chapter

# 1

## *INTRODUCTION : BRAIN SCIENCE : INSIDE OUT*

*BY CHEAH PIKE SEE*

BRAIN – remains as the most sophisticated organ in the known universe. While more has been learned about it in the past two hundred years, we are still at a very early stage in our understanding. The field of Neuroscience is still in its infancy, but is rapidly exploding – turning many yesterday's brain "myth" to today's brain "facts". The emergence of Homo sapiens as a distinct species had begun nearly 200,000 years ago. What is the uniqueness of human brain as compared to others? Partly it is our versatility. Humans are like pentathlon experts. We may not be able to do any one of these things as well as others, but human is the ONLY species that can run a kilometer, swim a river, climb a tree, learn multiple languages, has foresightedness and a deeper range of emotions!

Does size really matter? When it comes to brain, bigger doesn't always mean better or smarter. This lead to a long argued and focus of much discussion amongst those concerned with brain evolution. The average human brain weighs ~ 1,300 to 1,500 g but it is not the largest on earth. Its weight is roughly the same as that of a dolphin. An elephant's brain weighs about 6,000 g and the sperm whale's brain being the heaviest one at 7,800 g. The bigger-means-better argument is over-simplistic. The human brain has 100 billion neurones and by comparison, the elephant brain has only 11 billion neurones, despite being 4 times heavier. This suggests that human brain (higher primate) is much more efficiently organized than that of non-primate brains. Besides neurones, human brain has an estimated 900 billion of glia cells that serve as supporting actors (or nerve glue) to the neurones.

An amazing fact is that the dry weight of human brain is 60 % fat, making it the fattiest organ. Thus, human brain is not solid. It is soft and squishy similar to the consistency of soft gelatin. The weight of human brain is only 2 % of total body weight. Surprisingly, 20 % of the blood is devoted to supply it! Brain is very vulnerable to oxygen deprivation that will result in unconsciousness if this supply is cut off for as short as 8 to 10 seconds. If the blood supply is not restored in 4 minutes, brain cells can be damaged and it may cause stroke. The Blood-brain barrier (BBB) is a dynamic interface that separates the brain from the circulatory system to protect it from harmful substances. But it doesn't work to shield the brain from all hazardous molecules. The nicotine in cigarette crosses the BBB in seconds and alcohol, takes only a few minutes. In Alzheimer's disease patient, who suffers memory loss, is found associated with compromised and leaky blood-brain barrier.

The journey of a developing baby begins with the fusion of human ovum and sperm. During nine months of gestation,

the 3 to 4 kilos of baby is fully equipped with internal organs, limbs, and a brain with most of its 100 billion neurones in place, is somewhat easy to describe, but yet hard to explain. During the nine-month pregnancy, neurones are formed at the astounding rate of 25,000 per minute, giving rise to 100 billion of neurones to form the human brain. Each neurone connects with, on average, 40,000 synapses that the entire network forged literally can handle the information of 1,000 supercomputers. This number is almost a thousand times as great as the number of stars in the Milky Way. Impressively, brain signal moves faster than 418 kph. This figure is faster than Formula 1 racing cars which top out at 380 kph. The brain can generate about 12 watts of electricity and this is enough to power a low energy LED light bulb.

You may notice that the human brain has intricate pattern of hills and valleys. This wrinkly surface is formed by a 2-to-4 mm thick layer packed with neurones. By 25-day of gestation, the embryo is about 5 mm long and the simple tube-like brain is formed. By the time the embryo is 13 mm in length, the early brain and spinal cord are formed. By the fifth month of gestation, in order to fit into the developing skull, the surface area has begun to show its characteristic wrinkled appearance. Most of the main features of the convolutions are apparent by the eighth month of gestation. Large-brained mammals such as dolphins and great apes have much more in-folding of the convolutions. However, small-brained mammals such as rodents, have relatively smooth brain. Clinically, human brain with smooth surface (termed as “lissencephaly”) can be seen in baby with small head (microcephaly) that can lead to seizure and mental disorders.

