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From Learning Disability to Disability Expertise

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Abstract

In the post educational research was mostly geared towards the needs of mainstream population. However, recent advances in neuroscience and neuropsychology have reoriented educational efforts towards the population of learners with special needs. Especially the frontiers of research in neuroplasticity has opened immense possibilities for the mentally challenged. Drawing on the bold findings of Edward Taub in the area of neuroplasticity, the present review analyses the struggle and success of Barabara Arrowsmith born with the mental handicap of learning disability. Her journey from learning disability to learning expertise not only depicts the formidable challenges encountered by the mentally challenged it explicates the importance of educational support system and parental mentoring. More importantly the need for cerebral exercise is highlighted. It is asserted that the conventional compensatory education where deficits are identified and additional exercises are given is not just enough. The process requires vigorous mental exercises that help to rewire the brain such that some of the dysfunctional areas become vitally functional.

Keywords : Neuroplasticity, Learning disability, Cerebral exercise, Compensatory education, Localization, Equipotentiality, Competence building.

Introduction

Arrowsmith Rehabilitation School is a leading centre in Toronto (Canada) where children with learning disabilities correct their underlying problems. It is quite a paradox that this school is a brain-child of Barbara Arrowsmith Young who herself was a girl with severe learning disability. Generally, the scientists who make important discoveries about the brain are often those whose own brains are extraordinary. It is rare that the person who makes an important discovery is the one with the defect. But there are exceptions. Barbara Arrowsmith Young is one of these exceptions.

Barbara was born in Toronto in 1951. Asymmetry is the word that best describes her mind when she was a school girl. Barbara had areas of brilliance as a child, her auditory and visual memory were excellent. But her brain was "asymmetrical" meaning that these exceptional abilities co-existed with areas of retardation.

Her right leg was longer than her left, causing her pelvis to shift. Her right arm never straightened, her right side was longer than her left, her left eye was less alert. Her spine was asymmetrical. She had a confusing assortment of serious learning disability. The area of her brain devoted to speech (Broca's area) was not working properly; she had problem pronouncing words. She also lacked capacity for spatial reasoning. When we wish to move our body in space, we use spatial reasoning to construct an imaginary pathway in our heads before executing our movement. Spatial reasoning is important for baby's crawling. Barbara had trouble in movement.

Spatial reasoning is also necessary for forming a mental map of where things are. We use this kind of reasoning to organize our desks or remember where we have left our keys. Barbara lost everything all the time. With no mental map of things in space, out of sight was literally out of mind. She became a "pile person" and had to keep everything in front of in piles.

She had a "kinesthetic" problem. Kinesthetic perception allows us to be aware of where our body or limbs area in space, enabling us to control our movement. She could not hold a cup of juice in her left hand without spilling it. She frequently stumbled.

She had a visual disability as well. Her span of vision was narrow. When she looked at a page of writing she could take in only a few letters at a time.

But these were not her most debilitating problems. The worst problem was her inability to understand the relationships between symbols. She had trouble understanding grammar, math concepts, logic and cause and effect. She could not distinguish between "the father's brother" and "brother's father". The double negative was impossible for her to decipher. So she couldn't read a clock because she couldn't understand the relationship between the hands. She couldn't literally tell her left hand from her right, not only because she lacked a spatial map but because she couldn't understand the relationship between "left" and "right".

Unable to understand cause an effect, she did odd things socially because she couldn't connect behaviours with consequences. She could memorize math procedures but couldn't understand math concepts. She could recall that five times five equal twenty-five but couldn't understand why. Her teachers responded by giving her extra drills, her father spent hours tutoring her, to no avail. Her mother held up flash cards with simple math problems. But the attempts of remediation didn't get at the root of the problem.

Wanting desperately to do well, she got through elementary school by memorizing during lunch hours and after school. She learned to use her memory to cover her deficits and with practice she could remember pages of facts.

A Silver Lining

The whole Young family was high achievers. Barbara's father, Jack, was an electrical engineer and inventor with thirty-four patents for Canadian General Electric. Her mother Mary had the positive attitude; she said, 'you will succeed no doubt, solve the problem you have'. Barbara was always incredibly sensitive, warm and caring.

