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Thoughts About the Study of Cognitive-linked Brain Dysfunction Physiology After Mild Closed-head Trauma

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Some people, after a mild closed-head trauma of either direct-impact or non-impact acceleration/ deceleration type, do not return to pre-trauma cognitive and emotional behavior. While their brain functioning appears relatively intact under some circumstances, it performs poorly under others.

The putative damage is thought to be both physical and biochemical at the micro level. It is diffusely spread with foci of magnitude depending upon the dynamics of the trauma and the predisposing physiology of the person. An important anatomical consideration is the predilection for the anterior brain to consistently be more severely functionally damaged.

A conceptual approach of "disconnection" (i.e.. misinformation) (Weinberger, 1993) aids in the understanding of the varied behavioral performance. The prefrontal cortex (PFQ is connected to most brain regions including heteromodal association cortices, all sensory association cortices, non-sensory basal ganglia and thalamus, limbic structures (amygdala, hippocampus, and hypothalamus), and brain stem nuclei (especially those sending afferents to the cortex.) Each of these regions is also a component of various fundamental information processing networks: attentional mnemonic, emotional autonomic, motoric, and intellectual (Fuster, 1989; Nauta, 1971). We speculate that when these distributed networks are "disconnected" by trauma, higher order mental processing diminishes.

It is the temporal "disconnection" of this anterior brain which sets the stage for the understanding of dysfunction of coordination of the entire brain from the standpoint of anticipation, decision and action (Teuber,1978). A hierarchy of organized integrated fixed functional systems has been attributed to the frontal brain, more specifically the PFC (Stuss & Benson, 1986). It is suggested that in the PFC, information is "formatted" for potential executive action; that its executive role involves the recruitment and maintenance over time of the appropriate network or combination of networks for a particular context or behavior (Weinberger, 1993).

The complexities and subtleties of the PFC function cannot be understood simply on the basis of the available anatomical data (Teuber, 1978). It is an evolved system, built from organic chemistry and the distributed energies of nerve channels. The system uses gain and delay to modulate signals; certain signals, organized in certain ways, produce behavior (Subak, 1992).

The PFC is the only cortical region with direct projections to each of the biogenic aminergic

nuclei that project to the cortex as well as to the cholinergic nuclei of the basal nucleus of Meynert. These are recruited when there is heightened demand for focused cortical function, such as during cognitive or experimental stress (Sawaguchi & Goldman-Rakie, 1991).

Information is continually undergoing associative processing. Some tasks are performed by special purpose networks, i.e. vision and hearing. Most mental tasks in the brain, however, are performed by principles of self organization, trial and error, and best fit choices. They play fragmentary, short-lived roles in the modulation of current activity. The outcome is efficient and effective integration relationships looking ahead and complex programming But the underlying brain physiology is pandemonium style contention scheduling (Dennett, 1991).

The widespread brain connectivity of the prefrontal cortex means that "disconnections" involving intrinsic PFC neurons may cause cognitive, personality, and/or behavioral dysfunctions (Mesulami, 1986). Trauma affecting extra frontal systems, e.g. limbic, which have connectivity to PFC, also has a secondary dysfunctional effect upon the PFC. Perturbations in higher order brain functions may be generalized or cumulative. A decrease in speed of information processing has been shown in a recent study (Kay, current research). Temporal lobectomy which removed diseased limbic tissue stopped partial seizures and improved neuropsychological test scores (Sweney, 1992). Perhaps the "disconnection" (misinformation) of brain injury is more critical than no connection (no information).

Neuropathological considerations in brain injury resulting from either non-impact acceleration forces (Sweeney, 1992) or impact head injury (Adams, Graham, and Genneralli,) are central to these "disconnections" (misinformation). No cognitive neuroscientist should expect to make sense of human consciousness by building only from the neuroanatomy. Functional studies based on observations to stimuli are needed. Neuropsychological assessment testing, electro-encephalography, and radioactive compound screening (Goldman-Rakie & Friedman, 1991; Friedman, Bhalla & Goldman-Rakie, 1991; Humayun, Pretsky & LaFrance, 1989) aid in the clinical understanding of brain functioning. Such studies represent different windows and provide separate but complementary information (Mandel, Satalof & Schapiro, 1993).

Neurotherapy with its clinical results and putative physiologic understandings is another window with which to explore brain function. Double blind studies with computer program driven treatment choices are suggested.

References

Adams, J. H., Graham, D. I., & Gennarelli, T. A.(1985). Contemporary Neuropathological Considerations Regarding Brain Damage in Head Injury. In D. R. Becker & J. T. Povlishock (Eds), *Central Nervous System Trauma Status Report.* NIH Grant # N 519591.

Dennett, D. C. (1991) *Consciousness Explained.* Boston: Little Brown & Co.

Friedman, H. R., Bhalla, S., & Goldman-Rakie, P. S. (1991). Metabolic Activation of Dorsolateral, Prefrontal, and Inferior Parietal Cortex by Cognitive Processing: a 2-DG Study in Rhesus Monkeys Performing Mnemonic Tasks. *Society for Neuroscience Abstracts.* 135.

Fuster, J. M. (1989). *The Prefrontal Cortex* (2nd. edition. New York: Raven Press.

Goldman-Rakie, P. S. & Friedman, H. R. (1991). The Circuitry of Working Memory Revealed by Anatomy and Metabolic Imaging. In Levin, H. S., Eisenberg, H. M., & Benton, A. L. (Eds.), *Frontal Lobe Function and Dysfunction* (pp. 72-91). New York: Oxford University Press.

Humayun, M. S., Presty, S. K, LaFrance, N. D., et a]. (1989). Local Cortical Glucose Abnormalities n Mild Closed Head Injury Patients with Cognitive Impairments. *Nuclear Medicine Communication,* 10 (5), 335-344.

Kay, T (Current research) Research Study R 15. NYU Research and Training Center on Head Trauma & Stroke, NY

Mandel, S., Satalof, R. T, & Schapiro, S. R., (1993). *Minor Head Trauma: Assessment, Management and Rehabilitation.* N. Y: Springer-Verlag.

McLean, P. D. (1990). *The Triune Brain in Evolution: Role in Paleocerebral Functions (pp.* 519-563). N.Y.: Plenum.

Mesulam, M. M. (1986). Frontal Cortex and Behavior (Editorial). *Annals of Neurology,* 19, 320-325.

Nauta (1971). Neuroanatomical Considerations. *Journal of Psychiatric Research,* 8,167187, Fig. 2-7

.Sawaguchi, T, & Goldman-Rakie, P. S. (1991).DI Dopamine Receptors in Prefrontal Cortex: Involvement in Working Memory. *Science, 251, 947-950.*

Stuss, D. T, Benson, D. F. *(1986). The Frontal Lobes (pp. 240-249).* New York, Raven Press.

Subak, J. *(1992). In the Image of the Brain: Breaking the Barrier Between Human Mind and Intelligent Machines.* Boston: Little Brown & Co.

Sweeney, J. E. *(1992).* Non-impact Brain Injury: Grounds for Clinical Study of the Neuropsychological Effects of Acceleration Forces. *The Clinical Neuropsychologist, 6, #4, 443-457.*

Teuber, H. *L. (1978).* The Riddle of Frontal Lobe Function in Man. In J. M. Warren & Y. L Akert (Eds.), *The Frontal Granular Cortex and Behavior (pp. 410-444).* New York: McGraw-Hill.

Weinberger, D. R. *(1993). A* Connectionist Approach to the Prefrontal Cortex. *journal of Neuropsychiatry & Clinical Neurosciences, 5, 241-153.*

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