BOOK REVIEW : I

***Human Cognition : A Multidisciplinary Perspective* (EDS.) Indramani Singh and Raja Parasuraman New Delhi/Thousand Oaks/ London:Sage Publications, 1998, pp. 372, Price Rs. 425(cloth).**

The rise of the *Cognitive Paradigm* has been one of the most exciting achievements in the last 40 years in developing a framework for the scientific study of cognition, cognitive phenomena and intelligent systems. This is responsible for the dramatic shift away from Behaviorism that dominated the field since around 1913.

The emergence of the Cognitive Paradigm allowed one to study not just learning (E.C.Tolman, 1930, 1938[1]) but memory (F.C. Bartlett 1932[2]) not just speech but language (Georage A. Miller and Noam Chomsky, 1963, G.A. Miller 1956, 1986, N. Chomsky 1957[3]); and not just stimulus and response but the rpresentations (Kenneth Çraik 1943[4]) and processes (J.R. Anderson 1983[5])that mediate them.

The paradigm eventually resulted in an integrative discipline, called *Cognitive Science*. Its objective is to study human cognition "scientifically", i.e. instead of addressing questions relating to human cognition in a purely speculative fashion,Cognitive Science formulates empirically assessable statements and theories about a wide range of mental phenomena and devises powerful falsification procedures to test them.

Cognitive Science is a product of the interaction among several disciplines- psychology, linguistics, philosophy, anthropology, neurobiology, Artificial Intelligence- all of which are engaged in understanding cognition. This interdisciplinary area has come a long way from its nascent form in the formalism of mathematical psychology through the work on language, information theory and neuroscience-with interchange among psychologists, linguists, philosophers, neuro-biologists-to the current stage of hopeful maturity.

We are beginning to appreciate Kant's contribution, what he himself called the *Copernican Revolution* in epistemology: the revolution of construing the mind as active in the accrual,construction, storage, representation, development and deployment of knowledge, in our attempts to understand and explain human intentional behaviour. This *mind's new* *science* resurrected the mentalistic explanations, mental states and processes, and demonstrated their necessity, proving that the Behaviourists are wrong in their claim that mental states and processes are redundant and unscientific. Ulric Neisser says,

> "The basic reason for studying cognitive processes has become as clear as the reason for studying anything else : they are there ...Cognitive processes exist, so it can hardly be unscientific to study them ."

Johnson-Laird remarked that

> "if cognitive Science does not exist then it is necessary to invent it ".

Robert C. Richardson states,

> "It was unfashionable to think we can think. Fortunately fashions Among philosophers and psychologists alike, it has once again become common to speak and think in terms of mental acts, cognitive processes, internal representations, information, interpretations, or any of a host of related conceptions when attempting to explain or understand human behaviour."

Nevertheless, some researchers have accused that Cognitive Science does not have a common research paradigm and is often treated merely as an umbrella discipline. This has provoked N.E. Sharkey to say that the experts in the constituent disciplines get together in search of research funds and confuse each other about how to proceed with their research. The remnants of the Behaviourist tradition of strict experimental control and the use of quantification still persist in certain areas of research in Cognitive Science. This led Gilbert Harman to remark that specialists in Cognitive Science often differ in their ideas about what the relevant issues are, how they should be addressed and their research paradigms are often very different. In spite of this diversity, the common concern with the issues relating to human cognition appear to unify the field. The diverse disciplines play the complementary role which provide a bond that seems to be as strong as the one binding microphysics and astrophysics together. We must see why people are not right when they reach dismissive conclusions and reject Cognitive Science as a coherent discipline.

However, in order to get a feel for what binds these disparate disciplines together it is very important that any student, researcher or professional concerned with human cognition is able to form a clear perception as to what the pertinent issues are, how they are to be addressed, and what the dominant research paradigms are. The book under review not obly exhibits the richness of the contemporary research on cognition, but provides evidence for the diverse methodologies and the difficult choices that remain to be made in studying cognition.

