

# Chapter I

## Corticofugal Modulation of Tactile Responses of Neurons in the Spinal Trigeminal Nucleus: A Wavelet Coherence Study

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### **ABSTRACT**

*It is well known that the temporal structure of spike discharges is crucial to elicit different types of neuronal plasticity. Also, precise and reproducible spike timing is one of the alternatives of the sensory stimulus encoding. This chapter studies a new mathematical analysis of the temporal structure of neuronal responses during tactile stimulation of the spinal trigeminal nucleus. We have applied the coherence analysis and the wavelet based approach for quantification of the functional stimulus - neural response coupling. We apply this mathematical tool to analyze the decrease of tactile responses of trigeminal neurons during the simultaneous application of a novel tactile stimulation outside of the neuronal receptive field (sensory-interference). These data suggest the existence of an attentional filter at this early stage of sensory processing.*

## INTRODUCTION

Repetitive synaptic activity can induce persistent modification of synaptic efficacy in many brain regions in the form of long-term potentiation (LTP) and long-term depression (LTD). Such synaptic plasticity provides a cellular mechanism for experience dependent refinement of developing neural circuits and for learning and memory functions of the mature brain. The precise timing of presynaptic and postsynaptic spiking is often critical for determining whether an excitatory synapse undergoes LTP or LTD.

This chapter proposes a new mathematical analysis to study the temporal structure of neuronal responses to sensory stimulation. We have applied the coherence on the wavelet based approach for quantification of the functional stimulus - neural response coupling and its modulation when two tactile stimuli appear simultaneously. This analysis reveals that modulation of sensory responses may imply an increase/decrease in the number of spikes elicited by a sensory stimulus and an increase/decrease in the temporal coherence of evoked spikes with the stimulus onset, as well.

Recent electrophysiological studies indicate the existence of an important somatosensory processing in the trigeminal nucleus which is modulated by the cortico-fugal projection from the somatosensory cortex. The somatosensory cortex may enhance relevant stimulus. Also, it may decrease sensory responses in the trigeminal nuclei when a novel (distracter) stimulus is applied. We interpret this decrease of the response as sensory-interference. The objective of the present chapter is to demonstrate that sensory interaction may occur in the first relay station of the trigeminal somatosensory pathway changing the number of spikes evoked by a tactile stimulus and temporal coherence with the stimulus onset. Data suggest the existence of an attentional filter at this early stage of sensory processing.

## BACKGROUND

Somatosensory information coming from the face (including the mouth and the cornea) is collected, processed and finally sent to the thalamus by the trigeminal complex. For experimental study of the mechanism of information representation and processing the vibrissae sensory system of rodents is one of the most used models since it is particularly well organized and structured. Indeed, the large mystacial vibrissae of the rat are arranged in a characteristic, highly conserved array of five rows and up to seven arcs (Brecht et al., 1997; Welker, 1971). Rats use these facial whiskers to perform a variety of tactile discriminative tasks and behaviors (Carvell & Simons, 1990; Gustafson & Felbain-Keramidas, 1977). Sensory information from the vibrissae arrives to the trigeminal complex, which is organized in three sensory and one motor nuclei. The sensory trigeminal nuclei include: the principal nucleus (Pr5), the spinal nucleus (Sp5) and the mesencephalic nucleus (Me5). In turn Sp5 is divided into three subnuclei called oralis (Sp5O), interpolaris (Sp5I) and caudalis (Sp5C). In the trigeminal complex primary afferents and neurons form the “barrelettes”, which replicate the patterned arrangement of the whisker follicles on the snout (Ma, 1991).

Three classes of morphologically and physiologically distinguishable neurons reside in the rat trigeminal nucleus: barrelette cells, interbarrelette cells, and GABAergic or glycinergic inhibitory interneurons (Ressot et al., 2001; Viggiano et al., 2004).

The Pr5 and Sp5 trigeminal nuclei are obligatory synaptic relays for somatic sensory information originated in the large mystacial vibrissae or “whiskers” on one side of the face to the contralateral ventral posterior medial (VPM) nucleus of the thalamus (Peschanski, 1984; Smith, 1973). Pr5 projection neurons are characteristically described as having single-whisker receptive fields (RFs), whereas the rest of the population has RFs

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