

**SOME ASPECTS ON THE STRUCTURAL
ORGANISATION OF THE NUCLEUS
OF THE LATERAL OLFACTORY TRACT**

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INTRODUCTION

The nucleus of the lateral olfactory tract forms an important primary olfactory centre. It is composed of a spherical mass of cells overlying the medial edge of the lateral olfactory tract (Fig. 1.A).

Although this nucleus was described in the studies of Johnston (1923), Gurdian (1925), Young (1936), Hunphery (1936) and Fox (1940), real interest of neuroanatomists in its cyto-architecture began only with the work of Valverde (1965), Tömböl and Szafranska — Kosmal (1972) Hall (1972), and Kamal and Tömböl (1975). These authors gave a general description of some cells observed in their golgi studies on the amygdaloid complex. No studies were made on the ultra-structure of this nucleus. For these reasons it was deemed to focus this work primarily upon the cytoarchitecture and on the synaptic architecture both in golgi preparation and in electron microscopical specimens.

MATERIAL AND METHODS

Brains of 2—3 months-old cats were prepared by Golgi-Kopsch perfusion technique, as modified by szentagothai (1963) and tömböl (1966—1967). The successfully impregnated blocks were embedded in celloidine and frontal serial sections of 100 to 120 μ m thickness were cut.

The electron microscopic analysis was performed on normal brains after perfusing animals under phenobarbital anesthesia with Karnovsky (1965) solution. Excised materials were post-fixed with 2% osmium tetra-oxide solution. The sites of excision were identified by routine histological examination of the brain specimens.

RESULTS

Golgi observations :

Two types of neurons were observed.

1. Neurons with long axons (projective neurons) : Most of these neurons were pyramidal in

shape with strong apical dendrites and several basal dendrites (Fig. 1. B). The terminal arborisations of both the apical and basal dendrites were covered with dendritic spines. Usually the pyramidal cells were arranged with their apical dendrites directed to the center of the nucleus, while the bases gave rise to the axons which appeared projecting from the surface of the sphere. The axons were usually directed to the anterior amygdaloid area.

2. Neurons with locally arborising axons (Golgi type II. interneurons): The somata of these neurons were usually smaller in diameter (Fig. 1.C). Some of these somata were oval in shape while others were multi-angular. They usually gave rise to poorly arborising primary dendrites. These dendrites had virtually no spines. The axons of these neurons arose from the cell body and arborised locally after a short distance from their origin.

Electron microscopic observations :
Cell types :

In agreement with the Golgi results, examination of the ultra-structure of the nucleus of the lateral olfactory tract revealed that the cells in this nucleus could be classified into 2 types :

1. Relatively large cells, usually rounded or oval in shape.

In some sections these neurons showed pyramidal « triangular » configurations (Fig. 2 A). with an apical large dendrite extending vertically from one angle of the cell body. These cells were rich in plasma structure. Their cytoplasm contained relatively a large number of lysosomes, ribosomes arranged in rosettes and was rich in granular endoplasmic reticulum. The organelles of these cells continued for certain distances into the dendrites, but their density rapidly diminished.

2. Relatively smaller cells, rounded or oval in shape (Fig. 2. B). Their plasma seemed to be reduced relative to the size of the nucleus. The plasma structure was light containing a less amount of lysosomes, ribosomes and granular endoplasmic reticulum. However, these cells were characterised by a plenty of axosomatic synaptic contacts. It was obvious that the larger cell type corresponded to the projective pyramidal neurons, and the relatively smaller cell type corresponded to the Golgi type II interneuron.

Dendrites :

Two types of dendrites could be distinguished in the neuropil of the nucleus of the lateral olfactory tract.

1. Dendrites of projective neurons (Fig. 3.A). exhibited all the organelles found in the perikar-

yon. As observed in Golgi preparations, the proximal portions of these dendrites bear no spines. Their surface membrane was richly covered with terminal boutons establishing axo-dendritic synaptic contacts. The distal portions of these dendrites gave rise to many dendritic spines (Fig. 3. B).

2. Presynaptic dendrites (Fig. 4. A): were characterised by relatively small pale dendritic profiles containing mitochondria and a mixture of flattened and rounded (i.e. pleomorphic) synaptic to the large dendrites of cisterns and ribosomes were occasionally observed. These dendrites were usually presynaptic vesicles. Endoplasmic the projective neurons and postsynaptic to the other axonal boutons containing rounded vesicles.

Most probably these dendrites were belonging to the Golgi type II interneurons which were present in the nucleus of the lateral olfactory tract.