Cognitive Science in its efforts to explain intentional behaviour and other cognitive activities of humans formulates theories that postulate the representations used by the cognitive systems to perform the various tasks[6]. There are two dominant approaches to modeling representation: the symbol manipulation approach modelled by Turing machines and the *connectionist* approach conceived in terms of neuron networks. The problems faced by these approuchas such as *symbol grounding problem*[7] frame problem[8] for the symbol manipulation approach and the problem of *training a very large set to learn* relevant structures and the problem of determining what the emerging networks represent through learning[9], have led to increased emphasis on understanding the nature of representations in the biological systems based on empirical findings in psychology and neuroscience. The book under review takes precisely this approach.

In the *introductory article* the editors acknowledge this *diversity in Cognitive Theory* and then go on to identify the most dominant approaches. The book does not, however, pretend to provide a comprehensive survey of the field, but does a very good job in delineating some of the most important research paradigms and areas of concern.

There are three sections in the book. The papers are grouped in terms of their relevance to the following topics:

(i) elaborating one of the most important research paradigms, viz,. Cognitive Neuroscience,

(ii) providing explanations of some of the most important cognitive phenomena, viz.,attention, memory, language and emotion, and

(iii) applying the cognitive paradigm to two real world issues, viz., human factors and medical education.

(i) Cognitive Neuroscience

Cognitive Neuroscience is an interdisciplinary field that grew out of dialogue between Cognitive Psychologists and Neuroscientists (LeDoux and Hirst, 1986)[10]. In the late 1950s and early 1960s, many Cognitive Psychologists took pains to distinguish their endeavour from neuroscience under the influence of a philosophical view, known as ***functionalsim*** (forcefully articulated later by Putnum 1975, Fodor 1983)[11] and an argument, called **the multiple realisability argument** (Neisser 1967, pp.6-7, and made popular by Marr 1982)[12] In short, it was claimed that the models of the mind could be devised independent of any consideration of the nature and function of the brain. However, this attitude changed gradually due to the success of neuroscience in clarifying issues important to the cognitive psychologists.

In the recent past considerable progress has been made in our understanding of the nervous system and brain functions based on the analysis at

(1) the molecular level,

(2) the cellular and intercellular level,

(3) the behavioural level, and

(4) the level of systemic breakdowns i.e., brain pathology

1. Analysis at the molecular level

At the molecular level the neuroscientists have been able to isolate and identify the specific molecules used by nerve cells for maintaining their functional identity. The information about molecules peculiar to certain classes of nerve and non-nerve cells can now be obtained from extremely specific antibodies. Moreover by using certain biophysical techniques, such as mass spectrometry, nuclear magnetic resonance and liquid chromatography, it is possible to give more detailed chemical descriptions of the nervous system.

Recent developments in genetic engineering have made it possible to isolate and describe specific proteins of certain neurons which play a role in synaptic transmission and in the functioning of the nervous system, especially peptides and receptors.The classical biochemical techniques failed to detect them.

2. Analysis at the cellular and intercellular level

At this level an improved understanding of the biology of nerve cells and bettter insight into the molecular bases underlying communication between them have enabled us to comprehend the nature neuronal circuits. Based on the advances made in enzymology, immunology and cell physiology the neuroscientists and anatomists today can identify specific classes of cells and trace the pathways linking one neuron to another by using techniques of cell marking and staining. Our knowledge of interneuronal çommunication has also improved because of the insights provided by our knowledge of circuits on synaptic transmission. The synthesis and simulation of new neurotransmitters have led not only to a better understanding of certain illness and diseases, but also to devising new diagnosis and methods for their treatment as well.

3. Analysis at the behavioural level

In the recent past the range of techniques available to record the electrical and biochemical activities of the brain during the performance of a strictly monitored task or behaviour has improved considerably. These techniques vary from those recording unitary activity of an isolated neuron within a specific brain structure to various non-invasive techniques.

With the help of microelectrodes which register the action potentials emitted by the neuron in response to a particular stimulus it is now possible to record the electrical or biochemical activities of the brain corresponding to clearly defined behavioural tasks of freely moving subjects. However, the microelectrodes provide information only of the activity of a precisely located individual cell in the immediate vicinity of the microelectrode, but fail to give comprehensive information about brain activities involving aggregate of concurrently active neurons.

