

## sLORETA and the Anterior Cingulate Gyrus: Feeling No Pain

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A recent market research report indicates that more than 1.5 billion people worldwide suffer from chronic pain (Global Industries Analysts 2011). Epidemiology studies vary, but one put the prevalence of chronic pain, as defined by the WHO World Mental Health Surveys, at 37% in developed countries (Tsang, Von Korff et al. 2008). Another study found a 33% prevalence in the United States with back pain being the number one complaint followed closely by osteo-arthritic pain (Croft, Blyth et al. 2010).

Allopathic medicine utilizes drug treatment for most chronic pain conditions. Chronic pain patients treated with medication are vulnerable to addiction very often the direct result of opioid analgesia. While most pain patients use their medication responsibly, according to one study as many as 18% develop an addiction (Fishbain, Rosomoff et al. 1992). Many will suffer from decreasing functionality and affective disorders. The sheer magnitude of the problem presents an opportunity for alternative treatments.

Pain experts often refer to the "perception of pain" making distinctions between chronic and acute pain that acknowledge that chronic pain may not have well-defined underlying pathological causes. The brain regions involved in the processing of pain cited in the majority of studies include: Primary and Secondary Somatosensory Cortex, Anterior Cingulate Cortex, Insula, Thalamus, Basil Ganglia, and the Cerebellum. One meta-analysis concluded that the brain network for acute pain perception in normal subjects is moderately distinct from that seen in chronic pain conditions. The study revealed that chronic pain preferentially engages brain regions important for cognitive/emotional assessments. The involvement of these limbic brain regions imply that the emotional and cognitive component of pain may be a distinctive feature between chronic and acute pain (Apkarian, Bushnell et al. 2005).

The Anterior Cingulate Gyrus and the Insular Cortices, structures of the limbic system, have been implicated in the affective processing of pain (Price 2000; Morrison, Lloyd et al. 2004; Singer, Seymour et al. 2004; Apkarian, Bushnell et al. 2005). Apkarian identified the Anterior

Cingulate Cortex (ACC), as cited across many studies, for having a particularly robust activation pattern in both chronic and acute pain. Those studies have divided the ACC into as few as four and as many as six components with affective reactions to pain localized to perigenual (rostral) ACC and cognitive processes to mid-cingulate activations.

The alpha band is a particularly useful one in neurofeedback training for a variety of clinical presentations . It has been hypothesized to direct the flow of information to task relevant brain structures while inhibiting regions that are task irrelevant(Knyazev 2007; Klimesch, Fellinger et al. 2011). More generally, it may have a preventive inhibitory role in sparing brain regions from continuous excitatory impulses(Simonov 1968). This quieting function of the alpha band may have been helpful with a recent chronic pain client when the Anterior Cingulate Cortex was trained with sLORETA neurofeedback, substantially reducing the intensity of pain.

### **The Client**

The client was a 72 year old male who suffered a "stroke like event" that resulted in reduced functionality of his right forearm and hand. The MRI analysis was normal. The MRI made clear that the insult to the client's brain did not result in tissue damage. The client was not naive to neurofeedback having been trained in several modalities before the introduction of sLORETA training. The QEEG analysis revealed insufficient power in the central, bilateral posterior Temporal, and Parietal areas from 1-3 hertz and some mildly insufficient power at various areas at 4 and 5 hertz. Mildly insufficient power was evident in posterior regions from 21 to 30 hertz. Neuroguide Z Scored LORETA Analysis revealed reduced current sources in the Superior Frontal and Anterior Cingulate Gyri (See panel A). Additionally, hypo-coherence was discovered in all bands with most deviance in the high beta band between frontal and posterior regions of cortex. The client's reduced functionality in the right arm and hand hindered his ability to play the piano, a much prized avocation.

### **sLORETA Training**

Training was executed with BrainMaster Inc's Discovery amplifier and the BrainAvatar sLORETA software. The trained regions of interest (ROI) were imaged with BrainMaster's Live

sLORETA Projector. Z Score training was employed using Neuroguide's Normative Database with Brainmaster BrainAvatar software.

A simultaneous combination of sLORETA and surface four channel Z Score training was implemented targeting the deeper structures that included the Superior Frontal Gyrus, Post Central Gyrus, Anterior Cingulate Gyrus, sensory, and motor areas in posterior regions. Bilateral central and parietal ten/twenty sites were trained with Z scores while simultaneously training to increase either 1-3 or 1-5 hertz in the aforementioned structures with sLORETA.

Nine sessions were completed with minor improvement in the mobility and dexterity of the right arm and hand. However, the client did report an unusually vivid "clean windshield" effect after the first session:

*Wanted to report back to you on the treatment of this morning, as you had requested. What took place holds ENORMOUS promise for healing the weaknesses in the brain we discussed today, as of this moment, 9 pm. When I left your office and walked down the hall toward the elevator, I could tell that something significant had taken place. I felt wider and larger and clearer in some unknown way. I felt, and still feel, that my right side was working better than when I woke up this morning. All this is talk but something did happen. My right foot landed cleaner on the ground at least for a time. It may have regressed later in the day somewhat. Is that possible? That's how it felt.*

That the client was not naive to neurofeedback argues that the report may reflect a genuine treatment effect rather than placebo. Additionally, this kind first response, reflecting a profound sensorial clarity, has been the reaction of several of my patients trained with sLORETA.

