effect of vitamin C on anaphylaxis in the normal guinea-pig is worthy of further investigation.

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The pharmacology of amygdaloid neurones

SIR,—The amygdala contains several potential neurotransmitter substances together with their enzymes of synthesis, for example, 5-hydroxytryptamine, noradrenaline (Vogt, 1954; Kuntzmann, Shore, Bogdanski & Brodie, 1961) and acetylcholine (Hebb & Silver, 1956). However, the direct response of single cells in the amygdala to these substances is unknown. This letter describes the response of amygdaloid neurones to various biogenic substances introduced into their environment by microelectrophoresis.

Four cats anaesthetized with chloralose or diallylbarbituric acid and urethane were used. The skull was opened on one side and the structures overlying the amygdala aspirated. The exposed area of brain was then covered with 3% agar in Ringer's solution to prevent drying. Using the stereotaxic co-ordinates of Jasper & Ajmone-Marsan (1960) the surface of the agar was now marked in several places overlying different areas of the amygdala. Five barrelled glass micropipettes (tip diameter 4 to 8μ) were now inserted through the marks in the agar to the required depths in the amygdala. At the end of the experiments the position of the micropipette tracks was checked histologically in celloidin sections. Eleven out of the fourteen tracks were in the amygdala.

The technique for preparing and using the micropipettes for microelectrophoresis was essentially that described by Krnjević & Phillis (1963). The four outer barrels contained aqueous solutions of the various drugs to be tested, whose pH was adjusted to give maximal ionisation compatible with stability. Drug ions were expelled from the tip of the pipette by appropriate currents. Extracellular spike responses from single cells were recorded simultaneously through the saline-filled central barrel of the pipette. After amplification these spikes were displayed on an oscilloscope and counted on a ratemeter. The ratemeter output was then displayed on a penwriter.

One hundred and thirteen cells were studied; two thirds of these were in the lateral or basomedial complex of the amygdaloid nucleus, the rest in the amygdaloid area. Some cells were firing spontaneously, or could be evoked synaptically through stimulation of the olfactory bulb. Otherwise quiescent cells were

excited by L-glutamate discharged into their vicinity by microelectrophoresis. L-Glutamate excited and γ-aminobutyric acid depressed cell firing in all the cells tested, as shown in Fig. 1. These effects had a rapid time course and were essentially similar to those seen elsewhere in the central nervous system (e.g. Curtis, 1965).

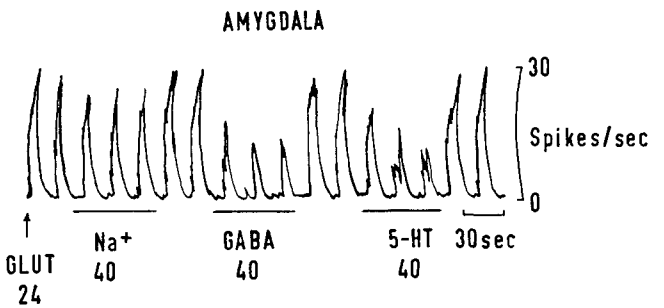

FIG. 1. Ratemeter record of firing of a cell in the lateral amygdaloid nucleus of the cat. This cell was quiescent but could be fired by the regular application of L-glutamate 24nA for 5 sec in every 15 sec (only the first application is indicated at ↑). A background current of 40nA through the saline control barrel (Na^+ 40) indicated by bar below record, had only a slight depressant effect on glutamate-induced excitation. The application of γ-aminobutyric acid with a current of 40nA (GABA 40 and bar below record) had a strong depressant effect which developed and reversed quickly.

The application of 5-hydroxytryptamine with a current of 40nA (5-HT 40 and bar below record) also depressed glutamate-induced excitation, and this depression was progressive.

N.B. When this unit was evoked synaptically by stimulation of the olfactory bulb, the depressant action and time course of γ-aminobutyric acid and 5-hydroxytryptamine was almost identical to that shown in this figure.

The scale to the extreme right of the record shows the number of extracellular spike potentials counted per second by the ratemeter. Time calibration 30 sec.

5-Hydroxytryptamine depressed 32 out of the 42 cells tested. This effect is shown in Fig. 1 and it can be seen that the onset of depression was typically slower than that seen with γ-aminobutyric acid. A similar depression was produced by noradrenaline and dopamine. The depression produced by 5-hydroxytryptamine would appear to be on the post-synaptic membrane since cells were similarly affected whether activated synaptically or with L-glutamate. Excitation by 5-hydroxy-tryptamine was not seen.

The proportion of acetylcholine-sensitive cells was low; thus only 8 cells were excited out of the 48 cells tested. These amygdaloid neurones were also directly excited by acetyl-β-methylcholine and carbachol as shown in Fig. 2. The time course of excitation by these three choline esters was generally slower than shown in this figure, so that recovery might take several minutes after stopping the expelling current.

In general the cells in the amygdala respond to the various potential neurotransmitter substances used, in much the same way as the cells in the pyriform cortex (Legge, Randić & Straughan, 1965). It is of interest that 5-hydroxytryptamine and acetylcholine-sensitive cells appear to be distributed throughout the amygdala and are not concentrated in the basomedial complex. For the concentration of 5-hydroxytryptamine-containing nerve terminals and acetylcholinesterase-containing fibres in the basomedial complex (Carlsson, Falck & Hillarp, 1962; Krnjević & Silver, 1965) would suggest that the 5-hydroxy-

tryptaminergic and cholinergic innervations (if they exist) are confined to that area. Current experiments are concerned with the effect of specific pharmacological antagonists on the synaptic activation of amygdaloid cells. It is hoped that these studies will throw some light on the function of 5-hydroxytryptamine, noradrenaline and acetylcholine in this region.

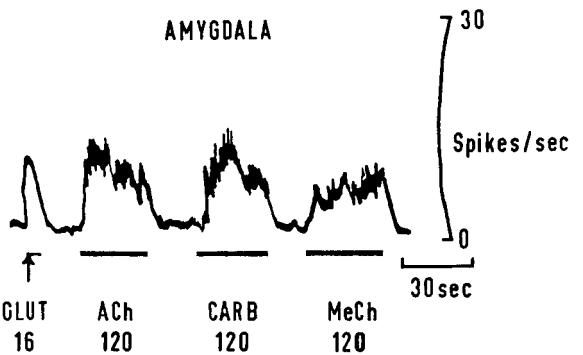

FIG. 2. Ratemeter record from cell in the basomedial complex of the amygdala. On the left of the record L-glutamate applied for 5 sec with a current of 16nA (GLUT 16 and ↑ below the record) rapidly excited the cell. Acetylcholine was then applied with a current of 120nA (ACh and bar below record) and this also excited the cell. Carbachol and acetyl-β-methylcholine caused similar excitation. Note that the onset of excitation with L-glutamate was immediate, while there was a characteristic delay before the choline esters induced firing.

The scale to extreme right of the record shows the number of extra-cellular spike potentials counted per second by the ratemeter. Time calibration 30 sec.

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