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A review and perspective on maximizing brain plasticity: priming the nervous system to learn

Abstract

Although we know the central nervous system is adaptable and can respond to learning based behavioral training to recover from trauma, disease or aging, in the clinic the effectiveness of recovery can be limited. Part of this limitation in recovery is due to the severity of the brain insult but part of this incomplete recovery is due to the conditions surrounding the individual patient that may need to be addressed to maximize plasticity. In this brief review, a perspective on the need to prime the nervous system to learn is provided for consideration and reflection.

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Introduction

We are in the midst of a Brain Plasticity Revolution.[1–7] Today we know our brain's machinery is undergoing continuous rewiring throughout our lifetime even in the face of an injury.[3–6] Neuro plasticity serves as a primary source for the maintenance of refined skills and abilities despite aging.[6]

Fifty years ago, students learned the nervous system was only adaptable and plastic during the developmental years, physical exercise was only needed if you were going to play a sport, heavy labor was a common component of traditional work, many were without cars and walked to work/school and the average longevity was less than 70 years. Today we are living longer, immobility is a primary health problem[8–10] falls in the elderly are common[11] over 70 million people will be stroke survivors by 2030[12,13] opiod addiction is a national crisis with serious adverse events.[14,15] Alzheimer's Disease is considered as a "Type 3 Diabetes"[7,16] stressful, stereotypical repetitive job tasks are degrading cortical representations and disrupting voluntary motor control[17,18] auto immune diseases are on the rise and the population is consuming excessive amounts of gluten[7,19,20] Gluten (a sticky protein) is associated with a leaky gut and an increase in inflammation and cytokines in the vital organs, especially the brain.[7,10,19–22,]

Since 1979, the World Health Organization has promoted adequate exercise, good nutrition, stress management and positive lifestyle behaviors as part of Healthy People 2000[8,9,23–25] yet less than 50% of Americans meet the criteria recommended for physical activity.[8,9,23–25] When the WHO guidelines are combined with recommendations for life long dynamic cognitive learning, it is not only possible to maintain cognitive, sensory and fine motor skills with clarity, reliability and efficiency despite aging, but also to maximize recovery and function from serious trauma, disease and cancer.[1,3,8] Unfortunately, the growing science of positive health and brain plasticity in animal studies has not been associated with significant improvement in the clinical effectiveness of restoring community participation and quality of life for individuals with impairments.[3,4,5]

Over the last 10 years, researchers have clarified some basic guidelines to promote behavioral plasticity.[1,2,4–6,26] These principles must be integrated into neurological rehabilitation strategies and activities of daily living (Table 1). Given some consumers and health care practitioners doubt the science of plasticity, it is not surprising some individuals are unwilling to commit to exercise, follow a nutritious diet, drink adequate fluids, achieve adequate sleep, address stress, stop smoking or decrease ETOH consumption Thus, a large percent of the population is pathologically overweight, depressed, isolated, challenged with chronic pain and have lost the motivation to learn, think positively and set meaningful goals[8,10] These individuals put physiological systems, especially the brain, at risk for oxygen deprivation and central hypersensitivity[3,8,9,14,23,24] Further, while older people are worried about developing Alzheimer's disease as a consequence of aging, many still chose to isolate themselves at home and disengage from challenging learning activities[9,6] In fact, these life style issues may contribute more to falls and cognitive decline than aging or genetics.[8,9,27]

Table 1 Principles of experience dependent plasticity[3,5,22,24]

Expect to improve	Make learning fun
Use it or lose it	Make training salient
Use, remap and improve it	Adjust training to be age
Include adequate repetitions	relevant
Make training intense (2-8	Reinforce learning with
hrsiday, 2-5 days/week)	feedback/accuracy
Space training over time	Transfer learning to new
Attend to training activities	situations
-Vary training sequence	Strengthen learning with
Progress task difficulty	interference /surprise
-Be specific	

To facilitate maximum neuroplasticity the body, especially the brain, may need to be "primed" for learning. For example, for many individuals, priming the nervous system may begin with medical treatment strategies (eg. medications, surgery, radiation). Prescription medications can help manage a variety of conditions (eg high blood pressure, diabetes, seizures, spasticity, dystonia, anxiety, depression, pain). However, if the patient does not self manage other behavioral and environmental issues like stress, sleep, nutrition, exercise, and hydration, then the prescription medications cannot be effective.[14,18]

Priming the brain to learn may also be accomplished by simply helping patients develop a positive attitude (e.g. expecting to age gracefully or recover quickly from a minor injury).[14] Educating the patient to accept that pain may be learned and persistent even after the injured tissues have healed can also be considered priming.[14,15,28] In other cases, giving positive feedback (e.g. a follow up phone call) may help keep patients committed to carrying out their exercises.[4–6,11,23] General physical exercise can also be viewed as type of priming for the nervous system to learn. Physical activity can improve cardiopulmonary dysfunction, metabolism, oxygen delivery, weakness, inflexibility, edema and degenerative joints.[8,6] Healthy eating (e.g. avoiding excessive glutens, fats, sugar) smoking cessation and reducing alcohol can also be considered primers for the nervous system to learn by decreasing secondary diabetes, kidney disease, heart attacks and cancer.[7,26]

For those who suffer challenging brain trauma, musculoskeletal injuries or neurodegenerative disease, life style components may need to be supplemented with novel priming strategies. For example, there is evidence remote ischemic limb condition (RILC) can prime the heart and the brain to tolerate heart surgery.[29,30,27] There is also early evidence the same RILC techniques can prime the brain for more efficient motor learning even in healthy individuals.[29] In other situations, repetitive transmagnetic stimulation (rTMS) may improve connectivity and reorganization when delivered prior to retraining for patients post stroke[31,32] or those with movement disorders like dystonia.[33,34] If fascia is tight, retinaculum thicker than normal or joints are restricted from scarring or aging, negative compression techniques, soft tissue mobilization and/or joint manipulation may be needed to prime the neuromusculoskeletal system to move and allow restoration of normal biomechanics and mobility.[35–37] In other cases, assistive robotics may prime the neuromusuloskeletal system to move, initiating the potential to recover normal voluntary movements.[38]

In summary, the brain is soft wired. Neuroplasticity is a process which can continue across the lifespan when paired with positive life style behaviors, dynamic learning and physical activities. Exploiting neural adaptation may require initial neural priming, especially for individuals challenged with disease, injury and degeneration. When the brain is primed and ready to learn, the science and principles of plasticity can be integrated more effectively.

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Conflict of interest

The author declares no conflict of interest.

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