Synopsis of the LEAP® Model of Learning

Charles T. Krebs, PhD
Lydia Center for Innovative Medicine
Cambridge, MA 02138

In summary, the LEAP® Model of Learning is based on the following suppositions about the nature and location of neural processing underlying learning and memory:

- Sensory processing initiated by sensory receptors generates initially linear neural flows that rapidly diverge at each successive processing centre (spinal and cranial nerve ganglia, brainstem nuclei, subcortical nuclei, limbic cortices, and finally neocortical columns) into a number of different complex data streams. All processing below the neocortex is subconscious.
- Each processing centre, at each successive level within the spinal cord, brainstem, diencephalon, basal forebrain and cortex elaborates the sensory data, defining some aspect more than another, or adds additional types of information needed to define the sensory data further at the next level of processing. All processing below the neocortex is subconscious. (Simplified Schematic of Sensory Processing)
- At the higher cortical levels, input from many lower levels both cortical and subcortical is integrated to form a conscious perception of the initial sensory experience.
- These higher cortical levels not only integrate processing of the "raw" sensory data, but also include integration of input from memory areas about past experiences with similar sensory stimuli.
- At the highest cortical levels the conscious perceptions formed at lower cortical levels are further processed asymmetrically in either Gestalt or Logic cortical columns, and hence perceived as a visuospatial pattern or a Gestalt, or abstractly as a verbal word based language or an abstract symbol based mathematical language.
- The very highest levels of conscious processing that underlie our thinking about conscious perceptions, while dependent upon input from all areas of the brain, are generally frontal lobe and particularly involve working memory areas in the Dorsolateral Frontal Cortex and Prefrontal Cortex
- A whole set of basal brainstem mechanisms maintain the organism in a state of homeostasis, such that higher level conscious sensory processing can proceed effectively: These include the Reticular Activating System, the Periventricular Survival System, the Vestibular System and the Sensory-Motor System. Imbalances within or between these systems may disrupt on-going sensory processing and integration at this and higher levels. Processing at this level is totally subconscious.
- The initial "raw" data stream is "sampled" by the Amygdala, the Fight or Flight control center, and other survival centres in the brainstem. Survival emotions paired or associated with similar stimuli in the past now "colour" the raw data stream of the sensory stimuli still being analyzed, including the physiological responses to these emotions, and is the basis of Conditioned Learning, e.g. Pavlov's dog. These primary survival emotions may disrupt on-going sensory processing and integration at the brainstem and higher levels. Processing at this level is subconscious.
- When survival emotions of the Fight or Flight response are activated above some "threshold" value, the Amygdala and other brainstem structures such as the

Periaqueductal Grey Matter (PAG) of the midbrain actively inhibit frontal cortical processing by reducing blood flow, interfering with reasoning and problem-solving. The cause of this loss of higher level conscious cortical processing is a direct consequence of activation of the subconscious primary survival emotions of the Limbic System and Brainstem for survival.