There are several non-invasive techniques that can gather electrophysiological indices for spatial and temporal distribution of brain activities, known as *event related potentials*, viz., measurement of blood flow and the local brain metabolism that reflect regional variations in brain activity, advanced brain imaging techniques, such as positron emission tomography (PET), the use of unclear magnetic resonance imaging (MRI) for obtaining images of issue metabolism, functional MRI (fMRI), electroencephalography (EEG), event-related potentials (ERP)etc. These highly efficient techniques enable the cognitive psychologists and neuroscientists to describe the normal mode of functioning of the brain when the subjects are at rest or enhahed in performing such tasks as memorizing, paying attention, solving problems, recognizing objects, dreaming, and so on.

An example of such research can be given from the work done in ***language learning.*** The instinct to learn, speak and understand language has ever remained a mysterious cognitive feat. Research in ***language learning*** is one of the most active areas in Cognitive Science as it goes beyond the conventional Behavioural approach that language acquisition and development is merely the result of vocabulary growth based on stimulus-response and operant conditioning. Computational Science and Technology is also extremely interested in this problem because of the need to reduce the man-machine gap so that computers become easier to interact with and the benefits of information technology are available to a much wider cross-section of people.

The Cognitive approach to language learning implies the construction of *models* in order to explain the cognitive processes that are involved and provides the *representation* of the rules at several levels that define the conditions of well-formedness of sentences, e.g. at the levels of phonology, morphology, syntax, semantics and pragmatics.

Considerable effort has been made (by Osherson et al and Wexler et al[13]) to understand the *formal properties of systems* for language acquisition. However, such *studies on learnability* must relate to natural language [14] and need to be supplemented by data from psycholinguistics, psychobiology[15], infant studies[16] and the effects of the linguistic environment that illustrate the use of the experimentl method in Cognitive Science, in order to

- understand the boundary conditions of the initial state of the cognitive system, e.g., infant studies,
- uncover the characteristics of language processing units across

languages, e.g., the ability to discriminate phonemic categories, and

- determine at what level environmental effects, say speech perception in a multilingual environment, modify functional architecture, e.g., 'the modularity of mind.'

One of the active areas of research is infant study. Lenneberg (1967) claims that at birth the brain is equipotential and that the left hemispheric localization of language is a by-product of language acquisition. However, several other infant studies (cited in the endnote 7) carried out using PET technique with the objective of understanding the boundary conditions of the initial state of the cognitive system suggest that the brain is lateralized at birth for all languages and becomes progressively attuned to the maternal tongue. Besides, the studies reveal that from birth infants are able to discriminate foreign languages from the prosodic information present in the speech signal.

The fundamental issues mentioned above have inspired investigations into the computational aspects of language acquisition and construction of machinery which automatically acquire language. Fundamental insights into cognitive processes of language learning can lead to the development of actural ***algorithms***[17] and ***computational structures***[18] for lexical, syntactic, semantic and pragmatic knowledge underlying language acquisition.

In the very first article of the book ***Posner*** surveys the research findings in Cognitive Neuroscience relating to the structure and function of the underlying neural circuitry of the human brain which from the basis for the understanding and explanation of various cognitive processes. The findings reveal four important properties of the cognitive tasks, viz., locaization, networks, attentional modulation and plasticity. The studies of the cognitive tasks mentioned in Posner's article include selective attention, lexical access and number processing. Posner shows how the imaging techniques, like PET, MRI and ERP, were used in order to detect increased local neural activity and the mechanism underlying cognitive processes.

Rammsayer's paper emphasizes the significance of the pharmacopsychological approach in cognitive-neuroscience by examining the effects of drugs on the neurochemical systems in the brain that mediate specific cognition, e.g. time perception. His studies show how time estimation or temporal processing of very brief durations, say below 100 msec, are largely automatic and are based on the activity at lower level of the brain. The studies also enhance our understanding of the role played by DA (dopamine) receptor activity in the basal ganglia for the lower sensitivity to time. Therefore, the author concludes that temporal processing of very small durations is beyond cognitive control and independent of pharmacologically induced deteriorating brain mechanism and cortical arousal. However, the author maintains that discrimination or temporal processing of longer durations, say in the range of seconds or more, is primarily based on memory processes and the processing is done at a higher level of the central nervous system. Thus, the paper elucidates the mechanisms underlying temporal information processing.

