

## **Neurons that fire together wire together!**

### **Hebb's Postulate**

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Often the human nervous system is compared to electrical wires and circuits. It was once thought that after a certain age these connections were stationary and unable to regenerate. In 2000, American neuropsychologist, Eric Kandel was awarded the Nobel prize in neuroscience for his discovery that the brain's neural connections can be strengthened and regenerated. Therefore, unlike the filaments in our electronic gadgets our nerves are not inanimate wires, they are alive and with the right stimulation can strengthen and form new connections. This ability for neurons to adapt to stimulus is called neuroplasticity.

Neuroplasticity is often a focus in rehabilitation for individuals with neurological dysfunction, such as post stroke and traumatic brain injury. However, the importance of including the brain in rehabilitation should not be forgotten in individuals with orthopedic injuries. For example, new research has demonstrated altered activity in the motor cortex, somatosensory and visual sensory processing area of the brain in individuals post ACL injury and / or reconstruction surgery. These changes are found not only early in rehabilitation but several years after rehabilitation and return to sport. This poses the question, "How can we modify our rehabilitation strategies to address and improve these neurocognitive deficits?"

Think of tuning up all senses and the brain's ability to process the sensory information effectively and efficiently. Like the computer server when too many people log in at once the system is overloaded, therefore gradual increase in sensory and cognitive challenges are required to allow the patient/ client to achieve successful outcome and not "crash". We are born with a large number of neurons in the brain with random and multiple connections. Through our experiences the pathways utilized most often in the brain are strengthened and those connections not stimulated recede and die off in what is called neuronal pruning. Just like in gardening the brain trims back what is not needed so that the remaining connections thrive, grow and become stronger. Hence the saying from Hebb's postulate, "Nerves that fire together wire together". The opposite is also true, just like our musculoskeletal system, "If you don't use it, you lose it". Unfortunately, after injury or with pain the compensatory patterns our body develops can become ingrained by this mechanism. In some, pain pathways are sensitized leading to lower thresholds for nociceptive perceptions, even in the absence of new injury. To alter this course requires cognitive awareness, repetition and an ideal environment for the nervous system to function.

Various ways to promote neurogenesis (strengthen the connections) and stimulate the brain is to integrate the following into your rehabilitation exercises:

1. Ask the client to perform two or more physical tasks such as:
  - a. throw and catch a ball while balancing on one leg

- b. walking forward and backward while tying and untying a towel into a knot.
2. Add cognitive tasks to the physical activity or balance challenge.

Examples include:

- Name things/ words: for example types of flowers, breeds of dogs, flavors of ice cream, men's names, states, types of cars etc.
  - Random digit generation: ask patient to randomly state a number through a given range such as 0-300.
  - Counting backwards: by twos, threes etc.
  - Imagine and verbally give road directions, for example: from home to post office
  - Recite backwards: numbers, days, months etc.
  - Alphabet math: add or subtract a number to a letter for example k-1=j
  - Ask the person where they grew up, how to spell their home town forward and backwards
  - Stoop test (color reading interference) color words but name the color of the ink. Some might ask why is this so difficult. The answer is related to selective attention, essentially the ability to respond to certain environmental stimuli while ignoring others, and requires us to do something we never learned. This task is a demonstration of mental control.
3. Incorporate visual or auditory and cognitive processing with motor output. For example,
    - a. Blow a whistle one for move right and two whistle blows for move left.
    - b. Assign a certain task or exercise to a color then call out the color or hold up different color cards.
  4. Include cardiovascular conditioning to the program. The brain uses 20% of oxygen we take in therefore increased physical activity increases blood flow to the brain as well as the heart and skeletal muscles
  5. Perform multiple repetitions with variations: Neural connections are strengthened with use.
  6. Have clients mirror image a partner's movements.
  7. Incorporate problem solving.
  8. Vary the rhythm and or speed of a task. If you just train at one speed you are only good at that speed.
  9. Move in all different directions and planes.
  10. Make it fun, laugh.

Laughter reduces stress, releasing various chemicals increasing the efficiency of the immune system along with changing the brain wave activity towards what is called a "gamma frequency," increasing memory and recall.
  11. Encourage good hydration and nutrition.
  12. Promote time for relaxation and meditation. Excessive stress has been shown to reduce neuroplasticity of the brain.

The best part about neuroplasticity and being made up of ‘live wires’ is that although it may happen faster and to a greater extent in the young it possible to train your brain not matter your age.

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