acting in parallel in the manner that actual human brains presumably operate when they process natural language. In this case, we have to say that *S does* understand what he is manipulating.

Searle raises some valid points against this objection. First of all; the above objection is self-defeating. The entire point about the Heuristic view is that reasoning consists in symbolic manipulation and input-output; it does not look into the actual structure of the brain to determine how humans reason. Second, Searle says that his Chinese Room argument, with slight variations, can be adopted here. Instead of monolingual *S* with Chinese symbols, let us think of an individual *P* who is locked in a room with an elaborate set of pipes and valves.

Searle says,

> When the man receives the Chinese symbols, he looks up the program, written in English, which valves he has to turn off and on. Each water connection correspond to a synapse in the Chinese brain, and the whole system is rigged up so that after doing all the right firings, that is after turning on all the right faucets the Chinese answers pop out at the output end of the series of pipes.
>
> Now where is the understanding in this system? It takes Chinese as input, it simulates the formal structure of the synapses of the Chinese brain, and it gives Chinese as output.But the man certainly does not understand Chinese, neither do the water pipes, and if we are tempted to adopt what I think is the absurd view that somehow the *conjunction* (sic) of man and (sic) water pipes understands, remember that in principle the man can internalize the formal structure of the water pipes and do all the "neuron firings" in his imagination.[17]

What this shows is that merely by simulating the neural sequence of firing in a machine (or in this case in *S's* brain), one cannot say that the machine or *S* thereby understands the relevant reasoning pattern.

Furthermore, another objection, which Searle calls the *Combination or Berkeley and Stanford Reply,* has been raised against Searle's Chinese Room. According to this objection, the only way we know that a native Chinese *understands* his language is through his behavior; why cannot we say the same thing about *S?* The objection here is the same as above - a mere input/output series does not make symbols meaningful. So far we have dealt with the heuristic view of reasoning, which, as we saw, can be simulated in a machine. This cannot be called reasoning or inference as no understanding is involved here.

One objection, which Searle calls the *Other Mind or Yale Reply,* has been raised against Searle's Chinese Room. According to this objection, *S* knows that *P* has a mind through observing *P's* behavior. Similarly, we can say of a machine, by observing his behavior, that he has a mind. Searle objects to this reply by saying that the problem with this objection is that the Chinese Room argument is not concerned with knowing another person's congnitive states but as Searle says, "What it is that I am attributing to them when I attribute congnitive states to them. The thrust of this argument is that it could'nt be just computational processes and their output because the computational processes and their output can exist without the congnitive state. It is no answer to this argument to feign anasthesia. In "congnitive sciences" one presupposes the reality and knowability of the mental in the same way that in physical sciences one has to presuppose the reality and knowability of physical objects."[18]

A further objection, which Searle calls *The Many Mansions or Berkeley Reply,* has been raised against Searle's Chinese Room. According to this objection, Searle's arguments are not directed towards *AI* as such but only towards analogue and digital computers where the input-output has no intentionality; but that has more to do with the present state of technology than *AI* itself. Eventually, scientists may be able to make a machine with intentionality in its input-output series. According to Searle this objection reduces the whole purpose of *AI* to that which produces cognition. The aim of *AI* is to produce mental processes that are computational processes over formally defined elements. By redefining this claim the original purpose of *AI* is lost.

Moreover, I object to the Heuristic Theory of Reasoning, as it does not accurately reflect human concept-acquisition process. The theory assumes that each time an individual thinks of a concept (say, mother-in-law), he represent it in the form of proposition which individuates it. This ignores an important component of learning process of humans: habit formation and internalization of propositions. Moreover, perhaps at first individuals do learn concepts *de dicto*, gradually, however, these concepts become *de re* for him. He does not have to remember or evoke the entire proposition every time he thinks of the concept. This power of *internalizing* concepts is absent in machines and is present in humans. Flores observes, "Even though a beginner in a field like chess starts by following rules, a mid-level player dispenses with such rules and uses more intuitive, holistic, and seemingly immediate knowledge about what is happening in the game and what the player should do. A high level expert, on the other hand, appears to combine more experience-based rules of thumb with intuition".[19]

In addition, according to the Heuristic view a concept is a static entity which is individuated by the same set of propositions for an individual during his lifetime. Concepts, I contend, are dynamic and the same concept may have different implications for the same individual at different times. Moreover, problem arises as subject, the inferrer, is involved in the inferential process. According to the Heuristic view of reasoning, each proposition in an inferential process is independent and can exist outside a human being. One proposition can be inferred from another without being part of the subject's epistemological framework; the relationship between an inferrer and what he is manipulationg, according to the Heuristic view, is thus an external one. Lastly, I object to the Heuristic view of reasoning or inference as it does not provide any scientific framework for a philosophy of mind to support reasoning or inference.

