The Challenges of Cognitive Neuroscience in the 21st Century

Basic neuroscience has been the backbone of neuroscience studies and as a result a tremendous amount of knowledge has been learned from research on how human brain works. But there are still challenges to be answered on the neural mechanisms responsible for the higher levels of human neural activities.

The last decade of the 20th century was designated the "Decade of the Brain" by the US congress. But some scientists argued that this was overly optimistic and suggested that we should instead designate the 21st century as the "Century of the Brain" (Bear et al., 2001).

The reason for being overly optimistic about the destiny of the "Decade of the Brain" is that a vast amount of research in basic neuroscience has demonstrated that a lot is already known about the function of the human brain. But what we know today is insignificant compared with what is left to be learned especially if we consider understanding the neural correlates and mechanisms responsible for the higher levels of human mental activity (Bear et al., 2001, P.20).

It is claimed that today we are far from understanding how objects, and perceptions are encoded in the brain by the activities of neurons. As a result, the hypothesis that there may be a neuron in our brain that only recognizes our "grandmother" deserves some serious reconsideration (O'shea ,2005).

It has also been suggested that perhaps the greatest challenge of neuroscience in the 21st century is to understand the neural mechanisms responsible for the higher levels of human mental activity. Three major areas of higher levels of human mental activity have been proposed (Bear et al., 2001):

- **Self-awareness**

- **Mental imagery**

- **Language**

The major research aim at each level is to see how the activity of the brain creates the mind or higher mental activities.

With respect to neural foundations of language as a higher mental activity, the classical brain-language models derived from studies by great neuroanatomists and neuropsychologists (Broca, Wenicke, Geshwind and others) have been claimed to be empirically wrong and anatomically underspecified (Poeppel &. Hickok, 2004). Consequently, new models have been proposed based on neurobiological basis of words and sentences in terms of forming specific neural networks in the brain (Pulvemuller, 2004).

Also some new serious questions have been raised in cognitive neuroscience about the origin and nature of human language:

- Do animals naturally use language?

- Can animals be taught human language?

Some neuroscientists have argued that it is clear that most animals certainly use language but if we generalize the definition of language, we miss a very major point. Human language is a remarkably complex, flexible, and powerful system of communication that involves the creative use of words according to the rules of a systematic grammar. Non-human primates at their best have a very limited system of communication used in the stereotypical situations. While human language is a much more complex and creative system limited only by the rules of grammar which are effectively finite (Tallerman, 2005).

Focusing on cerebral cortex, neurobiology and brain imaging studies indicate that the cortex probably does not possess innate representations. ,i.e. regions of neocortex do not appear to be intrinsically predestined to support particular classes of representations such as faces and language (Ibid, p.20). Rather, the fairly consistent structure-function relations observed in the cortex of a normal human adult appear to be the consequence of multiple constraints both intrinsic and extrinsic to the organism.

In fact, new methods in neuroscience have provided an exciting opportunity to elucidate major commonalities about the nature of species differences that make us uniquely human, for example:

• The human species is characterized by two fundamental cognitive abilities that are poorly developed or lacking altogether in other primates: imitation learning and the faculty of language. They are assumed among the most important fundamental cognitive abilities in the human species with the discovery of mirror neuron system (Dehaene, et al., (2005), , P.213).

• Imitation learning and the faculty of language are assumed to be among the most important fundamental cognitive abilities in the human species.

• Humans have a remarkable ability to invent symbolic systems such as numbers and the alphabet. This capacity is unique in the animal kingdom. Thus one has to ask what is so special about the human brain that allows it to expand functionality by acquiring new cultural tools. (Dehaene et al., 2005, p. 133).

Taking the position of a biologically based epistemology offers a major opportunity to extend our scientific view of animal behavior and human nature. This position accepts physics and evolution as two main pillars for philosophical reflections. Based on this argument, Edelman has suggested that it is "as a result of our individual embodiment and mutual grammatical exchanges that allow us to experience higher- order consciousness (Edelman, & Tononi, 2000, P.222). He has also suggested that "While we remain prisoners of description, our freedom is in grammar" (Edelman, 2002).

Social brain is another area of interest and challenge for cognitive neuroscience. Despite claims about an innate module for social cognition, or innate representations relating to socially relevant stimuli like language and faces, a new line of research in developmental neuroscience claims that complex representations for processing information about other people, their probable thoughts, and likely future actions emerge in the developing brain as a result of at least three sets of factors (Johnson, 1997, p. 125):

- Initial bias to attend to socially relevant stimuli such as faces and language

- Complex interactions with other people

- The basic architecture of the complex and relevant sub-cortical structures

The claim is that an abnormality in any of these sets of factors could send the infant on a deviant path in which only components of normal social cognitive abilities develop.

Taking the great challenges of cognitive neuroscience into consideration, the need to initiate and expand interdisciplinary research in cognitive neuroscience which is beyond animal studies in neuroscience, is of ample importance.

The initiative of developing PhD programs in neuroscience and major fields of Cognitive Neuroscience at the Ministry of Science and Higher Education and the Ministry of Health and Medical Sciences can be seen as a step forward to develop interdisciplinary studies in cognitive neuroscience in Iranian higher education institutions.

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References

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2001). Neuroscience: Exploring the Brain. 2nd Edition. Lippincott Williams & Wilkins, USA.

Poeppel, D. &. Hickok, G. (2004). Towards a new functional anatomy of language. In Cognition)92(2004. 1-12.

Pulvermuller, F. (1995). Agrammatism: behavioural description and neurobiological explanation. Journal of Cognitive Neuroscience, 7, 165-81.

Dehaene, S., Duhamel, J-. R., Hauser, M. D., & Rizzolati, G.; Eds. (2005). From Monkey Brain to Human Brain. MIT Press.

Tallerman, M. Ed. (2005). Language Origins: Perspectives on Evolution. Oxford.

Edelman, G. M., & Tononi, G. (2000). Consciousness. The Penguin Press.

O'shea, M. (2005). The Brain: A very Short Introduction. Oxford University Press.

Johnson, M,. H. (1997). Developmental Cognitive Neuroscience: An Introduction. Blakwell Publishers, Cambidge, Massachsetts, USA.