- Secondary processing of the sensory stimuli in the Brainstem, Limbic System and lower cortical levels generates a series of control functions defining the nature of the sensory data stream (e.g. control of pupils in vision) and second-order integration of this sensory data (e.g. movement, shape and location of object in space). Processing at this level is subconscious.
- Further processing in the palaecortical components of the Limbic System (e.g. cingulate, subcallosal and orbitofrontal cortices) generates secondary emotions relative to the sensory data stream based upon the primary emotions already evoked by the amygdala and other brainstem areas via sampling memory of related events. These secondary limbic emotions may also disrupt on-going sensory processing and integration at this and higher levels. Processing at this level is largely subconscious.
- Initial cortical processing is predominately bilateral and subconscious, and is dependent upon earlier processing at brainstem and subcortical levels. Emotions, either primary or secondary, may disrupt on-going sensory processing and integration at this and higher levels.
- At some level of cortical processing the sensory data stream emerges into a conscious perception, and is dependent upon earlier processing at brainstem, subcortical, and earlier cortical levels. Emotions, either primary or secondary, may disrupt on-going integration at this and higher levels
- At the highest levels of cortical processing, the processing is largely done in one hemisphere or the other and perceived consciously as a logical, rational thought or a visuospatial pattern or form (Gestalt), and is dependent upon earlier processing at brainstem, subcortical and cortical levels. Emotions, either primary or secondary, may disrupt on-going integration at this level, and any "thinking" dependent upon this level of processing.
- Thinking about the fully processed and integrated sensory experience in the frontal lobes, based upon remembered sensory experiences relevant to the current experience may lead to decisions, which will be represented neurologically by activation of either Logic or Gestalt "lead" functions or both.
- These "lead" functions will then initiate a cascade of neurological flow, which is initially frontal cortical, but rapidly flows into other cortical areas and subcortical structures like the basal ganglia, thalamus, and cerebellum, which in turn feedback to the cortex and each other. Emotions, either primary or secondary, may disrupt on-going processing and integration at any level of this process, and thus overtly affect the final outcome of the cognitive functions taking place.
- Coherent neurological processing at any stage of the above process is dependent upon both uninterrupted flows along integrative pathways and within integrative processing centres. Disruption or de-synchronisation of the timing of these integrative neural flows or disruption or de-synchronisation of processing in any of the integrative centres may result in loss of cognitive function.
- Maintaining integration along all integrative pathways and within all integrative centres produces optimum function, a state called Brain Integration in LEAP.

- Loss of integrated brain function is the principal cause of dysfunction in both mental and physical performance, called Loss of Brain Integration in LEAP.
- The primary mechanism causing Loss of Brain Integration is de-synchronisation and loss of timing of neural flows along integrative pathways and within integrative centres is by inhibition or excitation of these pathways and centres by neural flows originating from brainstem and limbic survival related emotions.
- On-going Loss of Brain Integration is often generated by early childhood traumas that create long-term disruption of Brain Integration as a mechanism of coping with these traumas.
- Other factors affecting Brain Integration are genetic, structural, organic brain damage, and environmental stressors:
  - Structural defects or abnormalities can be of developmental origin, e.g. neuronal migration problems, or result from toxin exposure at specific critical periods of development, e.g. fetal alcohol syndrome. Many cognitive defects have been shown to correlate with abnormalities in brain structure, e.g. cortical ectopias.
  - Organic Brain Damage may result from a head injury, and this damage often results in sclerosis or scarring of the brain tissue that disrupts neural flows underlying Brain Integration, e.g. hippocampal sclerosis and subsequent epilepsy are often associated with learning disorders.
  - Genetic Factors affecting Brain Integration are often genes that code for specific alleles for specific enzymes involved in maintaining normal levels of neurotransmitters or receptors in brain circuits. Deficiencies in either neurotransmitters or receptors will compromise Brain Integration, and have behavioural consequences. This is both the basis of much ADHD behaviour and the justification for drug use to ameliorate these behaviours.

    Other genes may code for alleles that affect fatty acid metabolism and utilisation, especially in maintaining neuronal membrane stability and function. This affects physical co-ordination and reading, but may also underlie ADHD.
  - Diet and nutritional deficiencies may also compromise brain function and result in loss of Brain Integration. Diets rich in fast or junk foods often create marginal nutritional deficiencies that may disrupt brain function, and often contain various preservatives and additives, like the azo-food dye tartrazine, that may cause a total loss of brain integration in sensitive individuals.

    Indeed, the misbehaviour and academic performance of children and young adults have been shown to improve significantly with diet change or nutritional supplementation, and several recent books have discussed this aspect of behaviour and learning problems.
  - Environmental factors such as electromagnetic fields emitted from man-made electronic equipment and Geopathic stress from distortions in the earth's electromagnetic fields may affect the brain integration of sensitive individuals and result in learning problems. Many people feel tired and often brain "fag" when working for long periods on computers with traditional TV like monitors.