I provide below a scientific theory of the mind. First, any scientific theory of the mind must show how our reasoning is rooted in the model of mind. Second, the theory must be based on real experimental science and not on some a *priori* arguments. Third, it must have a multi-level approach to the complex function of brain and nervous system. Lastly, such a theory (like all good scientific theories) must be falsifiable. I present below what I consider a solid scientific framework to support my theory of reasoning or inference: Edelman's theory of Neuronal Group Selection.

2. The Naturalistic Theory of Inference

According to what I call the Naturalistic theory of Inference, inference is an interconnection of belief states. Belief states, I contend, are states of consciousness whose intrinsic feature is recognition.[20] Edelman defines recognition as, "Continual adaptive matching or fitting of elements in one physical domain to novelty occurring in elements of another, more or less independent domain, a matching that occurs without prior instruction."[21] If recognition is the intrinsic feature of belief states then this definition clearly brings belief down to the realm of biological studies and relieves it of abstract propositional content. I consider below some aspects of Edelman's theory.

Edelman applies the theory of evolution to neurons. The interesting thing about Edelman's concept of evolution is that he applies it to groups instead of to individual cells. Cells, according to Edelman, form the embryological basis of our structures. The most important feature of these cells is that they migrate from one place to another; this migration is only partly determined by the DNA structure of the cells. There are two factors that affect this migration: (1) the internal structure (DNA) of the cell (the release of a particular DNA at a particular time is entirely determined by its position in the entire structure); (2) the way the cell reacts according to its definite position in the entire structure. DNA therefore is not the only factor that directs each individual where to go and what to do. The trajectory of cells is undetermined; they live in an undetermined amount of time (depending on internal resource and the environment) and respond and function according to their internal DNA programming and their location within the whole structure. Cells, including neurons, survive as individuals. These migrations of cells are responsible for tissues, organs, and subsystem; the nervous system is such a subsystem and it is composed of (at the basic level) neurons with dendrites at their ends loosely in contact with other dendrites through synaptic connections (which are neurotransmitters or electrically charged bio-molecules) through the limbs at the end of the dendrites. The number of neurotransmitters fired between receptors are directly proportional to the electric current charged between them. The strengthening or weakening of neural connections is caused by the amount of neurotransmitters. The more signals pass through these dendrites the stronger the connections are; the fewer signal pass, the weaker the connection. The connections amongst neurons (directly or indirectly) form maps. Thus, say, $neuron_x$ of $cluster_1$ is connected to all other neurons of $cluster_1$, to neurons of $cluster_2$, to tissues and organs (internal and external), and to a remote neuron in $cluster_6$ through $cluster_2$. These connections among neurons and clusters can be mapped; thus we have several maps tracing various connections among neurons [See Figure 1 (next page)]. Edelman[22] says,