Axon terminals :

Four types of boutons could be identified in the neuropil of the nucleus of the lateral olfactory tract :

1. The first type of boutons, B I. (Fig. 4.B) was densely filled with rounded vesicles and was relatively uniform in size. The Four type of boutons could be

sicles between the rounded vesicles was a common feature of this type of boutons. They were presynaptic to neuronal perikarya, large and small dendrites, presynaptic dendrites and dendritic spines.

In the area of the synaptic contacts, the postsynaptic membrane was usually thicker than the presynaptic membrane was usually thicker than the presynaptic membrane characteristically fewer rounded cal synapse.

2. The second type of boutons, BII (Fig. 5.A). contained characterising to the asymmetrical vesicles which were loosely scattered throughout the terminals. A characteristic feature of these boutons by which we could easily differentiate was their electron lucent appearance. This type of boutons most often contacted the perikarya, large and small dendrites, and the dendritic spines. They usually established asymmetrical types of synaptic contacts.
3. The third type of boutons, BIII (Fig. 5.B) was characterised by the presence of flattened vesicles. This type of boutons was presynaptic to the cell somata, large dendrites, less frequently to the small dendrites and virtually never to dendritic spines.

4. The fourth type of boutons, BIV (Fig. 5.C) contained small and large spheroidal vesicles. Occasionally dense-core vesicles could be observed in these boutons. This type of terminales was presynaptic most frequently to the dendritic spines, less often to the somatic membranes or small and large dendrites. Usually the synapses were of the asymmetrical type.

DISCUSSION

Concerning the cell types in the nucleus of the lateral olfactory tract and the characteristics of the dendrites of each type, the ultrastructure pictures are in a fair agreement with the Golgi results. The cells are identified as projective neurons and Golgi type II interneurons. The soma of the projective type is large, pyramidal in shape and rich in the plasma structure and cytoplasmic organells. The cell membrane has scanty or no axosomatic contact. On the other hand the soma of the Golgi type II interneuron is relatively small in size and poor in the plasma structure and the cytoplasmic organells. The cell membrane usually has a plenty of axosomatic contacts.

As regards the dendrites of the projective neurons, the main stem of these dendrites bears no spines. Their surface membrane is richly covered with terminal boutons forming axodendritic synaptic contacts. However, the distal parts of

these dendrites establish their synaptic contacts by means of the dendritic spines, which are present in abundance along the course of these dendrites.

A considerable interesting finding in this study is the observation of the new presynaptic dendrites in the neuropil of the nucleus of the lateral olfactory tract. In the present study it was unable to demonstrate them at their origin from the soma but according to the results of Rall et al, (1966), Dowling and Boycott (1966), Ralston and Herman (1969), Famiglietti (1970), Famiglietti and Peters (1972), Wong (1970), Le Vay (1971), Pasik et al (1973), Hajdu et al (1974) and Hamori et al (1974) it is assumed that these dendrites belong to the Golgi type II interneurons which appear in the Golgi specimens. However, the existence of these dendrites in the phylogenetically old nucleus of the lateral olfactory tract, which acts as a relay station for olfaction, is suspected. This is because these dendrites have been observed only in the lower centres, particularly in the systems for sensory and other relays such as the olfactory bulb (Rall et al, 1966), retina (Dowling and Boycott, 1966), and the lateral and medial geniculate bodies (Famiglietti, 1970). No such dendrites have been found in the new cortex.

According to the shape of their synaptic vesicles the terminal boutons are classified into 4 types: BI with round vesicles which are equal

in diameter; BII-With round vesicle Within translucent profile BIII-with flattened vesicles and BIV-with rounded synaptic vesicles but with marked variation in diameter.

The functional significance of the differences in the shape of the synaptic vesicles is still uncertain. In the cerebellar cortex the rounded and the flat vesicles can be correlated with the excitatory and inhibitory functions of the respective neurons (Uchizono 1965). Additionally, there are many regions of the central nervous system : notably the thalamus and geniculate nuclei, and the spinal cord. Uchizono concept seems to be accepted whether this correlation will hold as general principle applicable widely through the central nervous system remains still to be seen.

SUMMARY

The neuronal structure of the nucleus of the lateral olfactory tract was studied in cat with golgi-kopsch perfusion technique. Two types of neurons were distinguished. a) Projective neurons "Long axonal" pyramidal in shape. b) Golgi type II interneurons. This was confirmed by electron microscopical examination which also threw more light on the types of dendrites and terminal boutons as well as their synaptic contacts.

