Comments on the Fine Structural Organization of the Dorsal Lateral Geniculate Nucleus of the Mouse

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Summary. Neuronal perikarya, dendrites, extraglomerular neuropil, and synaptic glomeruli were examined by electron microscopy in the dorsal lateral geniculate nucleus (LGd) of the mouse. Particular attention was paid to boutons containing ‘flattened’ synaptic vesicles.

In line with recent studies of rat LGd (Lieberman and Webster, 1972; Lieberman, 1973), but in contrast to the findings of Rafols and Valverde (1973) on the mouse LGd, two distinct classes of ‘flat’-vesicle-containing boutons could be distinguished. P-boutons—were traced to and probably originate entirely from the presynaptic dendrites of the intrinsic neurons. They are concentrated within the glomeruli and are postsynaptic as well as presynaptic, being the intermediate elements in numerous intraglomerular serial synapses. F-boutons—are interpreted as axon terminals and are exclusively presynaptic. Some were traced from myelinated fibres. Synaptic vesicles are more concentrated in F-boutons than in P-boutons, appear flatter, and lie in a darker matrix. F-boutons synapse extensively in the extraglomerular neuropil, but are outnumbered by P-boutons in the glomeruli.

The synaptic relationships established within the glomeruli are summarized.

Key words: Dorsal lateral geniculate nucleus — Morphology (ultrastructure) — Mouse — Synaptic vesicles.

Introduction

In a recent paper, Rafols and Valverde (1973) have described the structural organization of the mouse dorsal lateral geniculate nucleus (LGd) based on Golgi and electron microscope studies. Their observations and interpretations differ in certain respects from those we have made in our own investigations of the LGd in the closely related rat (Lieberman and Webster, 1972; Lieberman, 1973), and in hitherto unpublished studies of the mouse LGd. In view of these differences and because of current interest in the nature of boutons containing vesicles with pleomorphic profiles (‘flattened’ vesicles) in thalamic synaptic glomeruli (Guillery, 1971; Szentágothai, 1973), some of our observations on the mouse LGd are presented here for comparison with those of Rafols and Valverde.

Methods

The animals utilized were unoperated mice of the C57 BL/6J strain weighing 25–30 g. They were anaesthetized with ether and fixed by perfusion with a mixture of 4% paraformaldehyde and 0.5% glutaraldehyde in a pH 7.4 phosphate buffer at 35–40°C. The fixative, preceded in some cases by a small volume (2–5 ml) of warm phosphate buffer, was delivered through a needle in the left ventricle or through a cannula lodged in the ascending aorta. The brains were removed immediately, and thin (<1 mm) coronal slices cut through the region of the diencephalon containing LGd were passed through 2 changes of pH 7.4 buffer containing 7% sucrose, postfixed in 2% osmium tetroxide in the same buffer, and after dehydration and block staining in ethanol and ethanolic uranyl acetate, were embedded in Araldite. Thin sections of LGd were cut in the frontal, horizontal and sagittal planes.
Two classes of neuronal perikarya, two classes of dendrites and two varieties of synaptic neuropil can be recognized. The larger neurons (Fig. 1) and the exclusively postsynaptic dendrites (D, Figs. 1, 4) are interpreted as those of the thalamo-cortical relay cells (TCR cells) and like TCR cell perikarya and dendrites in thalamic relay nuclei of rat thalamus, occasionally contain multitubular bodies (Lieberman, Špaček and Webster, 1971). The smaller perikarya and dendrites with both postsynaptic and presynaptic features (PSD, Figs. 1, 4, 5), which are covered over most of their surfaces by narrow astrocytic laminae, can be equated with the PSD cells (intrinsic neurons) of the rat LGd (Lieberman, 1973), and with the cell bodies and dendrites of the “pseudoamacrine cells” of Rafols and Valverde (1973). Synaptic islands or glomeruli of apparently varying degrees of complexity can be differentiated from the considerably more simply organized extraglomerular neuropil and are more or less completely separated from the latter by astrocytic processes (a, Fig. 2). Since the organization of the glomerular and extraglomerular neuropil in mouse LGd is very similar to that in rat LGd (Lieberman and Webster, 1972) and has been described in some detail by Rafols and Valverde (1973), a comprehensive description will not be attempted and attention will be focussed upon certain contentious anatomical features.

Within the synaptic glomeruli several classes of neural element can be differentiated. (1) Exclusively postsynaptic dendrites or dendritic protrusions of TCR neurons (D, Figs. 2, 5, 7). (2) Large, exclusively presynaptic axon terminals containing spherical synaptic vesicles and large mitochondria with tubular cristae (R, Figs. 2, 7). [In some glomeruli there appears to be a second class of axon terminal containing spherical synaptic vesicles, making similar synaptic contacts but differing in minor morphological details.] (3) Irregularly shaped boutons containing synaptic vesicles with pleomorphic profiles, elements of smooth endoplasmic reticulum and occasional clusters of ribosomes, identical in all respects with the P-boutons of rat LGd (P, Figs. 1, 2, 7) and like them traceable to unequivocal presynaptic dendrites (PSD, Figs. 1, 4, 5, 7) and to elements sharing the morphological features of presynaptic dendrites and of P-boutons (P, Fig. 5; P2, Fig. 6). (4) Exclusively presynaptic boutons containing tightly packed vesicles with pleomorphic profiles (but including a higher proportion of flattened profiles than in P-boutons and with a more electron dense matrix than P-boutons). These boutons resemble the cylindrical-vesicle-containing axon terminals (F-boutons)

Fig. 1. Perikaryon, stem dendrite and initial axon (i8) of a relay neuron (TCR). To the right of the cell is part of a glomerulus in which the shaft of a presynaptic dendrite (PSD) is in synaptic contact (arrow) with a TCR cell dendrite (D). Also present are a P-bouton (P) and an F-bouton (F). The pale P-bouton with loosely packed vesicles contrasts strongly with the adjacent F-bouton, and with another F-bouton synapsing close to the origin of the TCR cell axon

Fig. 2. Part of a well-defined synaptic glomerulus (a, periglomerular astrocytic laminae). Relay cell dendrite element (D), R-boutons (R) and P-boutons (P) can be distinguished

Fig. 3. Origin of an F-bouton from a myelinated axon