After the initial training session, the client began to complain of increased pain in both knees, a chronic arthritic condition, which he attributed to an additional intervention related to his presenting problem. As the training proceeded, the pain steadily increased to the point where the patients mobility was severely limited.

A review of the pain literature suggested several brain structures on which to focus treatment while the clients QEEGs, undergone every training session, continually revealed the Anterior Cingulate Gyrus as dysregulated. This structure is involved in pain and motor processes and became the focus of training with very little improvement in either complaint. Training in the ACC had been focused on the delta and theta bands. A fresh look at the Neuroguide Z Scored LORETA analysis revealed that the alpha band was deficient in the ACC(See Illustration B). It

was not the 2 standard deviations of deviance generally accepted in the field as a marker for pathology but the thought was that the lack of alpha could have been contributing to an overactive ACC producing a sensitivity to the painful condition.

At the eleventh session, the client was trained with a combination of surface Z Score training and sLORETA to increase 8 to 12 hertz in the ACC. The training was 17 minutes in duration. The next day via email the client stated:

*Felt blissful yesterday afternoon. Was walking extremely well. Felt on top of the world. A profound clarity. A seldom-felt calmness of the emotional system. Very "in the moment", if that makes sense. I had a wonderful full feeling in my chest and back, way out of the ordinary. Would not mind feeling like that again (oh, for the rest of my life).*

*1. Right hand. Two things mixed in. The soreness in my middle finger which runs up into my right forearm and into my right elbow. On top of this, the lack of dexterity and strength in the right hand, especially the pointing finger and the middle finger. Not sure if I've mentioned this to you before, but I often drop things from my right hand, silverware, tablets, pens and the like. Sometimes dishes. Strength is way down from normal. Am reluctant to shake hands often because of a weak grip and soreness in the middle finger.*

*2. Dexterity in the right hand is still compromised.*

***3. Knees felt very good yesterday afternoon. Was able to go up and down stairs close to normally.***

This report is striking for several reasons. The euthymic response is clear. The training produced a significant reduction in pain and an emotional response that is consonant with the literature. At the same time, there was no improvement in the right arm and hand. The mixed response argues against placebo and for a training response. Moreover, at the next session to address the client's concern with his chief complaint, the right hand and arm, the training moved away from the ACC to train other brain regions. After that session the client complained that the knee pain had returned and via email stated:

*Still experiencing profound clarity pretty much continuously. **Knees still sore.***

At the next session we returned to training an alpha increase in the ACC in combination with Z Score training of bilateral Central Parietal 10/20 sites. The training session was 20 minutes in length. The next day via email the client stated:

*I experienced immediate relief in the knees after the session yesterday. Up and down stairs was significantly better. Remains so today. 50% better. Mathematically though, 50% still remains.*

I would argue that the clients training is a de facto A-B-A research design. Observe the reduction in pain with the initial sLORETA training of the ACC with alpha, the A condition. Then the return of painful stimuli when the training is focused on other brain structures, the B condition. Then the reduction in pain with the reimplementation of the A condition: sLORETA training of the ACC with alpha.

Three more sessions of sLORETA training of an alpha increase in the ACC were performed. The level of pain continued to improve, although more slowly, without the dramatic reductions of the earlier sessions.

At the next session:

*I am experiencing a slow but steady improvement in my knees and ankles and hips and right elbow.*

And after the last session:

*Am experiencing incremental but perceptive lessening of the knee and other joint pain. I just walked up the stairs in our house and could feel the improvement in my steps. Have experienced this pretty much since the session yesterday. The elbow pain has improved. The forearm pain has improved. The ankle and hip pain has improved. If this is a placebo effect, then that would be fine also. I understand the placebo effect is a VERY powerful healing phenomenon.*

There are several factors that may have contributed to the clients positive response that should be considered. The literature points to placebo being effective for more than a third of patients presenting with certain conditions, pain being one of them(Beecher 1955). Although not naive to neurofeedback, sLORETA training requires a full cap rather than the few electrodes that characterized his early neurofeedback training, increasing the potential for a subject-expectancy effect. This definition of placebo happens when a client expects a certain result and unconsciously affects the outcome. The most salient argument against a treatment effect would be the misattribution of the effect to another agent. The client discontinued an herbal intervention at the approximate time of his pain reduction. The increase in pain may have been attributable to the remedy and the decrease due to its removal.

I would make several arguments for a training effect as the cause for the client's experience of pain reduction. The client did not submit to neurofeedback for the pain condition and so had no preconceived notion that the training might improve the condition. The client's comments make it clear that he was aware of the potential for a placebo effect. This awareness may reduce the

unconscious power of placebo in the intervention. His swift positive response to increasing alpha in the ACC argues against the expected slower resolution of discontinuing the herbal remedy. Finally, the client was not made aware of the changes in cortical location and frequency during the course of training. The increase in pain after moving away from Anterior Cingulate training and the reduction in pain following the return to ACC alpha training are strongly suggestive of a treatment effect.

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