Two types of dendrites were identified (a) Dendrites of projective neurons, having synaptic contacts on their proximal smooth part. Dendritic spines were abundant in the distal portion of these dend-

rites. (b) Dendrites with synaptic vesicles, most probably belonging to Golgi type II interneurons. According to the shape of their synaptic vesicles four types of synaptic boutons were identified: B (I) with round vesicles equal in diameter, B (II) with round vesicles within a translucent profile, B (III) with flattened vesicles and B (IV) with round vesicles but with marked variation in diameter.

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EXPLANATION OF FIGURES

Fig. (1. A) The nucleus of the lateral olfactory tract (marked by arrow) as seen in Forntal section of cat brain stained with Nissl. The nucleus is overlying the medial end of the lateral olfactory tract, X 15.

Fig. (1. B) Pyramidal projective neuron in the nucleus of the lateral olfactory tract. Note that the axon is directed dorsally (marked by arrow). Golgi-Kopsch, X 500.

Fig. (1. C). Golgi type II in interneuron. Note that the axon arborises locally (marked by arrow) Golgi-Kopsch, X 500.

Fig. (2. A) Electron micrograph of a nerve cell in the nucleus of the lateral olfactory tract. Note that the body is triangular in shape and the cell membrane has no axosomatic contacts X 7000.

Fig. (2. B). Electron micrograph of a nerve cell in the nucleus of the lateral olfactory tract. Note the presence of many axosomatic contacts, (marked by arrows). X 7000.

Fig. (3. A) Main stem of a dendrite of a projective neuron (D). The surface membrane is totally covered with terminal boutons in synaptic contact. (marked by arrows) X 22356.

Fig. (3. B) Dendritic spine (S) arising from a dendrite of a projective neuron (D). X 22356.

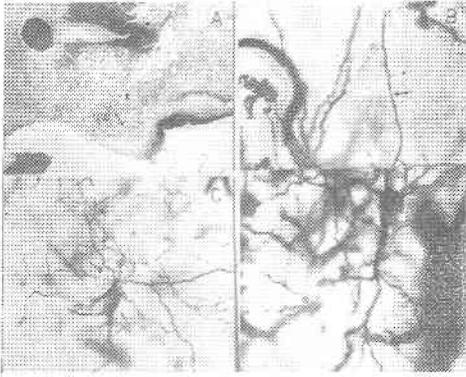
Fig. (4. A) Presynaptic dendrite (PD) with its characteristic flattened and small spheroidal vesicles. It is presynaptic to dendrite of projective neuron (D) and postsynaptic to BI boutons. X 47655.

Fig. (4. B) BI bouton densely-filled with rounded vesicles that are uniform in size. X 22356.

Fig. (5.A) BII bouton contains rounded vesicles within a translucent profile. X 22356.

Fig. (5.B) BIII bouton contains flattened vesicles synapting with a soma (marked with arrow). X 20000.

Fig. (5.C) BIV bouton contains small and large spheroidal vesicles and some densecore vesicles. X 47655.



Figs. (1. A, 1. B and 1. C)



A



B

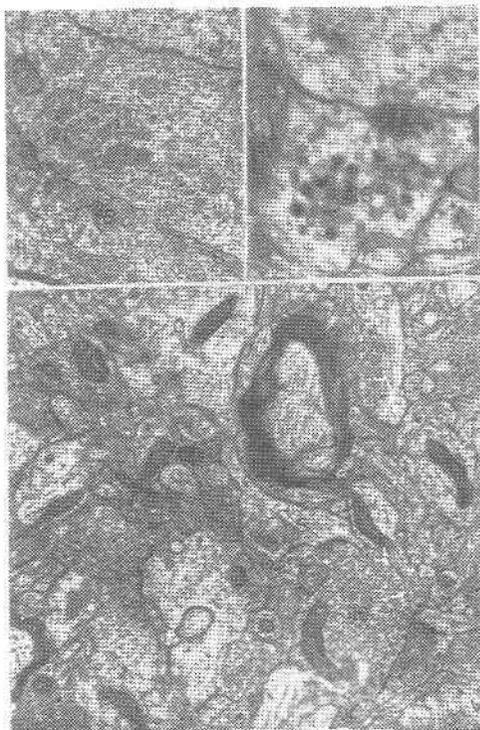
Figs. (2. A and 2. B)



Figs. (3. A and 3. B)



Figs. (4. A and 4. B)



Figs. (5. A, 5. A and 5. C)