Barbara gravitated towards the study of child development. As an undergraduate at the University of Guelph (Canada), she had areas of problem. But her teachers fortunately saw her remarkable ability to pick up non-verbal cues in the child-observation laboratory, she was asked to lead the course. Then she was admitted into graduate school at the Ontario Institute for Studies in Education (OISE). Most research students read a research paper once or twice, but typically Barbara had to read twenty times as well as many of its sources to get a sense of meaning. She survived on four hours of sleep a night.

Barbara was brilliant in many ways and adept at child observation. Some of her teachers had trouble in believing that she was disabled. It was a happy coincidence that she came across. Joshua Cohen another gifted but learning disabled student at OISE. Joshua was running a small-clinic for learning-disabled kids. He used standard treatment method – compensation procedure. In compensation method, attempts are first made to identify areas of deficits and additional training is given to make up the deficits. Kids with reading problems are given audio-tapes for listening. Kids who are slow are given more time for tests.

Joshua designed a compensation programme for Barbara, but found it too time-consuming. One day Joshua suggested she look into some books by Aleksander Luria. Luria born in 1907, was a master of brain physiology. He developed interest in neuroscientific basis of Freudian psychoanalysis. He corresponded with Freud and studied neural basis of Freud's psychotherapy. A productive outcome of research interest was the evolution of neuropsychology. Since he was working during the difficult period of Stalin's era in Russia, he chose medical sector to escape political control.

There was another coincidence that worked in her favour. While reading Luria, Barbara knew about a typical disabled person, Zazetsky whose problems were similar to Barbara's. Zazetsky was a Russian military officer who was injured by the invading Nazi war machine. The medical examination revealed that the damage in his brain involved the joining area of three lobes – occipital, parietal and temporal. It may be indicated here that temporal lobe is linked with thought and language while occipital is associated with visual experience. The parietal lobe is linked with spatial relation and integration of sensory experiences. Thus, the resulting outcome is self-explanatory.

Over thirty years Luria observed Zazetsky and predicted that Zazetsky's relentless fight would help him "to live, not merely exist".

Barbara read Zazetsky's diary and realized how Zazetsky's life mirrors Barbara's.

Dogma of Fixed Entity

For quite some time, human brain was considered as a fixed entity. The main reason that contributed towards this persistence of this belief was the **principle of localization**. Localization denotes a rigid connectivity between structure and function. It implies that a specific neural centre in the brain is responsible for particular behaviour or function. Brodmann, a German neuroscientist, prepared a brain map where different centres, were numerically indicated. For example, backside of our brain was known as Brodmann's Area Number 17 and it was responsible for visual experience. Similarly, a point in our frontal brain (behind our forehead) was known as the Area Number 10 and it was considered responsible for multi-tasking. The neural link that runs from the left ear to right ear (or right ear to left ear) was designated as sensori-motor cortex. It is comparable to GPS provided by google engineers. The sensori-motor cortex provided the map of the body. The level of its sophistication is so high that the very thought of this cerebral apparatus drives google engineer crazy.

However, different parts of the body have representation in sensori-somato cortex in terms of its sensitivity. For example, lip has a greater representation for its touch sensation compared to other body parts. Similarly finger tips have greater representation for touch sensitivity than other parts of hands and arms. Brodmann provided a brain map indicating 1 to 52 numbers with specification of corresponding functions.

This structure-function relationship was further strengthened by Penfield. Penfield the famous neuroscientist from Canada electrically stimulated different parts of the brain as provided by Brodmann's list. It was shown that the specific brain stimulation produced feelings in corresponding organs. For example, individuals reported visual experiences when Area No 17 (occipital lobes) was electrically simulated. Similar findings were obtained for other brain stimulation.

Both Brodmann's work and Penfield's research were reported during the nineties of the twentieth century. People as well as specialists believed that there is a rigid relationship between structure and function. A specific centre of the brain controls the specific behaviour.

Hearing Lightening and Seeing Thunder

It is a common experience that we see lightening and hear thunder. In other words, the visual cortex (occipital lobe, the brain part just behind our head) sees and the auditory cortex (the brain part temporal lobe, the upper part of our head) hears. This view is in consistence with localization principle.

However, Taub's innovative experiments with monkeys and other follow-up studies indicated an unbelievable possibility. William James, the renowned psychologist, also made such a miraculous prediction. It is important to recognize that William James was as famous as Sigmund Freud was. In, 1892, his book *Psychology: A Briefer Course* was approved as the first text-book of psychology at University level. James made a prophetic statement about the nature of human brain. He made a statement that humans could *see thunder and hear lightening*. He suggested that a day may come when auditory cortex could see and visual cortex could hear. People as well as specialists laughed at this statement.

