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Cognitive Neurodevelopmental through Movement Intervention:

A Neuropsychological Approach to Learning and Attention Span

"Movement is crucial to every other brain function, including memory, emotion, language and learning."

Dr. John J. Ratey. MD, Professor of Psychiatry, Harvard Medical School, author of *A User's Guide to the Brain.*

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Introduction

I was finishing my university degree in psychology and two years of nursing when, 35 years ago, I was first introduced to the neurodevelopmental approach linked to the concepts of neuroplasticity and movement. This document reports the research on the neurodevelopmental intervention whose results have attracted interest in clinicians as well as in researchers. Earlier scholars such as Delacato (1959; 1974), Cratty (1972, 1973), Kephart (1975) and Ayres (1979) believed that movement requires neural organization and functioning of the lower systems in order to reach efficiency in the higher level systems for learning and attention span.

The neurodevelopmental intervention is a non-invasive program of movements which aims to promote development of the nervous system through the integration of primary movements (or primary reflexes). Researcher Jean Piaget argued that the "sensorimotor stage" is the first stage of development to facilitate all the cognitive functions. The movements that are used naturally by a baby and a young child, gently encouraged the central nervous system to mature and become more open to learning and attention span. It is well recognized that those hierarchic movements are the basis for growth and development. When there has been an interruption in the development of the central nervous system's functions related to learning, attention span, and emotional regulation. doing these movements can give the brain a "second chance" in order to encourage neurodevelopment maturity.

Appendix A will review some of the main neurodevelopmental-neuroplasticity interventions used in the world at this time.

In the first section of Appendix B we are presenting eleven case studies from our clinical work using different psychometric tests as well as the quantitative electroencephalogram to document the student's progress when the program was done at home by the mother; Section 2 of Appendix B reports the changes observed by the facilitator at our clinic in Barrie, Ontario; Section 3 reports academic progress from students registered in a "remedial program of neurodevelopment" at a private school.

Research conducted by different authors have provided growing evidence which supports the long held theory that control of balance, motor skills, and the integration of early movements are linked to academic achievement. Appendix C provides several of these researches. The first document is a thesis from Dr Soezin Krog, from South Africa, "Movement programmes as a Means to Learning Readiness" presenting the neurodevelopmental approach in details (116 pages).

Following this brief introduction we first summarize the principles of neurodevelopment and its processes, the impact of trauma altering the neurodevelopment, and finally some emerging intervention trends. The concept of neuroplasticity will finally be presented as well as some of the great discoveries in neuroscience that provide insights into why this approach yield so much results.

Section 1 – Concept of Neurodevelopment Outlines

PRINCIPLES OF NEURODEVELOPMENT

- The development of the brain starts at conception
- The brain is underdeveloped at birth
- The brain organizes from the "bottom" up – brainstem to cortex and from the inside out
- Organization and functional capacity of neural systems is sequential
- The brain is activated by universal primitive movements or reflexes moving the body toward more complex functions of the central nervous system
- To fire a cell in the cerebellum, the target has to move at the same time as the head moves (Dr.Masao Ito, Japan)
- Experiences do not have equal influence throughout development (sensitive periods)
- Interruption of development places the person in a "survival mode"

NEURODEVELOPMENTAL PROCESSES

- Synaptogenesis
- Mylenation
- Synaptic pruning
- Procedural and declarative memory
- Neuronal networks coming "on-line"
- Maturing inhibiting networks

TRAUMA AND ALTERED NEURODEVELOPMENT

- Trauma that places the baby in a Flight/or Flight reaction may affect the way his/her senses interpret the world
- Altered cardiovascular regulation
- Behavioral impulsivity
- Increased anxiety
- Increased startle response
- Sleep abnormalities

EMERGING INTERVENTION TRENDS

- Importance of early identification and treatment of genetic risk and/or failed developmental processes
- Role of medications and fine tuning brain functions – performance enhancement
- Power of intensive relational and neurodevelopmental treatments
- Development of specific neurophysiologically targeted interventions
- Functional imaging and brain mapping guiding assessment and treatment

Section 2 – Concept of Neuroplasticity

The brain consists of neurons and glial cells which are interconnected. Learning occurs by adding or removing connections. We have heard more consistently about the concept of neuroplasticity (or cortical re-mapping) in the past ten years.