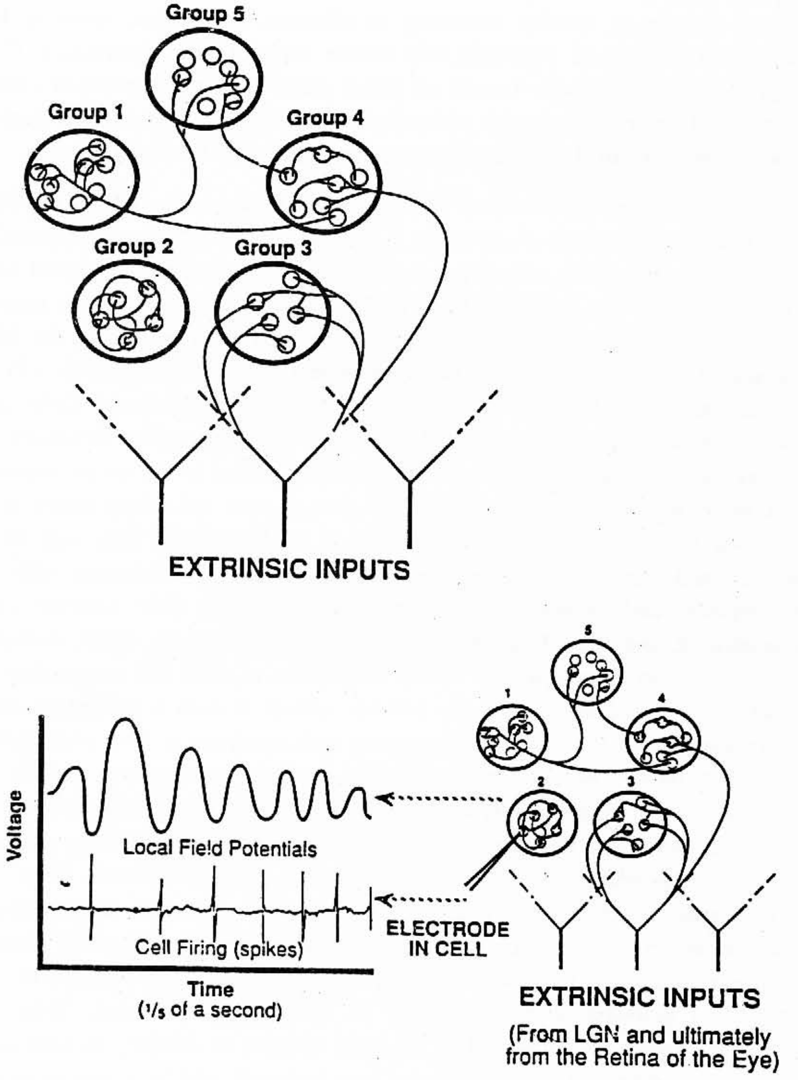
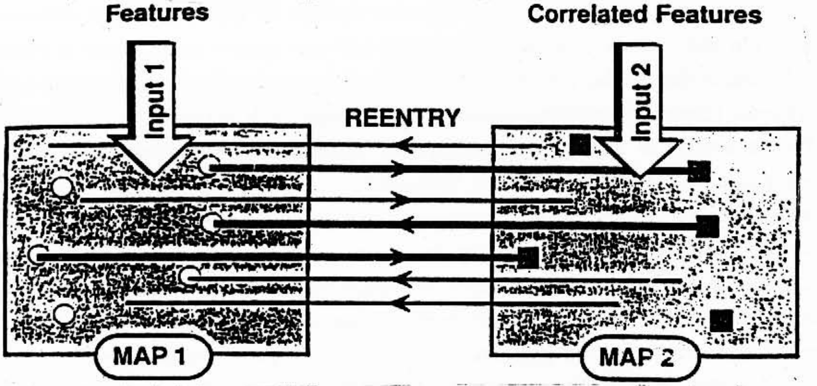


Figure 1 : Cells and Stimulus

Each map *independently (sic)* receives signals from other brain maps or from the world (in this example, the signals come from the worls). Within a certain period, reentrant signaling strongly connects certain active combinations of neural groups in one map to different combinations in the other map. This occurs through the strengthening and weakening of synapses within groups in each map and also at their connections with reentrant fibers. In this way, the function and activities in one map are connected and correlated with those in another map. This occurs even though each map is receiving independent signals from the world : One set of inputs could be, for example, from vision, and the other from touch. [See Figure 2 (below)]



Reentry. Two maps of neuronal groups receive independent inputs (1 and 2). Each map is functionally segregated; that is, map 1 responds to local features (for example, visually. detected angles) that are different from those to which map 2 respond (for example, an object's overall movement). The two maps are connected by nerve fibers that carry reentrant signals between them. These fibers are numerous and dense and serve to "map the maps" to each other. If within some time period the groups indicated by the circles in map 1 are reentrantly connected to the groups indicated by the squares in map 2, these connections may be strengthend. As a result of reentrant signaling, and by means of synaptic change, patterns of responses in map 1 are associated with patterns of responses in map 2 in a "classification couple." Because of synaptic change, responses to present inputs are also linked to previous patterns of responses.

