# Neurocognition and Neuroplasticity: What Does It All Mean for Clinical Practice?

Orofacial pain specialists are aware that pain perception is modulated by the central nervous system (CNS), but dentists are less familiar with the fact that a dysfunctional modulation of oral somatosensory inputs to the CNS may cause maladaptation to dental rehabilitative interventions. Like nociception, somatosensation also undergoes top-down modulation by higher brain centers, and this may be associated with neuroplastic alterations in the CNS, that is, with changes in neural connections, in connection strengths, and in cerebral cortical areas representing parts of the body.

The dental literature is very sparse on how oral perception is centrally modulated. However, several lines of evidence indicate that the inputs to the CNS from periodontal, dental, and oral mucosal receptors may be regulated in the same manner as that of the cutaneous receptors. Attention to or distraction from a stimulus evoking a sensation are two examples of a powerful top-down modulation: attention leads to an increase and distraction to a decrease in sensation. For instance, the CNS areas involved in tactile perception were found to be significantly more activated when the subject attended to a vibratory stimulus than when the same stimulus was presented in a passive manner.[1,2] Of note is the fact that attention regulates neuronal excitability not only in the presence but also during expectation of the stimulus[3,4] or when an individual is required to attend to the spontaneous sensations of a body part in the absence of external stimuli.[5] Somatosensation depends also on the frequency and duration of the incoming peripheral input and on cerebral cortical reorganization. Tactile acuity and discrimination are enhanced, for example, after repetitive sensory stimulation of a finger.[6,7] This increase parallels an enlargement of the cortical areas representing the stimulated finger.[8–10] Enhancement of tactile discrimination also occurs after high-frequency repetitive transcranial stimulation of the primary somatosensory cortex, an effect that outlasts the stimulation time[11] and that parallels an increase in the cortical representation area.[12] Cortical reorganization happens not only as a consequence of an increase but also of a loss of somatosensory input. After denervation, the region of the somatosensory cortex that normally responds to somatosensory inputs from the part of the body that has been denervated can be activated by stimuli to an adjacent body part that would normally activate an adjacent region of the somatosensory cortex.[13,14] This may also occur after tooth removal: after extraction of the incisor tooth in naked mole-rats, neurons in the region representing the tooth become responsive to tactile inputs from surrounding orofacial structures.[15] Such denervation-induced cortical reorganization has been implicated in the development of a phantom limb pain, and could also conceivably be involved in mechanisms underlying phantom tooth pain that may sometimes arise after tooth extraction or root canal treatment.

The primary motor cortex also receives somatosensory inputs and is therefore not only involved in the generation of motor activities but also in the modulation of motor function, in particular in learning new motor skills, as well as in the process of behavioral adaptation to alterations in the environment.[16] Thus, oral afferent inputs are important in modifying oral motor behavior, and dental manipulations may lead to neuroplastic changes within the orofacial sensorimotor cortex, which is made up of the orofacial somatosensory cortex and the orofacial motor cortex. For instance, the extraction or trimming of a rat's lower incisors alters the representation of masticatory muscles in the motor cortex, alterations that are likely due to the sensory changes in the oral tissues produced by the extraction or trimming and/or the alteration of the oral behavior caused by these manipulations.[16–18] Neuroplastic changes in the orofacial sensorimotor cortex have also been documented in humans after the insertion of an implant-supported prosthesis in edentulous patients.[19–21]

What are the implications for clinical practice? In the vast majority of cases, neuroplasticity may allow patients to adapt positively to changes in the oral environment that happen after practically each dental intervention. An example is the modification of jaw movements to meet a new occlusion, a new jaw position, or a new vertical dimension. However, in some cases, the neuroplastic changes may not be positive but instead may lead to a maladaptive behavior, for instance as in the case of occlusal dysesthesia, movement disorders such as dystonia, or lack of adaptation to a removable prosthesis. The lack of recognition that maladaptation to dental intervention can be the consequence of a dysfunctional modulation of somatosensation and motor control processes leads the dentist to insist on somatic interventions (new splints, new occlusal adjustments, new dentures). Such an attitude reinforces the patient's conviction that there is a physical error, and this makes him/her even more vigilant to oral sensations. Typically, after each therapy, the patient is asked whether he/she feels better,

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and this runs the risk of enhancing the vicious cycle of hypervigilance and negative thoughts, which may worsen the situation.

These examples show that the topic of modulation of somatosensation, neuroplasticity, and neurocognition should become an integral part of dental education. Adaptation to dental interventions should no longer be seen merely as depending on the degree of treatment perfection but within a broader framework that takes into account that somatosensory inputs from the periodontal, dental, and mucosal mechanoreceptors are modulated by the CNS and that these somatosensory inputs to the CNS and their modulation may be associated with sensorimotor neuroplasticity. The integration of this knowledge will provide dentists with a better understanding of the important role that somatosensory modulation and neuroplasticity have on clinical success. There is no longer room for the view that the success of a dental intervention is simply due to a perfectly performed somatic intervention and that a failure is due to a treatment error. Not diminishing the importance of the necessity of always performing the most accurate dental work, it is time to appreciate that clinical success is a complex phenomenon that includes also nonphysical factors such as cognition, emotions, and psychological factors that influence neuroplastic changes and thus directly influence treatment success.

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