> The idea was first proposed in 1890 by William James in *The Principle of Psychology*, though the idea was largely rejected for the next fifty years. The first person to use the term *neuro plasticity* appears to have been the Polish neuroscientist Jerzy Konorski, the author of two important books on associative learning and neurobiology of perception and motivation: *Conditioned Reflexes and Neuron Organization* (1948) and *Integrative Activity of the Brain* (1967). He is considered by many among the most important neurobiologists. (from Wikipedia)

Neuroplasticity can be summarized by "neurons that fire together, wire together" and "neurons that fire apart, wire apart".

One of the first researchers in the United States to bring the attention to the brain plasticity was Dr Temple Fay, a renowned neurosurgeon, who in the early 1940 worked with brain-injured children. He was convinced that:

> "the severely injured brain might have a residual potential sufficient to make possible the establishment of memory traces or engrams, particularly those related to locomotion, which might results in effective locomotion capability." His research led him to realize the importance of sensory inputs (Le Winn, p. 6).

Carl Delacato, a psychologist added to Dr Fay's research team, introduced the concept of neurological organization in connection with disorders of neurological functions, especially those involved in speech and reading (Delacato, 1959).

We had to wait until the late 1970s and early 1980s for several groups to pursue this research. Michael Merzenich, Jon Kaas, and Doug Rasmusson used the cortical map.

In his recent book (2007) *The Brain that Changes Itself*, Norman Doidge, a research psychiatrist and psychoanalyst, explains the concept of neuroplasticity:

> At first many of the scientists didn't dare use the word "neuroplasticity" in their publications, and their peers belittled them for promoting a fanciful notion. Yet they persisted, slowly overturning the doctrine of the unchanging brain. They showed that children are not always stuck with the mental abilities they are born with; that the damaged brain can often reorganize itself so that when one part fails, another can often substitute; that if brain cells die, they can at time be replaced; that many "circuits" and even basic reflexes that we think are hardwired are not" (Doidge, p. xv).

Norman Doidge gives the example of scientist Paul Bach-y-Rita who witnessed the dramatic recovery of his own dad after a disabling massive stroke. He explains "I decided that instead of teaching my father to walk, I was going to teach him to crawl."

After crawling for several months, his father went back to teaching in a New York college. Norman Doidge calls the practitioners of this new science “neuroplasticians”.

Section 3 – Neuroscience

D.O. Hebb, a Canadian psychologist from McGill, was probably one of the most influential psychologist of the 20th century. His great achievement was to persuade a generation of psychologists that in order to understand the behaviour of living organisms, it made sense to study the neural machinery responsible for that behaviour. The basis for this integration lies in understanding how genes and experience shape neural networks underlying human thoughts, feelings, and actions. In his 1949 monograph*, The Organization of Behavior: A Neuropsychological Theory*, Hebb proposed that neural structures that he called ‘cell assemblies’ constituted the material basis of mental concepts. Hebb’s ideas were disseminated worldwide by his students who were in great demand to establish laboratories for studying the physiological bases of behaviour. These laboratories made many pioneering contributions to the new field of physiological psychology. It is the neuroimaging that allows our generation to pursue this research.

Our desire is to better understand at the biochemical level what is happening in the neurodevelopment when the primitive movements or reflexes move the baby’s body in a series of developmental patterns that are universal.

One of the questions is: How developing nerve cells are told what connections to make? Dr. Yancopoulus, and several other teams discovered that the nerve cells talk to the muscle cells by sending a chemical code in the form of the neurotransmitter acetylcholine located in the nucleus basalis.