In the third paper ***Panicker*** and ***Parasuraman*** review the research on the neurochemical basis of cognitive functions, for example attention. The sophisticated brain imaging techniques, such as PET,MRI, fMRI, EEG, ERP etc have provided us with a better understanding of the role of subcortical neurochemical systems in the modulation of cortical functioning. Moreover, attentional deficits that accompany such diseases as Alzheimer have also given us valuable insights into our understanding of neurochemistry of attention. The authors identify different neural mechanisms controlling specific functions for attention:

- the noradrenergic system originating in the locus ceruleus appear to perform a ***general*** arousal or altering of attention,

- the midbrain mesocorticolimbic and nigrostriatal dopaminergic system play a *specialized* role in activational or motoric aspects of attention, and finally

- the basal forebrain cholinergic system is responsible for the selective modulation of sensory inputs that are transmitted to the cortex via thalamocortical projections.

These systems, however, function as interacting networks operating in parallel substantiating the validity of the subsymbolic connectionist approach.

The review of research presented in the last paper of this section by *Matthews*, *Harley* and *Davies* provides a model involving two levels of explanation for extraversion and arousal effects on attentional task performance. On the one hand, the model links individual differences in arousal and extraversion to specific information processing mechanisms, such as visual attentional resources, for attention. On the other hand, the model incorporates the psychobiological interactive effects of extraversion and arousal with diurnal regulation of activity. For example, the extraverts benefit from high arousal in the morning because of the energy-intensive motor and cognitive responses at that time of the day.

4.Analysis at the level of systemic breakdowns, i.e., brain pathologies:

The analysis indicates the way in which psychological functions or dementia are affected by disease, genetic disorder, neurosurgical intervention and physical injuries to the nervous system resulting in a profound deterioration in cognitive abilities. Such studies not only have obvious bearing on clinical diagnosis, treatment and rehabilitation, but also reveal the way the complex neurophysiological system breaks down and thereby provide valuable data for developing theories of cognitive function for both human beings and artificial systems as well.

The earliest impetus for the development of Cognitive Neuroscience came from the studies on adults suffering from reading and writing disorders, known as *dyslexia* (e.g. unable to read non-words, such as *Thork*, or making semantic errors in reading, such as *little* read as small.) Disorders in object recognition was another important research area. In the late 1970s David Marr developed a detailed information processing model of. *object recognition*. This provided some understanding of impairment of object recognition by patients suffering from agnosia. For example, some patients are unable to classify an object, say chair, although they are capable of discriminating more elementary visual proprties such as colour, shape, size and texture.

(ii) Cognitive- Neuroscientific explanations of some of the most important cognitive phenomena :

Memory

One area in which the interaction between the Cognitive Psychologists and the Neuroscientists have been most intense is the field of momory. The reason for this is that the question as to how information is stored and retrieved is basic to all cognitive systems. However, the two disciplines, viz., Cognitive Psychology and Neuroscience, consider what each of them take to be important and tractable questions. The interest of the Cognitive Psychologist on memory center around such question as why recognition is much better than recall, why visual material is remembered better than verbal material. On the other hand the Neuroscientist may be more concerned with questions of the following kind: what areas of the brain mediate memory? Or which brain areas are connected to which other area ? Some aspects of Neuroscience of memory may provide answers to questions posed by the Cognitive Psychologists, others may be of little relevance. The overlaps may lead to fruitful interactions, which has certainly increased over the years.

Till late 1970s the study of amnesia provided the main basis for constructing the architecture of the memory system. The information processing models of human memory distinguishes several processes of storage and retrieval, and have subdivided memory stores according to the type of information they handle. Studies on brain damage have shown that such damages have selective effects on memory. It has been found, for example, that some patients with brain damage are unable to recall past events and suffer from, what is known as *retrograde amnesia*, whereas others are unable to recall recent events. Paradoxically, however, both types of patients have little difficulty remembering words, numbers and other types of information having no relationship with particular events. This has led to the conclusion that amnesia involves impairments in storage and retrieval of ***episodic*** information, and not of ***semantic*** kind.

