The role of Glyclinergic interneurons in the Dorsal Column Nuclei

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Extended abstract

The aim of this paper is to provide new insights about the circuitry and the role of the Dorsal Column Nuclei (DCN) in the processing of somatosensory information. The presence of glycinergic (Gly) cells, a second type of DCN interneurons in addition to well-known GABAergic interneurons, opens the door to more complex interactions between cuneate cells as well as to new hypothesis about the computational implications of such interactions. The research posed here fits in a broader context in the field of the sensory systems and regards with the general issue about the role of subcortical structures (i.e the thalamus) in the processing of sensory information.

The DCN are located within the brainstem, close to the most rostral area of the spinal chord, and are constituted by the Gracile (GN) and the Cuneate (CN) nuclei. They present a similar organization, but differ on the origin of their primary afferents. The DCN processes somatosensory information coming from Primary Afferent Fibres (PAF) and sends it to the thalamus via the Medial Lemniscus (ML). The experimental data were obtained from the dorsal part of the middle region of the Cuneate Nucleus (located from the obex to about 4 mm caudal to it in the cat). This region receives information from somatotopically organized primary afferents sensible to both light touching or hair displacement, and distal Receptive Fields (RFs). On top of that, the CN receives an important corticofugal projection from layer V of sensory motor cortex (Chambers and Liu 1957; Walberg 1957; Rustioni and Hayes 1981; Martinez et al. 1995) with a topographic organization similar to the Primary afferents (Amassian and de Vito 1957; Gordon and Seed 1961; Andersen et al. 1964; Dykes et al. 1982; Cheema et al. 1983; Berkley et al. 1986).

A key point to better understand the cuneate function would undoubtedly be the precise knowledge of the RF structure of the different cell types implicated in the CN circuitry: Relay or CuneoLemniscal (CL) cells, and GABAergic interneurons or non-CuneoLemniscal (nCL) cells. The current knowledge is limited mainly to CL cells. It has been recently shown that their RF has an excitatory center and an inhibitory surround (Canedo and Aguilar, 2000). This spatial arrangement is generated through somatotopically organized afferent organization consisting on direct excitatory input on CL cells and GABAergic mediated inhibition from surrounding areas (Canedo and

Aguilar, 2000). It has been demonstrated that when this circuit is constructed with realistic models of cuneate cells (Sánchez et al., 2003), it can perform edge detection as well as motion discrimination (Sánchez et al., 2002).
However, the presence of a second interneuronal type, the aforementioned Glycinergic (Gly) interneurons, which constitute about 30% of total neuronal population in the rat (Lue et al 1997), introduces further complexity into the circuit. It is known that Gly neurons evoke facilitation of Relay cells by inhibiting GABAergic interneurons (Aguilar et al 2001, 2002). Unfortunately we do not have experimental evidences related to the RF structure of these interneurons that could help us to better understand its role.
At this point we have resorted to computational models, constructed based on experimental data, in order to explore the influence that different spatial structures of Glycinergic cells could have on CL cells. The model assumes that CL cells show excitatory center-inhibitory surround RFs, in which the RF of GABAergic interneurons are mirror images of Relay ones, configuring a so-called push-pull structure. Our results indicate that when Glycinergic cells have a RF overlapped with the Relay cell RF it can increase the center-surround antagonism. On the other hand, when Glycinergic RF spatially includes a number of Relay cells it could facilitate motion detection as well as synchronize the activity of neuronal populations based on stimulus configuration. More specific arrangements on Glycinergic cell RF could even provide direction sensibility at this stage of sensory processing. These results can be used as guidelines for designing new experiments that are needed to determine the actual properties of nCL cells.

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