Ironically James made this prophetic statement 100 years prior to the growth of neuroscience. It may be indicated that neuroscience received great acclaim when the California doctor Roger Sperry got Noble Prize for his split-brain research in 1982. He showed that the two sides of the brain have different functions. While it is one structurally, the left brain is linked with language and logic while right-brain is associated with emotion and pattern recognition. William James' prediction came true with experiments of Edward Taub and other neuroscientists in the nineties of twentieth century.

Edward Taub and Neuroplasticity

Taub was born in Brooklyn (New York) in 1931. He went to the public school and graduated from high school when he was only fifteen. At Columbia University he studied "behaviourism". He was fortunate to work with his mentor Fred Keller, the close associate of B.F. Skinner (Harvard University) the most noted psychologist of his time. While Taub was interested to study mind and brain, both Keller and Skinner were indifferent to the concept of brain. Since all behaviourists are interested only in things observable and measurable, Keller and Skinner did not encourage Taub to pursue the study of mind and brain. At Columbia University experimental studies mostly dealt with rats and researchers were interested to study external and visible forms of behaviour. This did not satisfy Taub's research interest; he left Columbia University and came to Research Institute at Silver Spring in Maryland (USA).

In Silver Spring, Taub carried out bold experiments. Hs main interest was to help stroke patients whose one side of the brain gets paralyzed because of some reason or the other. It has been indicated earlier that the *brain has contra-lateral connection*. This implies that right side of the brain is neurally linked with left side of the body's limbs and vice versa. It means the right side of the body would be paralysed if left brain is injured because of stroke. Similarly, there may be problem in the left side of the body. Taub's primary interest was to find out whether the paralyzed side of the brain could be revived by some mechanisms. Since he could not make intervention at the level of human brain, he chose monkey's brain to find an answer.

Taub initiated finger-cutting experiments in monkeys. Technically this is known as **deafferentation experiments**. This is so called because afferent nerves which carry nerve impulses from limbs to the brain are cut. In Taub's experiment, afferent nerves which carry impulses from fingers to the brain were cut.

When Taub's bold experiments were going on, a big happening put a stumbling block.The animal protection group in America staged protests and Taub was dragged to the court of law. Although he wished to defend himself saying that his experiments were meant for human welfare in general and stoke patients in particular, he was not protected. The National Institute of Mental Health (NIMH) stopped its research grant and took custody of monkeys. A group of scientist made collective representation to NIMH not to stop research grant, but nothing positive happened.

The legal controversy dragged on and on. Gradually the legal battle lost its intensity. Taub was struggling with no job no-money situation. Suddenly he got a Faculty position at the University Birmingham (USA). The Head of the Department of Psychology asked him to continue his past experiments. The animal protection groups threatened protests and gave a warning that they would stall all animal research if Taub is allowed to continue. But the Head of the Department ignored all threats and permitted the scientific spirit of research to flourish. Fortunately, Taub also got back his old monkeys whose fingers were cut.

The long time-gap between the loss of monkeys and regain of monkeys (a number of years) offered an unique opportunity to Taub to look at the cerebral change. It is obvious that the sensori cortex of the monkeys whose fingers were cut did not receive touch sensation from fingers. Yet, it was found that the sensori cortex has not stayed idle. Without receiving touch inputs from fingers, the sensori cortex has changed its job; it has started processing touch sensation from the face. This gave clearer indication of the plasticity and reorganization of brain.

Encouraged by this novel experiments, more and more neuroscientist carried out studies to move forward. A researcher at the University of San Francisco trained monkeys to do a skillful job. The monkeys were trained for long hours to brush a highly moving disc. They had to do this work for quite some time. It was found that there were visible significant tinges in their somato-sensori cortex.

The discovery of brain plasticity gave impetus to human experiments. Researchers found it convenient to study the deaf and the visually impaired. It is obvious that the visual cortex of the visually handicapped does not receive visual inputs through the eyes. Similarly, the auditory cortex of the deaf does not receive auditory signals though ears. When the sophisticated imaging techniques of studying brain functions were used, it was found that *the auditory cortex can partly see and the visual cortex can partly hear*. It sounded as if James prediction that we can hear the lightening and we can see the thunder has come true. It was a major breakthrough in neuroscientific research. The finding when submitted for publication to the high states journal **Science,**it did not secure acceptance. However, its arch rival Journal Nature got it published in their April (1996) Issue.