Figure 2 : Reentrant Maps

The question now is, "How can this structure account for belief states with recognition as their intrinsic features?" The answer is as follows: Synaptic responses to stimuli vary according to stimulus types - visual, auditory, tactile, olfactory. Depending on the stimulitype, independent maps are formed. The signals that come to us from the environment create bio-molecular activity inside its own particular cluster forming maps. Let us call the stimulus coming from a ripe banana via our visual senses, map_1, the tactile stimulus, map_2, the olfactory stimulus, map_3. Now the map that forms between map_1 and map_2 is a reentrant map. These reentrant maps provide the basis of our recognition for association between things; they also form the basis for pattern recognition and recognition of the salient feature of a thing. Nervous system of individuals are different in different individuals. The structure of the nervous system is different in dirrerent individuals due to the variety of neuronal groups (selected through randomness), synaptic responses, reinforcement of maps; thus each nervous system is unique. The neurons in charge of perception created by reentrant loops provide perceptual categorization of the immediate present. Value-category memory, a special feature of the nervous system which is located in the frontal, temporal, and parietal cortex of the human brain, assigns value to this perceptual categorization and in the next state we reach belief states for which these values are intrinsic. The value category memory stores our rules of concepts usage and when this memory loop gets attached to the perceptual categorization we reach belief states. We are then aware of our surroundings; we recognize entities as *X's* or as a *Y's* Memory loop stores the rule of concept-usage, acquired in the past and applies them to the present perceptual categorization. As this loop is responsible for our conceptual categorization or belief states, Edelman terms the latter, "remembered present". This memory, where the rule of concept-usage is stored, is achieved through classification and reclassification of reentrant loops between different clusters of neuronal groups according to the adaptation to the environment achieved by our behavior/response to external stimuli. Our value-category memory stores the rule for concept usage (e. g. whale usage, apple-usage) and endows value or meaning to these reentrant loops.[23]

Inference, I contend, is a causal transition from one belief state to the next. Mere causal transition is nothing more than connection between one reentrant loop and another; such transition can be explained by the laws of biology. When value category memory regulates and puts constraints upon these reentrant loops. (i. e. when belief states are formed) the transition process instantiates inferential patterns. Such regulations are obtained by the usage of concept rule, involved within these belief states, in natural language. In all cases of inference the derived states are well-grounded on the basic states. When *S*, for example, is in the belief state that he sees an apple then, in the presence of some of his additional belief states, the former belief state will cause his belief state that an apple (not an orange) is there. These additional belief states are conducive to apples being in the environment. Further, as the whole transition process is guided by the rule of apple usage (that is its usage in ordinary language) it instantiates an inferential pattern.

In all inferences some additional beliefs (or propositions) are included. The question is: if inference is a transition between belief states, what is the function of beliefs as propositions? In other words, what is the point in bringing propostions into our ontology? Beliefs have propositional contents. The content of *S*'s belief is the proposition that Jones owns a Ford, which *S* takes to be true. In contrast, the content of *P*'s belief is that the apple is red, which *P* takes to be true. Beliefs are individuated by their content: *S*'s and *P*'s beliefs are different as the contents of these two beliefs. Millar says that beliefs with different contents are different *types* of beliefs. If *S* and *P*, however, believe the same things, their beliefs would be of the same *type*. If , for example, *S* and *P* both believed that *Jones owns a Ford*, their beliefs would be of the same type; they would, however, differ quantitatively as they are beliefs of two different people. To quote Millar,

> If Kate's belief *B* is the belief that *p* and Fred's belief *B'* is the belief that *q*, and the proposition that *p* is not the same as the proposition that *q* then B and *B'* are different beliefs in the sense of being different belief-types. This regiments the common-sense thought that people have the same belief only if what they believe is the same.[24]

Different belief states, in contrast to beliefs, are not of different types; thus, *S*'s belief state (believing an apple to be there) or *P*'s belief state (believing Jones to own a Ford) are not different types of belief states, but are belief states of different types. The primary difference between beliefs as propositional and belief states is that the former, unlike the latter, can be true or false. What makes beliefs true or false are their contents; contents do not perform the same function in belief states. Of course, each of these states necessarily has a content, or is focused on a proposition, and a person in that state must have a concept involved in, or appropriate to, that content. But the state is not thereby true or false; these properties belong to the state's content or the proposition it is focused upon. Nonetheless, these states do not have the properties of their content. Two token beliefs may be generically the same, yet may be causally different. Belief states are physical states and are causally efficacious. In the above case, *P*'s belief state (Jones owning a Ford) is sustained by belief states such as the following: *P* believing that Mary was right when she said that Jones owns a Ford (after all she is a close friend of Jones), *P* believing that Mary does not usually lie, and so on. Suppose *S* is also in the same belief state (Jones owing a Ford) which can be sustained by the following belief state: Jones has given *S* rides many times; *S* has seen Jones driving the car out of his garage for the last Fifteen years since he moved into the neighbouhood, etc. So the causal ancestry of *S*'s and *P*'s belief states are different.