In the book under review, the article by ***Dwivedi*** **and** ***Srivastava*** raises the important question as to whether episodic and semantic memories are structurally and functionally independent. The author's work based on famous and nonfamous names seem to support Tulving's contention that episodic memory is a unique extension of semantic memory, rather than a separate, parallel system[19]. The authors maintain that "...memory is an integrative, holistic, associationistic, conscious and cognitive structure, which calls for an interactive rather than a fully independent functional unitary system" (pp.201).

Attention

The other research area of Cognitive pathology covered in the book relates to ***attention,*** caused by Alzhier's disease (as reported in the article by ***Parasuraman and Greenwood***) and insidious onset and progressively worsening of brain functions due to normal aging (as investigated by ***Fisk and Rogers***). Apart from causing loss in the *detection* efficiency, the impairment in the cortical network due to *Alzheimer's disease* and *normal aging* may also affect other cognitive abilities such as momory and learning. A comprehensive review of the research on *Alzheimer's disease* and attention (Parasuraman and Haxby, 1993)[20] sheds light on how such studies of brain impairments can enhance our understanding of the underlying cognitive architecture and mechanism. ***Deaton*** and ***Parasuraman*** claim that age difference shows a greater performance decrement in *monitoring* sensory, cognitive tactical or vigilance tasks. However, no overall *performance* differences are noticeable between age groups for both sensory and cognitive vigilance tasks. This has implications for monitoring efficiency in pilots of different age groups.

Language and Communication

At the center of the study of human cognitive system lies the study of language. The reason for this is that language is widely regarded as the distinguishing characteristic of human cognition. Moreover, language use is ubiquitous and often forms a vital component of an enormous range of human activities.

According to some cognitive scientists (Pinker, 1994)[21], the *instinct* to learn, speak and understand language explains the remarkable communicative ability so characteristic of human species. The ability to use language normally involves the ability to deploy knowledge of words and grammatical rules in the service of communication intent. If the relevant genes, neurons or the identifiable part of the brain are disrupted, linguistic ability suffers while the other parts of intelligence carry on.

Studies on patients suffering from *Broca's aphasia* show that our knowledge of words is subdivided into semantic categories. For example, some patients have relatively preserved vocabulary for concrete words while others for abstract words. Similarly, the ability to structure speech grammatically can be impaired, a condition called *agrammatism*, even though general vocabulary is relatively preserved.

In his paper *G.C.Gupta* emphasizes the factors that are different from the biological ones. Some researchers[22] have claimed that apart from the biological factors, which provided the main basis for Chomsky's *theory of competence*, there are *contextual macro-and micro-environmental* or *ecological* fctors that contribute in shaping the language faculty in natural language generation based on human interaction in non-imaginary societies. These factors have effects on several aspects of language use and competence, such as translation, deep structure and idioms. Hence, the limits of *language-universal*, (i.e., those properties of grammar which are universally available to a child by virtue of his innate ability for language or understood to form part of the biological endowment of the mind/brain system with an initial state S_0 common to the species) needs to be compared with such language specific knowledge and processes that result in subsequent relatively stable steady state. Gupta uses the *competition model*[23] to explain cross- linguistic data in a linguistically diverse society, such as India, in order to justify his claim that "the change from the initial state of the *universal grammar* to the *acquired grammar* involves a process of enrichment of the language faculty constrained by the UG template "(pp.209)

Analysis of the acquisition of linguistic skills involves three levels : (a) biological, defining the boundary conditions of the initial state of the cognitive system, (b) sub-symbolic activation for the lexical access, and (c) the symbolic representation.

