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BRAIN RESEARCH

Research Report

Collateral projection from the forebrain and mesopontine cholinergic neurons to whisker-related, sensory and motor regions of the rat

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ABSTRACT

The primary goal of this anatomical study was to examine in the rat whether cholinergic neurons provide axon collaterals to whisker-related, sensorimotor regions at cortical, thalamic, and brainstem levels, using a combined method of retrograde tracing and choline acetyltransferase (ChAT) immunostaining. First, when injections were made at primary sensory (S1) barrel field/primary whisker motor (M1) cortices, cholinergic neurons with dual projections were observed in the basal nucleus of Meynert (BM), mainly at middle level; the projection was almost exclusively ipsilateral (99%±0.7%, $n=6$). Second, following unilateral injections of tracers into ventroposteromedial (VPM) barreloids/ventrolateral (VL) thalamic nucleus, dual-projecting cells were observed in the mesopontine tegmental complex including the pedunculopontine tegmental (PTg) and laterodorsal tegmental (LDTg) nuclei, mainly at rostral to middle levels; the projection exhibited ipsilateral dominance, i.e., 67%±1.3% ($n=6$) for the PTg and 64%±1.2% ($n=6$) for the LDTg. Finally, when injections were made at whisker-related, principal sensory trigeminal (Pr5)/facial motor (Mo7) nuclei, a relatively small number of labeled neurons were observed in the PTg and the LDTg at middle to caudal levels; within LDTg, labeled cells occupied the ventral portion of the dorsal LDTg as well as the ventral LDTg (LDTgV). This projection exhibited contralateral preponderance, i.e., 67%±2.0% ($n=6$) for the PTg and 69%±3.2% ($n=6$) for the LDTg. Taken together, the present observations demonstrated that each division of the BM, PTg, and LDTg possessed a differential functional organization with respect to its collateral projection to whisker-related sensorimotor targets, suggesting that the cholinergic projection might play a modulatory role in vibrissal sensorimotor integration, which allows the guidance of behavioral action essential for the survival of the animal.

1. Introduction

Rats actively whisk their vibrissae in the process of exploring environments, during which vibrissal sensation and movement occur almost instantly and continuously (Krupa et al., 2001; Shuler et al., 2002). Discriminative tactile information from the vibrissal follicle–sinus complex (FSC) of the rat muzzle is transmitted to the principal sensory trigeminal