The evidence was further strengthened when human volunteers were blind-folded and were asked to stay with visual deprivation for some days. Of-course they were provided with some daily necessities so that they won't die. When brain was examined after prolonged sensori deprivation changes and reorganization was noticed.

The immense possibility of changing brain is vividly manifest in an experiment of PascuaLeone. The researcher asked 200 professional violinists and asked them each to *think* *playing violin* for two hours every day in his laboratory. This continued for a couple of months. Following such contemplation their brain mappings were done. Surprisingly there were visible and significant changes in their somato-sensori cortex. It is obvious that changes are expected when violinists actually play violin. Their consistent movement of fingers, hands and arms are likely to bring about changes. Yet PascuaLeone found that even thinking can bring out cerebral change.

A Turning Point

It was at this point in her life, while she was twenty-eight and still in graduate school, she came across brilliant series of work by Mark Rosenzweig of the University of California at Berkeley. The researcher found that the brains of the stimulated rats were heavier and had more blood supply than those from the non-stimulated environments. Rosenzweig was one of the first scientists to demonstrate neuroplasticity by showing that activity could produce changes in the structure of the brain. For Barbara, lightning struck. Barbara now realized that the brain could be modified. Though many doubted it, Rosenzweig's and Luria's research convinced her the possibility of change.

Building a Better Brain

She isolated herself and began toiling to the point of exhaustion, week after week. She designed mental exercises and worked on them. Instead of practicing compensation, she exercised; Joshua Cohen helped her.

Barbara and Joshua Cohen married and in the 1980 they opened the Arrowsmith School in Toronto. They did research together, and Barbara continued to develop brain exercises and to run the school. Eventually they parted, and Joshua died in 2000.

Because few others accepted neuroplasticity it was tough job. Applicants to the Arrowsmith School — children and adults alike – undertake forty hours of assessments, designed to test which brain functions are weak. A lot of thoughtful brain exercises are given. For example, a child, like Barbara may be having problem to read a clock. Now the child works at computer exercises involving ten-handed clocks (with hands not only for minutes, hours, and seconds but for other time dimensions such as days, months, years). Children sit quietly with intense concentration, until they get correct answer.

Similarly, children learn Urdu and Persian letters to strengthen their visual memories. The shapes of these letters are unfamiliar and the brain exercise requires students to learn to recognize these alien shapes quickly.

We all have some weak brain functions and such neuroplasticity based techniques have great potential to help almost everyone.

Many students have to systematically exercise the brain function that gives us fluency and grace with symbols. In the Lincoln-Douglas debates of 1858 the debaters comfortably spoke for hours without notes. Today many of us raised in most elite schools, prefer the Omnipresent Power Point Presentations – the ultimate compensation for a weak premature cortex.

Barbara's work compels us to imagine how much good might be accomplished if every child had a brain-based assessment and if problem were found, a tailor-made programme is created to strengthen the essential areas in the early years, when neuroplasticity is greatest. It is better to meet brain problems in the bud.

Acetylcholine, a brain chemical essential for learning, is higher in rats trained on difficult spatial problems than in rats trained in simpler problems. Mental training or life in enriched environment increases brain weight by 5 percent in the cerebral cortex of animals and up to 9 percent in areas that the training directly stimulates. Trained or stimulated neurons develop 25 percent more branches and increase their size, the number of connections per neuron, and their blood supply.

These changes can occur late in life, though they do not develop as rapidly in older animals as in younger ones. Similar effects of training and enrichment on brain anatomy have been seen in all types of animals tested to date. Enrichment increases the number of branches among neurons. An increased number of branches drives the neurons farther apart, leading to an increase in the volume and thickness of the brain. The idea that brain is like a muscle that grows with exercise is not just a metaphor.

Today Barbara Arrowsmith is sharp and funny, with no mental blockages. She has shown the children with learning disability can go beyond compensation and correct their underlying problems. She has documented the success of brain exercise programmes. Her work has paved the way for building a better brain.

Policy Implications

i. Cognitive style (the style of processing information) of learners must find a righteous place in educational goals and objectives.

ii. Teachers, planners and educators need to abandon levelling students (learners) such as 'dull and backward'.

iii. Education process must be geared to divergent thinking process.

iv. The process of brain change (neuroplasticity) offers opportunities for the cognitive growth of learners

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