As most of us are aware, the brain is lateralized – asymmetrical, by design. We owe our multi-tasking ability to the hemispheric design of the brain. Like the human brain, many modern computers are coming with essentially two hemispheres or Dual Core processors. When one processor is busy checking email, the other is scanning for viruses. This is a perfect analogue to portray how brain hemispheres work. Asymmetry, is absolutely essential in order to complete the complex tasks we take for granted. In a conversation, the left brain will be processing the verbal language, while the right brain interprets tone and reflection. The male brains tend to be more asymmetric than female. All human brains begin as female, and then some “become masculinized” during foetal development, a “masculinization” for which a chromosomal difference is necessary but not sufficient. A key to this is the role that testosterone plays.

Humans are highly social beings and language is so fundamental to human life to enable us to communicate with each other. All animals communicate, including humans. Linguists have long argued that language is a behavior unique to humans. Though they have similarities, animal communication still falls short of matching human language in many ways. Humans are in possession of an innate universal grammar that only they can understand, readily demonstrated in similarities in languages across societies. Though all animals communicate, they do not share a common grammar that will facilitate understanding across species.

Children raised in a bilingual household grow up fluent in both languages. Adults, can pick up a second language too but often with struggle. The difference lies in the greater neuroplasticity of a child's brain. Although the brain is more sensitive to learning new language at younger age, it is never too late to benefit from this effective mental gymnastics, to keep the mind as sharp as it ages. A child born with only half a brain, generally can grow up with normal brain function, owing to the hemisphere's ability to adapt and compensate for the missing one. Dyslexic kids, who struggle with phonemic awareness and fluent decoding, can improve their comprehension and literary appreciation with proper training to stimulate neuroplasticity.

Our modern lifestyle is changing our brains, but not all for the better. It is shocking that the human brains are getting smaller. Over the past 20,000 years, the size of the average human brain has shrunk by the size of a tennis ball. Multitasking makes us less productive. When one multitask, the brain simply rapidly toggles back and forth between tasks. This results in decreases in attention span, learning, performance and short-term memory. Our attention spans are getting shorter. In 2000, the average attention span was 12 seconds, but in 2015, it has reduced to 8 seconds, shorter than that of goldfish (9 seconds)!

It is fascinating that when you hold a human brain in your hands, you are in fact holding someone's memory for his entire life. Memory is shockingly unreliable and perishable! Emotions, motivation, cues, context, and frequency of use can all affect how accurately you remember something. Memory is more of an activity than a space in the brain. Any given memory is deconstructed and distributed in different parts of the brain. Then, for the memory to be recalled, it gets reconstructed from individual fragments. It is never too late to improve memory and maintain brain health with exercise, meditatation, healthy diet, good night's sleep, mastering a new skill, and quitting multitasking.

# jury review 1

***MURALI A.L D KUPPUSAMI NAIDU***

The human brain is not only capable of reasoning, logic, analysis, mathematics, learning different languages, computations, perceive different senses, initiate movements, decipher visual and audio input; but it also can be creative, imaginative, intuitive, artistic, perceive emotions, dream and visualize among others. This NYAWA'16: BRAIN exhibition is a wonderful and applaudable attempt to bring these brain capabilities together and present it to the public artistically and scientifically.

This attempt is demonstrated through 24 incredible artefacts which cover basic neuroscience, engineering, innovation, and language. Popular subjects like Zika virus infection, neurodegeneration, neuroimaging, plasticity, neoplasia, environment, neural networks, dyslexia, learning, language and memory, including emotions during driving are well expressed by these exhibits, which should be easily understood and appreciated even by a lay person. Therefore, I wish to strongly urge the organizers of NYAWA'16: BRAIN to go public as these exhibits will surely help to educate an average person to appreciate and understand these common issues relating to the brain. For example, the exhibit titled "The Ambiguous Mystery" on effects of Zika virus infection which clearly shows microcephaly may help the public seek vaccination; "Plant Nervous System" may help school children to understand the simple mechanoreceptor mechanism; "Alzheimer's Brain Change", "The Master Hat", "Little Man Inside Us" and "Walking patterns" may help in basic understanding of neurodegenerative diseases. In addition "The Mind's Evaluation" and the "Green Brain" highlights the importance of preserving nature for our own well being, especially when one is surrounded by concrete jungle. "Word Illumination" presents the difficulty faced by dyslexic students brilliantly, and this may help the affected student to understand the condition, and the teacher to relate and adjust his or her teaching accordingly. All other exhibits are no less creative in conveying their intentions in a clear, scientific, and artistic way.