Stanley Cohen and Rita Levi-Montalcini discovered nerve growth factors (NGF) in 1950 but this discovery of neurotropins was not recognized until 1986 when they won the Nobel Prize of Physiology. The most recent result of this discovery comes from the findings of Samuel Pfaff from the Howard Hughes Medical Institute who observed partial restoration of injured spines in mice by injecting different nerve growth factor at each side of the damaged spinal cord. A press release of January 18, 2011, called *Unlocking the secret (ase) of building neural circuits*, reports:

> “Professor Pfaff and his team have uncovered presenillin’s productive side: it helps embryonic motor neurons navigate the maze of chemical cues that pull, push and hem them in on their way to their proper target. Without it, building motor neurons misread their guidance signals and get stuck in the spinal cord. This finding reveals an important link between the formation of neural circuits and neurodegenerative disorders. Samuel Pfaff explains “ It was a bit of a surprise since we always thought about presenillin in the context of severing neuronal connections rather than wiring the nervous system during embryonic development” ….Understanding how axons find their destinations may help restore movement in people….. To find their course, growing neurons, which need to travel very long distance to reach their targets, navigate their path one small segment at a time, guided at each intersection by intermediate guideposts-chemical cues that attract or repel approaching axons. What’s more in a tightly regulated choregraphy, axons often switch allegiances when they reach a critical junction.”

Nobelist Eric R. Kandel, (Nobel Prize of 2000), showed that:

> "when we form long term memories, neurons change their anatomical shape and increase the number of synaptic connections they have to other neurons. When we think, learn, and act, our minds affect which genes in our neurons are turn on or off, thus shaping our brain anatomy and our behaviour. Eric Kandel won the Nobel Prize in 2000, surely one of the most extraordinary discoveries of the twentieth century." (Doidge, p. 218)

This is described very well in his book *In Search of Memory* where Kandel concludes:

> "the road to a real understanding of mind must pass through the cellular pathways of the brain." (p. 429)

In a seminal paper, *A New Intellectual Framework for Psychiatry*, published in the American Journal of Psychiatry, 1998, 155 p. 460, Eric Kandel explains what happens in psychotherapy, and what he explains that happens in psychotherapy can also apply to the neurodevelopmental approach:

> "Insofar as Psychotherapy or Counseling is effective and produces long-term changes in behavior, it presumably does so through learning, by producing changes in Gene Expression that alter the strength of synaptic connections and structural changes that alter the anatomical pattern of interconnections between nerve cells of the brain. As the resolution of brain images increases, it should eventually permit quantitative evaluation of the outcome of psychotherapy…."

Michael Merzenich, a well-recognized neuroscientist argues that:

> "…practicing a new skill, under the right conditions, can change hundreds of millions and possibly billions of the connections between the nerve cells in our brain maps.…Unlike a computer, the brain is always "learning to learn"….The speed to which we think is itself plastic…..The key in developing exercises is to give the brain the right stimuli in the right order with the right timing to drive plastic change." (Doidge, p. 45-92)

Svea Gold summarizes it very well:

> "The advantage of collecting research is that we can now understand that if we make children go through the same movements which the early reflexes would have dictated their little bodies to make, these movements will create chemicals at the junction of the muscle and axons and the chemical markers will make sure that the messages go to the exact part of the brain that nature intended them to go. We cannot control what comes out of the child's brain, but we can control what goes in, by having the child repeat those movements."

Conclusion

We are at an amazing time of discoveries in that field of neuroscience which lead to a better understanding of the changes that occur in our behaviours. Fortunately, in their heartfelt desire to release suffering, keen and intuitive clinicians have not waited for the world to accept that the brain is plastic and to understand scientifically how the changes occur. Neurodevelopmental therapists as well as psychotherapists need to pursue their practice with a research mindset, collecting data to support their approach and inspiring the researchers to use their tools to better understand why this intervention works.

**"Never before has so much been known
to promote health in early childhood,
yet so little is applied!"**

J.Shonkoff, *Neurons to Neighborhoods*, 2000