Life, language and brain: is it possible to age gracefully?

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The long span of evolution of Homo erectus through the Neanderthal age, during which the lifespan increased from 29 to about 70 years in recent times, due to a variety of reasons, includes the benign cycle of structural development of the brain, especially the frontal cortex and the expanding cerebral dictionary and the capacity for abstract thinking. As any other organ, the brain is also subject to the process of ageing and certain degenerative changes in the neurons may lead to dementia, disrupting the benign cycle, thereby robbing the victims of their human dignity and graceful living in the twilight years of their life. However, David Snowdon's nun study, spanning a long period of about 50 years, unequivocally indicated that those who gained mastery over language during their early adolescent years, had enough reserves of neurons in their brains, to withstand the onslaught of ageing and far less number of such individuals fell victim to Alzheimer's disease.

Evolutionary aspects

One of the elementary requirements of learning a language is the ability to associate things seen and things heard and to learn that certain sound patterns or words are the names of objects and persons. It is difficult to produce such associations in most lower primates. Anatomy suggests one of the most important reasons for the difficulty. A certain visual area on the surface of the monkey's brain, on the sheet of nerve cells forming the cortex is concerned with the shape of images; another auditory area is concerned with patterns of sounds. Learning to associate an image and a sound is primarily a matter of establishing communications through connections between the two areas. But there are very few direct connections from one to another, as the main pathways in the macaque brain take an indirect course.

The situation in the human brain is entirely different and it includes a rich system of direct routes. There are fibres within the cortex itself, which by-pass the depths and connect not only visual and auditory areas to one another but also both these areas to a similar area concerned with the feel and texture of things. In fact, the fibres are so numerous that a special switching station, a super association structure has appeared during the course of hominid evolution. It occupies a strategic position on the side of the cortex, just behind the temple at the junction of the three areas. This super association structure includes Wernicke's area where the auditory signals from a spoken word reach. However, the word's meaning is evoked when brain structures beyond Wernicke's area are activated[1].

Extensive research indicates that the structure may be involved in the development of language. It plays a major role in the formation of connections which enable children to associate, for example, the image and the feel of a teddy bear with the sound pattern for the word, 'teddy bear'.

For today's actual languages, with many thousands of words and many special grammatical rules, the number of possible messages is practically infinite. Perhaps Australopithicus attained a vocabulary of fifty or more gestures by about three million years ago and during the next two million years or so acquired an increase in naming during the transition from Australopithicus to *Homo erectus*. This was accompanied by a near doubling in the size of the brain, partly in response to the need for a larger memory to store the new words of an expanding cerebral dictionary.

The development of language skills acted as a powerful stimulus and provided the necessary impetus for the development of the human brain. It is also significant that there is an apparent increase in the size of the frontal areas of Cro-Magnon brains, when compared to their Neanderthal ancestors. The frontal regions were involved in abstract thought, perhaps aided by new grammatical rules. If objects of significance to ancestral primates in the trees could be numbered in the dozens, hundreds of thousands of natural and man-made objects had special importance for prehistoric *Homo sapiens*[2].

Grammar and the brain

What has grammar got to do with the brain? Grammar is the study of the forms of the words of a language (morphology) and their relationships with one another (syntax). Civilizational history shows that grammar was given importance and serious study of grammar was undertaken very early. The earliest known descriptive grammar which gives an accurate account of the structures observed in recorded texts of a language is by Panini of Sanskrit during the fifth century BC. Many grammars of the ancient Greek and Latin languages are still influential today. Noam Chomsky is the proponent of the concept of generative grammar, the finite set of linguistic rules that generate an infinite number of grammatical sentences in the language. The original grammar schools established in the middle ages in Europe were preparatory institutions for universities or for jobs in which knowledge of Latin words was essential. Their role expanded during the renaissance to provide a broader education, and academic standards were generally supposed to be high.

Aging and memory

The concept of working memory was proposed to describe what must take place during most mental tasks. Mental arithmetic, reading, problem solving and reasoning require temporary storage of information as well as an interplay between information that is stored temporarily and a larger body of stored knowledge. Working memory therefore corresponds to the activated information in long-term memory, the information in short-term memory and the decision process that manages which information is to be activated. Significantly, this decision-making system is believed to involve the frontal lobes.