Emotion

Stewart and Singh also emphasize factors other than biological ones in their study on facial emotions. Non-verbal communication through *recognition* and *production of facial expressions* is a basic cognitive mechanism for social interaction[24]. Studies show that mentally retarded children and people with psychiatric disorder are found to lack the skill to recognize and produce facial expressions. Such lack of skill may not necessarily be caused by neurological impairment or function, rather it may be due to the inability to acquire the relevant processing routines or formal operational rules. Stewart and Singh claim that such skills in social interaction require the "ability to translate visual representations of the face into verbal representations (Comprehension of emotion) and verbal representations (instructions) into motor codes necessary to produce facial expression". The authors maintain that deficits in such skills can be remedied through instructions, training and directed rehearsal of the distinguishing features of the six basic facial expressions of emotion.

(iii) **applying the cognitive paradigm to two real world issues, viz., human factors and medical education.**

Automation and Human Factors

Modern control systems use advanced information technology for providing support to human decision making during supervisory control tasks and emergency management. Models of human information-processing abilities and limitations are prerequisites for the basic conceptual design of such systems.

The experience with early computer installations aiding human beings in their supervisory control tasks clearly indicated the pressing need for an analysis of operator's *cognitive* tasks and guidelines for *interface design*. The developments in psychology and AI, i.e., the transition in psychological research away from Behaviourism and the preoccupation of the early research in AI with games and theorem proving, did not provide the necessary guidelines for the analysis of cognitive tasks and interface design. The researchers in this area had to rely on the verbal protocols derived from real work situations in order to develop the conceptual framework.

Broadbent (1971)[25] suggested a model of human information processing and identified three distinct mechanisms: perceptual encoding, translation process, and response selection and execution. In this model Man-Machine interaction can be seen as a complex, multidimensional demand-resource matching process tuning of the sensorimotor schemata of the internal cognitive model to the time-space features in the environment. Breakdowns in such interaction take place whenever human-machine or human-task mismatches occur. For example, Broadbent and Sternberg (1969)[26] considered the influence of stress on the elements in the information process model. In order to try out these models it was necessary to perform experiments involving real tasks. The classic experiment that did precisely this was the one carried out by Bartlett (1943)[27] based on his analysis of the influence of fatigue on pilot performance.

The paper by ***Indramani Singh et al*** reveals another mechanism, viz., improper human adaptation to system changes, responsible for Man-Machine mismatch. Ironically this type of Man-Machine mismatch takes place in highly automated systems, e.g., automated cockpits, due to the pilot's loss of active adaptive control resulting from complacency or automation induced monitoring inefficiency. The most important effect of complacency or monitoring inefficiency is that they interfere with conscious attention, higher-level co-ordination and the smooth operation of cognitive processes. Under normal conditions the pilot perceives instrument indications as a whole and relates control actions to overall performance of the aircrft. Complacency of the pilot due to a highly automated cockpit results in the dissociation of the *stimulus field and actions* and hence loss of active adaptive control and automation induced monitoring inefficiency.

The next paper by *Ambardar* relates to the general area of investigation known as *Human-Computer interaction*. Ambardar in this paper addresses herself to the problem of interface design and the role supposedly played in interface design by individual cognitive styles and fundamental individual differences.

Human -Computer-Interaction (HCI) is often viewed as a typical human activity. Any human activity is considered to be goal directed. And the goals are linked with *tasks* and the solution of the *problems* that are given to a person or are developed by him/her. Hence, *besides task analysis*, HCI includes various aspects of *problem solving* as well. In order to achieve his goal the operator in the context of HCI is required to solve two types of problems: (i) the content problem, i.e., the task to be performed, and (ii) the interaction problem, appropriate use of the computer system to facilitate the realization of the tasks to be performed.

While the content problem requires domain knowledge, Cognitive Science provides a framework for HCI based on the relevant *cognitive functions, viz., perception, language, inference and memory, and action.* In HCI the major perceptual infromation comes from the visual display unit or terminal. There are studies relating to this aspect of HCI that are cocerned with visual search or readability of computer displays influenced by differences in display modes e.g., menu. The comparison of the different modes is dependent on their capabilities in arranging and structuring information during visual search. Obviously, visual search is highly dependent on the *subjective* organization of meaningful material. The problem to determine what might be the optimal principle of organization of menus requires search on semantic categories and memory structure in general. In this the study of certain perceptual cues together with general characteristics of the visual system is not enough. It is necessary to supplement such studies by further investigations into general aspects of memory structures, domain-specific knowledge representation. In addition one must incorporate in the interface design features pertaining to individual cognitive styles.