What strikes me the most is that, each and every artefact is unique and presented in a simple, yet impactful way. These modern artefacts are indeed world class, and are comparable to any other artefacts that I have seen elsewhere in the world like in Tate Modern, The Louvre, and Smithsonian.

Overall, NYAWA'16: BRAIN is not only educational, but an experience! This exhibition has brought not only science and art together, but both right and left brain together too. We surely need more of these types of exhibitions where scientific knowledge can be disseminated to general public via art in a simple way. Another very important point is that, this exhibition brought many scientists and artists from various disciplines together, hence crossing various technical language barriers which are common to each discipline. Moreover, each and every artefact can be considered as a "publication" in a non-conventional form. Nevertheless, it also should be borne in mind that, there might be visitors who may not have the cognitive ability to appreciate these exhibits or knowledge on the theme of these exhibits. For them, it is my hope that this exhibition would at least trigger their interest in neuroscience.

NYAWA'16: BRAIN is awesome and I would like to congratulate the organizer, curator, participants, and UPM for organizing this event.

# jury review 2

***IRMAWATI RAMLI***

NYAWA exhibition this time around brought a remarkable topic, BRAIN. No one can deny the fact that the brain is one of the largest and most complex organ in the human body. The human brain is made up of more than 100 billion nerves henceforth, serves as the centre of the nervous system in all vertebrate and invertebrate animals.

My first impression as I walked into the exhibition hall was that the exhibition was nicely done, with beautifully designed exhibits to respond to the magnificent organ that gives awareness of ourselves and our surroundings. Also, the lighting, spacing, colours and the models that grew out of the subject matter fascinated me in an instant. Then, I examined the exhibits' elements more closely and discovered that the exhibition presented various brain perspectives. From a real brain on display to dazzling art installations and revealing how the mind works, I instantly felt inspired. Thus, with the interactive exhibits, sculptures demonstrating brain matters, exploring emotions and brain development, I believe these fascinating exhibits would stimulate anyone's interest towards neuroscience.

Another fascinating element of this exhibition is that the exhibits are in different subject contexts such as medical, lifestyle, education, interaction with environment, and engineering. However, the randomly arranged exhibits would make learning experience and appreciation less effective. Henceforth, it would be better if the exhibits are displayed under special themes so that the exhibit exploration is more interesting. Some suggestions for the theme are thinking brain, changing brain, brain histology, and technology insights.

Other than the themes, a clear text explanation is important for the success of any exhibition. I noticed the tendency of the information texts in depicting a grandeur scientific and technical words that would compromise the transmission of information to the visitors. I am not denying the splendid, unique, and creative exhibit presentation that goes beyond the imagination of the public, and I believe the curator have used up a lot of effort and time to develop them. Henceforth, appraisals are meant for the curator in taking up the challenging task of engaging to deliver an abstract subject in a physical form for public view. However, if the writing is nonfigurative, it is feared that the exhibit might dampen the purpose to reach the audience. In some cases, a very difficult issue can be tackled by posting an inquisitive text form. This will surely spur thoughts in the mind that would lead to eagerness in order to find answers for the displayed model. What is most important for a successful exhibition is the exhibition content reaches the audience effectively. We obviously do not want visitors to feel ambiguous and only value the aesthetical features. Furthermore, I respect the backgrounds of the exhibitors who are of scientific, artistic, technical, and research-based. If the exhibition is meant for a similar set of audience, I suppose the critically technical and scientific write-up is suitable, but to the general audience at large with as young as a secondary school children, this has to be levelled down a little bit.

There is also a caring concern of slightly unsuited exhibits for the exhibition. It is not about the physical feature of it, but of the appropriateness of its content within the topic of the exhibition. The presence of such exhibits will detriment the chain of thoughts and rhythm of acceptance in the visitors' mind and might make them misperceive. Therefore, a selection of consequential exhibits is an important step to be taken as a process for a successful exhibition.

I am personally attracted to the dyslexia exhibit due to its simplicity, yet meaningful portrayal of the condition in the display. Not only that, the exhibit catches the immediate interest of anyone passing by and the messages are transpired clearly and vividly to the visitors. This is one of the perfect examples of a mind stimulus exhibit.