There are two types of long-term memory – episodic and semantic. Episodic

has information about specific events within the context of other events in a person's lifetime, for example, the memory of learning to play soccer while in school. Semantic memory concerns facts, concepts, rules and meanings. It contains information necessary for perceptual recognition and complex motor skills, including speech or typing. The cerebral cortex is thought to subserve much of semantic memory. In contrast to the role of the cortex in semantic memory, the hippocampus and associated structures are thought to be primarily involved in episodic memory. Patients with damage/degeneration due to aging in these latter areas, quickly forget events in their daily lives; for instance, where they are or what they had for lunch. It must be remembered, however, that aging is a complex set of factors, intriguingly intertwined, by nature and nurture.

OPTIMA, the Oxford Project to Investigate Memory and Aging and the collaborative initial effort at the University of Calicut[3], focused on some of these apparently corollary factors, such as low blood levels of folate, vitamin B12 and higher level of homocysteine, which go hand in hand with the cognitive decline, i.e. dementia, generally after the age of 65.

Aging gracefully

It is not difficult to understand that cognitive decline in dementia, depending on its severity, can therefore threaten the dignity of the aged, besides having to live with physical infirmities. It is remarkable that the acquisition of language skills early in life somehow seems to protect our brains against problems of dementia in later life. David Snowdon, a neurologist based at the University of Kentucky, came out with epoch-making findings regarding this relationship. In his famous nun study[4], Snowdon analysed various factors of nature and nurture that might contribute to Alzheimer's disease in later life.

Examining 93 autobiographies which were hand-written in the first person by sisters who took their vows between 1931 and 1939, Snowdon separated these sisters into one group that had clinical symptoms of Alzheimer's and another that did not, their healthy cohorts. Assessing the monosyllabic, multisyllabic and rarely used words in the autobiographies, Snowdon and his associates had reason to think that the healthy sisters had a richer vocabulary in early life and may have read a more diverse selection of literature as children.

A third and more rigorous analysis involved measuring idea density and separately measured grammatical complexity, by psycholinguists and the analysis was blind to rule out bias and to ensure objectivity. While idea density reflects language processing ability, grammatical complexity on the other hand, is associated with working memory capacity.

In order to write a complex sentence, one has to keep many elements in play, until they are properly coordinated. There is always the risk of losing the train of thought before one reaches the end of the sentence, in case of poor working memory.

The level of idea density in the autobiographies was strongly associated with the scores from the cognitive test that the sisters were administered every year. Grammatical complexity was also associated, but to a relatively lesser degree. On average, the sisters were 22 years old when they wrote their autobiographies and 80 years old when Snowdon and his associates assessed their mental function. After 74 sisters with early life autobiographies had been autopsied, the power of idea density, in predicting Alzheimer's disease in late life was about 80%, an incredible level of accuracy.

Susan Kemper, the psycholinguist who collaborated with Snowdon thinks that the idea density may signify properties of the brain, such as those related to perception, encoding and memory retrieval. To put it simply, it is the sum total of our conscious experience.

Conclusion

Most of the brain's growth comes during our earliest years. An infant's brain grows exponentially after birth. During this period, we can do a lot to increase and direct the brain's capacity by learning and experiencing in order to preserve its cognitive capacity in later life and thus ensuring as much as is possible, a graceful aging.

1. Ramakrishna, T. (ed.), *The Human Brain: Essays on Awareness*, Publications Division, University of Calicut, 2001.
2. Ramakrishna, T., *Brain, Language and Memory*, Publications Division, University of Calicut, 2002.
3. de Jager, C. A. *et al.*, *Neurol. India*, 2008, **56**, 161–166.
4. Snowdon, D., Aging with Grace (*The Nun Study and the Science of Old Age. How We can All Live Longer, Healthier and More Vital Lives*), Fourth Estate, Harper Collin Publishers, London, 2001.

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Value of introducing the 'science, technology and society' perspective into Indian science

Rustum Roy

Preamble

Balaram's editorial[1], 'Images and Icons: Chemistry, Physics and the Garden of Mendeleev', is itself a wonderful garden of significant issues regarding the very fundamentals of the human activity we call 'science.' I start with just a short list of ideas that resonated with my thinking, and produced these comments and suggestions.

(a) Does not the actual practice of 'science' today match, as we shall show, more or less exactly what is usually also described by the term religion? And not only in its parallel in the use of icons and images?

(b) Does not the immutability of the empirically derived 'first law of chemistry' ('periodicity of the element's properties with atomic number,' the heart of the