In the next paper ***Patel and Arocha*** undertake a cognitive psychological study of medical expertise and the characteristic form of reasoning used as strategies for arriving at a diagnosis as part of the general investigation into our understanding of medical cognition. They claim that clinical expertise is domain specific to the extent that the relevant cognitive processes and their modes, viz., reasoning, knowledge representation, perception, comprehension, problem solving and decision-making, differ in important ways not only between experts in medicine and in other domains but also between expert and novices and between the novices and intermediates in medicine itself. Whereas the knowledge representation structure in other domains generally conforms to rule-based representation, in medical expertise semantic network representation is found to be more common. Moreover, the investigations into the nature of diagnostic reasoning reveals that the medical experts normally use forward-directed reasoning while dealing with routine poblems, but resort to backward-directed reasoning when they are confronted with complex problems or abnormalities in the clinical data or what the authors call dealing with "loose-ends ". Besides, the authors observe that hypothesis generation and evaluation for the experts take place at an earlier point in the diagnostic process, but the interpretation of case information by the novice and intermediates is guided by text-books. The heuristics for advanced students involves more encompassing diagnostic hypothesis, which indicates a shift from depth-first strategies.

Kaufman and Patel in the next paper are concerned with the cognitive psychological research on expert-novice comparison, but from a different point of view. Their main concern is to assess one dominating paradigm in knowledge representation research, viz., mental model. Their research findings show that the change, revision or progression of mental models is a function of expertise. The authors in their case study on understanding cardiovascular and circulatory physiology maintain that transition from novice to expert can be construed as a process of model evolution in which students develop increasingly elaborate and consistent mental models adequate for solving increasingly complex problems involving intricate causal reasoning and increasingly robust knowledge structures as opposed to models that are fragmentary and isolated. The improved models and the related graphs must exhibit functional relationships, the relevant causal reasoning and advanced knowledge pertaining to cardiac output, venous return and the fluid mechanical properties of the cardiovascular system than the naive models.

In the final paper *Sivaramakrishnan and Patel* report the findings of their study on the mechanism involved in the revision of belief from naive, folk, commonsense everyday knowledge held by womenfolk in rural India encapsulated in the traditional medicines relating to the major childhood nutritional problem, viz., protein energy malnutrition, to explanations provided by biomedical models. The study was conducted in rural south India where the mother's concept of child nutrition is based on *Siddha* and *Ayurveda* systems of traditional medicine. The mechanism of the revision and restructuring of knowledge from folk knowledge, which is more story-like, to relevant biomedical knowledge with increasing differentiation and without any radical change in concepts, has been referrd to as weak restructuring of knowledge.[28] The traditional knowledge, say about the use of herbs to treat indigestion associated with childhood malnutrition, could be part of this weak restructuring and may also be beneficial. As opposed to this a *radical* or *strong* restructuring would involve increased schooling and presentation of the new theory alone, ignoring what one already knows. Implications of such findings may have significant impact on instructional strategies, which aim at modifying the existing traditional approaches by replacing some of the unfounded conceptual connections by ones that are justified.

Although in the introductory essay the editors dwell on the Indian tradition in the study of cognition, there is hardly any contribution from that tradition. One would have expected some contribution, especially the work on the concept of language accessor or ***anusaraka*** that has emerged based on the ***Paninian*** framework of *Karakas* representing semantico-syntactic relations. These relations play a crucial role in mediating between surface structure and meaning and can lead to a study of free word order languages. Since most of the human languages have free word order this approach has the potential to overcome the language barrier in this country but other world languages as well.

Nevertheless this book has much to recommend itself . It is a great relief to see a book in Cognitive Science that provides much scientific content and eschews the facetious patter, which characterises some of the writings in this area. This is indeed a good book for the students, researchers, teachers and scholars. All of them, I am sure, will derive much benefit from the survey of the various paradigms, research tools and research areas that are covered by the book.

AMITABHA GUPTA

NOTES

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