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Pain and the Brain: Emerging Research

We dedicate this issue of The Rehab Center's newsletter to review some recent research on chronic pain and the brain. Advances in neuroimaging technology allow for real-time studies on what happens in the brains of people experiencing pain.

The fascinating findings being reported shed light on the plasticity of the human brain: the way in which it can change – for better or worse-- in response to different circumstances. This preliminary research is very promising inasmuch as it reveals a new understanding of the brain as a malleable structure liable to worsen under prolonged stress and pain but also capable of repairing and normalizing its function with the right activities and treatment.

This is certainly good news for those people whose lives—and brain function--- have been compromised by the experience of living with prolonged pain. This research provides some explanation for the burdensome difficulties they often experience in addition to physical discomfort; but more importantly, it supports the very realistic ability to improve and achieve more normal function.

There is very realistic hope for people in pain, a message we have long championed at The Rehab Center. Emerging research confirms that cognitive behavioral therapy, the psychological basis of our Functional Restoration Program, helps to normalize brain function that may have been affected by prolonged pain. These findings confirm the convergence of medical, psychological and neuropsychological aspects of chronic pain. They solidify our recognition of the importance of having these disciplines work together as a team, long one of our strengths. The availability of cognitive rehabilitation interventions such as CogSMART as part of our program for appropriate patients is an added benefit whose value is becoming ever clearer.

Changes in the Brain's Gray Matter

Gray matter, composed primarily by nerve cell bodies in the brain, is very much involved in the various functions of the brain: carrying information from the senses, controlling speech and emotions, forming memories, and the like. Studies have shown that short-term memory is affected as the volume of gray matter decreases with aging. Gray matter has also been shown to decrease in both total volume as well as density as a result of chronic stress.

Experiments with rats showed that repeated exposure to stress actually shrinks the neurons in the hippocampus, which is crucial in processing memory, and in the brain region called the prefrontal cortex, which is crucial for decision-making and attention. A study on combat-exposed veterans with post-traumatic stress disorder (PTSD) found losses of gray matter that were significantly greater in comparison with combat-exposed twins without PTSD.

Loss of gray matter has also been shown among people with certain types of chronic pain, such as fibromyalgia, chronic back pain, and chronic tension headache. These changes appear especially noticeable in areas of the brain corresponding to pain perception and emotional processing.

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Disruptions in Brain Structure and Function

A recent study of upper limb amputees found a loss of gray matter in the areas of the brain that control the experience of pain among those who were experiencing greater phantom limb pain (PLP) but **not** among those with no or only mild PLP. Interestingly, the amputees with little or no PLP also had **increased** gray matter in areas involved in visual processing, suggesting that visual adaptation mechanisms may compensate for the lack of sensorimotor feedback and prevent the development of PLP. (Note: We have been using mirror therapy with amputees to this effect with considerable success, and may now have a neurological explanation for these results.) These results are important in that they demonstrate that gray matter can be increased as well as decreased. Thus, it is possible that changes in gray matter with chronic pain may either be reversible or compensated for by improvements in other parts of the brain as a function of adaptive activities.

A recent prospective study by Baliki and others followed patients with sub-acute back pain and found that those whose pain persisted showed significant loss of gray matter density and volume throughout the brain, and especially in the areas associated with pain perception. These changes were not seen in those patients whose pain improved. The researchers also found a potential predictor of chronic pain: the patients whose pain persisted showed an initially greater level of connectivity between a section of the brain called the nucleus accumbens, involved in the experience of pleasure, and the prefrontal cortex. This link was found to be an accurate predictor of the transition from sub-acute to chronic pain and suggests that those patients for whom pain pathways are strongly linked to emotional pathways are at greater risk of developing chronic pain once injured. In fact, those patients also showed higher scores on measures of the emotional dimension of pain, although not on any other measures of mood. It is unclear whether this link developed after the injury or whether it may have already been present earlier; nor was there any mention of any potential psychological correlates that identified these patients prior to developing chronic pain. However, the results are interesting as potentially identifying high-risk patients for chronic pain, possibly leading to targets for early intervention.

Dr. Christine Mratkowski at Harvard Medical School has followed children with chronic abdominal pain using both neuroimaging studies and neuropsychological testing. In research presented at the NIH in late May of this year, she found that these children develop structural brain changes associated with a loss of executive function (e.g., higher-order skills such as planning, organizing, and sequencing activities). These deficits were more pronounced in the children with higher pain levels. Interestingly, she also found that children who demonstrated poorer executive function initially demonstrated more severe pain later. Her conclusion is that both pain and executive function deficits contribute to worsening each other; and that skills training to improve executive function may be a way to break this cycle, and prove an important target of treatment. (In fact, this type of training is a basic component of the cognitive behavioral treatment of patients with chronic pain.)

Dysfunctional Brain Pathways Able to Normalize

Seminowicz and others (2011) showed that treatments that successfully reduce chronic pain lead to normalization of disrupted brain changes, with **increased** gray matter in the prefrontal cortex where there had previously been a loss of gray matter, corresponding as well to normalization of previously impaired cognitive function.

Exciting new studies presented at the NIH meeting in May 2013 by Dr. Emeran Mayer at UCLA suggests that these same improvements in brain structure and function may well be achievable with psychological interventions. He reported results of neuroimaging studies with chronic abdominal pain patients showing that they demonstrated activation of areas of the brain involved in pain processing when they were led to **expect** pain – without any actual painful stimulation. The very same degree and type of activation was then found when actual painful stimulation was delivered to these patients. Subsequent studies showed that cognitive interventions instructing patients to attend differently to pain resulted in the normalization of brain activation, along with diminished pain perception.

Similarly, Dr. Karin Jensen and colleagues at Harvard Medical School found that cognitive behavioral therapy (CBT) alters activation of the prefrontal cortex in response to pain among patients with fibromyalgia. They concluded that CBT appears to normalize brain networks that have presumably become disrupted with persistent pain (although they did not address whether these disrupted networks may have been present earlier, as potentially suggested by the Baliki et al study mentioned above).

These results are exciting inasmuch as we have long found CBT to be effective, when adhered to, in helping patients cope effectively with pain and stress. As stated earlier, CBT relies on the deliberate targeting and strengthening of executive skills. In the treatment of chronic pain, CBT emphasizes the teaching of coping skills to replace dysfunctional reactions to pain and to the expectation of increased pain. These include relaxation training; relabeling and altering attention to pain and the interpretation of painful sensations; and learning to plan, pace and sequence activities in a more functional way. These skills probably help to normalize brain pathways and improve cognitive function as well as helping to manage pain more effectively, as these studies suggest. CBT has been a crucial component of the Functional Restoration Program at TRC, serving as the guiding model of our psychological treatment and also the framework for the work done by our medical and physical therapy staff.

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