Brain Evolution and Why it is Meaningful Today to Improve Our Brain Health

You may feel overwhelmed by the stream of seemingly contradictory suggestions regarding the best way to maintain mental clarity as you age. Based on an analysis of seminal factors in the development of modern brain anatomy, I believe it is possible to make some very compelling recommendations for growing big brains, enhancing their function, and making them resistant to the aging process. These may be loosely categorized as factors pertaining to the mental or physical attributes of the brain. Although they are not truly independent entities, such a conceptualization provides a basis for the generation of brain healthy prescriptions. Diet, physical exercise, and stress reduction enhance neuronal resilience. Sleep and mental stimulation are vital for cognitive ability, learning, and memory.

Diet: Follow a modern shore-based/marine diet including seafood in its most general sense, non-starchy vegetables of all colors, berries, and eggs. Other sources of lean protein containing long-chain omega 3 fatty acids such as free range beef, chicken, bison, or elk are nutritious alternatives.

Physical exercise (Think 'fight or flight' activity.): Include all types. Aerobic activities such as swimming, bicycling, walking, or hiking for promotion of vascular health and weight control; resistance training for promotion of neurotrophic factors, naturally occurring compounds that make brain cells more resistant to aging, such as IGF-1 (Insulin-like growth factor-1) and BDNF (Brain-derived neurotrophic factor); and balance, coordination, and agility training such as ping-pong, balance beam, trampoline, and jumping rope to enhance cognitive speed and motor skills.

Stress Control: From an evolutionary perspective, stressors (such as meeting a cave bear) and intense physical activity (running or fighting) were brief in duration and usually occurred together. Modern stressors (psychological or emotional stress) tend to be unremitting and are generally uncoupled from the physical (fight or flight) component, meaning stress develops without any associated physical activity. Such intense physical pursuits are now called exercise. Not surprisingly, exercise is a perfect physiologic antidote for stress due to its beneficial impact on cortisol (the 'stress' hormone) and blood pressure and should be incorporated into any program of stress reduction.

Adequate sleep: The body needs rest, but the brain requires sleep. Acute or chronic sleep deprivation causes devastating short and long-term consequences to brain anatomy (synaptic loss) and function (memory and learning difficulties). Off-line information processing and memory consolidation are additional sleep-related benefits.

Mental stimulation: Brain-training, a cognitively challenging lifestyle, novelty, and socialization are vital for the promotion of neuronal plasticity and neurogenesis (the formation of new nerve cells and neuronal connections), the enhancement of specific brain functions such as memory, and the development of cognitive reserve –additional mental processing potential that may be brought online when needed.

The combination of these recommendations, each of which was instrumental in the transformation from primitive to modern nervous systems, provides a template for the most logical approach for enhancing mental function and resisting neurodegeneration as we travel through life.

The Evolutionary Rationale

The human brain clearly has the genetic potential for dramatic expansion. This was illustrated about 1,500,000 years ago. Enlargement from 900 grams to almost 1300 grams required less than a million years to complete – a mere speck on the evolutionary timeline. Why and how it happened are open questions. What remains undisputed are the magnitude of the change and the impact it had on human capabilities. The rapid volumetric explosion primarily involved the frontal lobe region, a portion of the brain that, until recently, was referred to as the 'silent' brain because of its relative lack of any discernable functionality. The frontal lobes are now viewed as the 'conductor of the orchestra' because they have been recognized as being responsible for articulating the 'big picture' and coordinating other brain regions, as needed, to execute the 'game plan.' The Prefrontal cortex (PFC), the most anterior portion of the frontal cortex, has dense connections with all the other regions it oversees. It is generally considered the most plastic cortical region because its synapses are continually being torn down and reconfigured in response to real-time experiences. Plasticity allows the brain to 'think on its feet.' Expansion of PFC enabled the cognitive preeminence of modern day humans over all non-human primates. The plasticity of the PFC and its massive connectivity with other brain regions rely entirely on the production and maintenance of point-to-point nerve cell connections, or synapses.

In addition to being a thinking machine, the brain is also a flesh and blood organ that must comply with the laws of metabolism and physiology. Insight into both its 'mental' and 'physical' properties is vital for comprehending key aspects of brain health and function. Much has been written about the facilitation of brain growth by cognitively demanding tasks such as tool use and hunting. However, there is a component of circular reasoning in this argument. For it to participate in such mentally demanding endeavors, the brain would have relied on the prior existence of sophisticated neuronal circuitry. I suggest a nutritional basis for the dramatic cerebral expansion, with enhanced functionality (such as development of tool use and hunting strategy) being the natural responses of a larger, more plastic organ to novelty and environmental challenges. The common link between the evolutionary cerebral expansion and modern brain health/function resides in the massive wiring demands inherent in both processes. This marked amplification in neuronal connectivity is made possible by the enhanced production of synaptic membranes (nerve cell membranes in the regions of points of nerve cell contact).

How was it possible to fuel the production of major increases in neuronal number and synaptic density? This required the concordant expression of genetic potential (likely driven, in part, by the provision of an uninterrupted energy supply) and proper nutritional content - meaning high, sustained caloric and nutrient density. Just as a certain level of

fat mass is a prerequisite for expansion of the female body to support a successful pregnancy, a persistent supply of nutrient dense calories is essential for brain expansion. In times of frequent starvation, this was a substantial nutritional demand. To fully appreciate how energetically expensive brains are, consider that modern brains comprise about 2.3% of the body mass, yet consume almost one quarter of the available energy. Newborn brains utilize fully 75% of the body's energy!

What type of brain-building diet might have been accessible 1.5 million years ago that didn't require the cognitive demands inherent in hunting? One solution would be a 'shore-based' diet. This means foraging for life forms such as mollusks, crustaceans, eggs, spawning fish, frogs, and contiguous plant life readily available along lake shores or river banks. In a warm clime it would have provided a year-round, high quality diet abundant in calories, fat and protein. It also supplied long-chain omega 3 fatty acids (including DHA), the building blocks of electrically active membranes in neurons and photoreceptor cells.

Big brains must also synthesize abundant cholesterol and other components of nerve cell membranes. This requires a water-soluble source of appropriate building blocks. Ketone bodies (acetoacetate and β-hydroxybutyrate) generated naturally from partially burned fat were, and continue to be, an ideal energy source for the brain while simultaneously providing key precursors for synthesis of nerve cell membranes and synapses. These facilitated the anatomic expansion of the brain, which provided the additional neuronal circuitry that made the learning of hunting skills a possibility.

Hence, what was compulsory for explosive brain expansion of the species is as vital today for optimal brain function and plasticity. It is the ongoing ability to produce high levels of the most functional sites of nerve cells – the synaptic membranes. Appropriate assemblies of nerve cells, as determined by their connections (synapses), provide the basis for the functional attributes we enjoy today. Stress reduction, mental stimulation and proper sleep enhance their resistance to the aging process.

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