Propositions are imported into our ontology in order to give *content* to our thoughts. It is possible to conceive of a distinction between (1) having a thought and (2) thinking a thought. I may think that the weather is good. In this case, the latter proposition (the weather is good) is the content of my thought and has a truth value, i.e., is either true or false. In contrast to this, I may also think about the above thought as follows: "The first thought that I had this morning' the latter thought, unlike the former, has no truth-value, for it has no distinct content. In other words, it is non-propositional thinking. Belief states do not have distinctive content. For example, in the case of the above inference the belief state of *S* that there are additional factors for his believing that there is an apple does not tell us *what* these additional factors are. One such factor is, "All experiences of apples are caused by real apples in the external world" (B). Subsequently, however, *S* may come to know that sometimes plastic apples cause humans to have experiences of apples. In such case *S* will attribute 'falsity' to the above general proposition or belief *B*.

To summarize, a belief state is a state of primary consciousness with recognition as its intrinsic feature. Inference consists of causal transitions from one belief state (state of primary consciousness) to the next. Such a transition is guided by the rules of concept-usage involved within these states. In such transition some additional beliefs are implicated.

NOTES

1. R. C. Schank. 'Conceptual Dependency : A Theory of Natural Language Understanding'. *Congnitive Psychology, 1972:3.*
2. G. M. Edelman. *Bright Air, Brilliant Fire : On the Matter of the Mind, 1992:* New York: Basic Books.
3. H. Dreyfus, H. *What Computers Still Can't Do, 1963..* Cambridge, Massachusetts, MIT Press, Introduction.
4. *Ibid.*
5. *Ibid.*
6. Hobbes, H. L. D. *Leviathan, 1958.* New York : Library of Arts, 45.
7. Schanks' original idea was that after hearing a story a machine can answer questions about the story which are not explicitly part of the story. I adopt this a little differently.
8. J. Searle, 'Minds, brains, and Programs'. *Behavioral and Brain Sciences, 1980:* 3, 418.
9. *Ibid,* 418.
10. *Ibid,* 418.
11. One can use the word "program" for rules.
12. Searle as above, 418.
13. *Ibid,* 418.
14. *Ibid,* 419.
15. *Ibid,* 419.
16. *Ibid,* 420.
17. *Ibid,* 421.
18. *Ibid,* 422.
19. I have quoted this from a part of Flores's unpublished Ph. D. dissertation which he presented at the CAP conference, Los Angeles, 1994. Later, on my request, Flores sent the document to me electronically.
20. I argue later that a belief state is some sort of "remembered present" because the memory loop which has the concept categorizes our reentrant loops.
21. Edelman as above, 74.

22 *Ibid*, 87.

23. I have borrowed the phrase "value-category memory" from Edelman (1992).

24. A. Millar. *Reason and Experience, 1991:* Oxford: Clarendon Press, 21.

Bibliography

1. Dreyfus, H. *What Computers Still Can't Do, 1992.*. Cambridge; Massachusetts: MIT Press. Introduction.

2. Edelman. G. M. *Bright Air, Brilliant Fire: On the Matter of the Mind, 1992:* New York: Basic Books.

3. Hobbes, H. L. D. *Leviathan, 1958.* New York, Library of Arts.

4. Millar. A. *Reason and Experience, 1991:* Oxford: Clarendon Press.

5. Ricardo, F. *Proposed Philosophical Framework for the Search and Development of Artificial Intelligence. 1993.* Unpublished dissertation proposal. San Diego. UC: Department of Philosophy

6. R. C. Schank. 'Conceptual Dependency: A Theory of Natural Language Understanding'. *Congnitive Psychology, 1972:3.*

7. J. Searle, 'Minds; Brains, and Programs'. *Behavioral and Brain Sciences, 1980:3.* University of New Mexico, Valencia.