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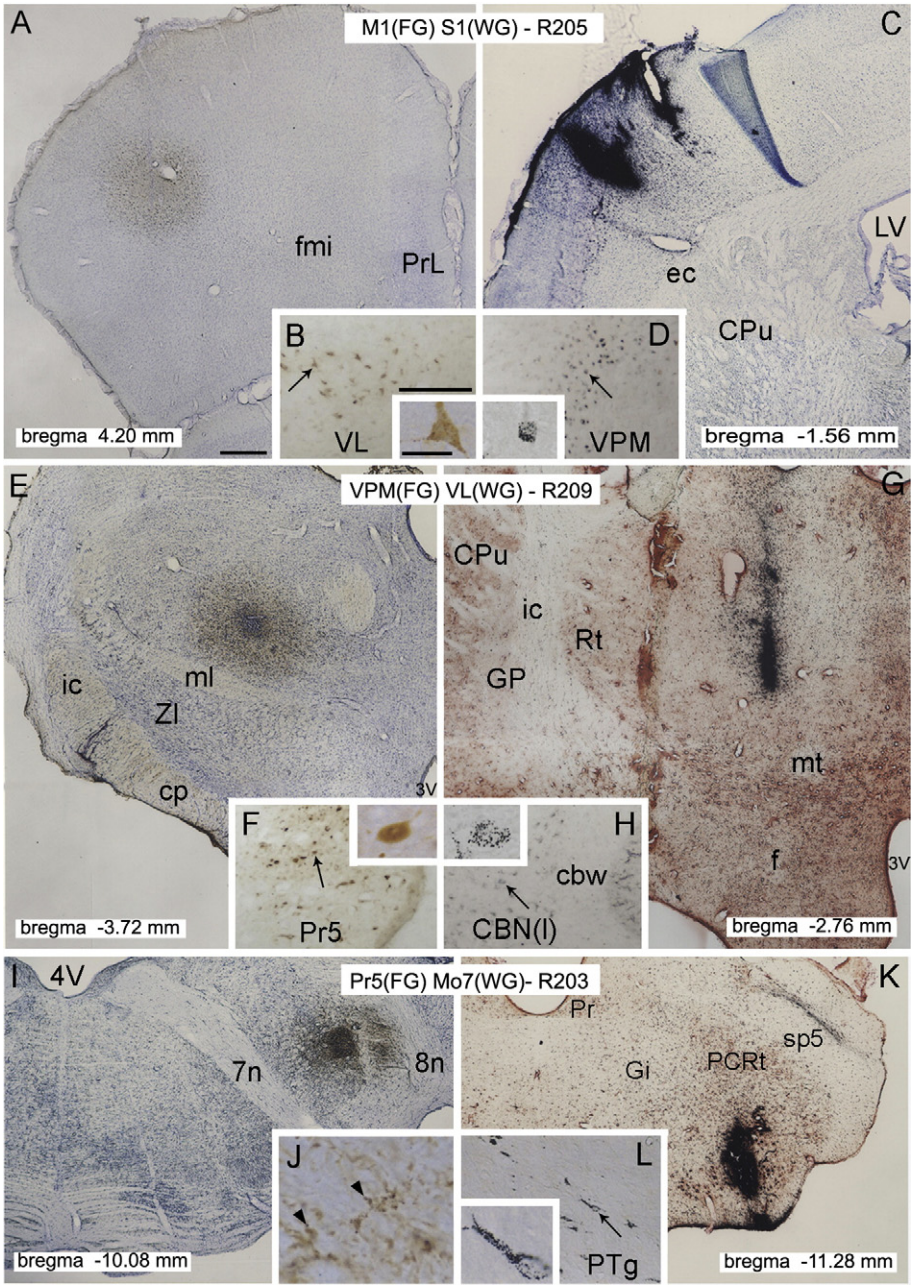

Fig. 1 – Representative examples of the M1-S1 (R205), VPM-VL (R209), and Pr5-Mo7 (R203) injection sites are depicted. The iontophoretic injection of FG produced spherical injection sites ranging in diameter between 400 and 500 μm (A, E, and I), whereas the pressure injection of WG exhibited columnar injection sites with medio-lateral dimension of 150–250 μm (C, G, and K). As a positive control for retrograde tracing, labeled neurons (B, D, F, H, and L) as well as nerve fibers (J) were observed in major afferent site for each injection. 3(4)V, third(fourth) ventricle;7n, facial nerve; 8n, vestibulocochlear nerve; CBN(l), cerebellar n.(lateral); cbw, cerebellar white matter; cp, cerebral peduncle; CPu, caudate putamen; ec, external capsule; f, fimbria; fmi, forceps minor corpus callosum; Gi, gigantocellular reticular n.; GP, globus pallidus; ic, internal capsule; LV, lateral ventricle; ml, medial lemniscus; mt, mammillothalamic tract; PCRt, parvicellular reticular n.; Pr, prepositus n.; Pr5, principal sensory trigeminal n.; PrL, prelimbic cortex; PTg, pedunculopontine tegmental n.; Rt, thalamic reticular n.; sp5, spinal trigeminal tract; VL, ventolateral thalamic n.; ZI, zona incerta. Scale bars = 200 μm (A and B; the bar in A applies to C, E, G, I, K, whereas that in B does to D, F, H, L), 25 μm (inset in B, also applies to J and insets in D, F, H, and L).

nucleus (Pr5) via the infraorbital branch of the trigeminal nerve. The Pr5 sends the vibrissal information to the ventroposteromedial (VPM) barreloid and finally to the primary sensory (S1) barrel field cortex. On the other hand, whisker-related, primary motor (M1) cortex provides descending projections to various thalamic and brainstem nuclei. And finally the lateral portion of the facial motor nucleus (Mo7) governs the skeletal muscle of the FSC via the buccal branch of