# BACKGROUND ACTIVITY OF SINGLE UNITS OF THE POSTERIOR HORN OF THE SPINAL CORD

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The background unit activity in the dorsal part of the posterior horn was studied in unanesthetized cats. The character of the extracellularly recorded unit activity was assessed in terms of the usual indices and of the function of expected density of discharges following each preceding discharge. The existence of different types of unit activity and its dependence on the localization of the neurons were demonstrated. Most cells of the substantia gelatinosa are characterized by irregular low-frequency discharges with independent distribution (uniform function of expected density).

Recent physiological investigations have shown that the dorsal part of the posterior horn of the spinal cord plays an important role in the reception, integration, and transmission of afferent impulses and in the mechanism of presynaptic control [14, 15].

The object of the present investigation was to study and make a statistical analysis of the background single unit activity in the dorsal part of the posterior horn.

## EXPERIMENTAL METHOD

Experiments were carried out on unanesthetized cats immobilized with displacin and maintained on artificial respiration. Animals whose arterial pressure was not below 80 mm were used in the experiments.

Unit activity in the posterior horn in segment L7 was recorded extracellularly by the usual method with glass microelectrodes (tip about 1-3 $\mu$ in diameter) filled with 2.5 M KCl solution with the addition of 0.5 M ferricyanide solution. The microelectrode was inserted from the lateral surface of the spinal cord by a method developed in the writer's laboratory by V. P. Lebedev [6, 7]. The localization of the microelectrode was determined by an ionophoretic method [4].

The single unit background activity (SUBA) was assessed in terms of the following indices: mean frequency, mean interval between spikes, type of distribution of discharges, histogram of distribution of intervals, and function of expected density (FED) of distribution of discharges after each preceding discharge [11]. A group of the FED was plotted from the oscillograms by the use of a cumulative matrix. Each unit of the matrix had the value of 10-20 msec.

## EXPERIMENTAL RESULTS AND DISCUSSION

Altogether 46 neurons possessing SUBA were studied; 31 were located in layers II and III of the gray matter of the spinal cord, corresponding cytoarchitectonically to the region of the substantia gelatinosa [14], while the remaining 15 were situated more ventrally (layers IV-VI).

The distribution of units with different firing rates in the cross section of the posterior horn of the spinal cord is illustrated in Fig. 1A. It will be clear from the figure and the histogram of distribution of

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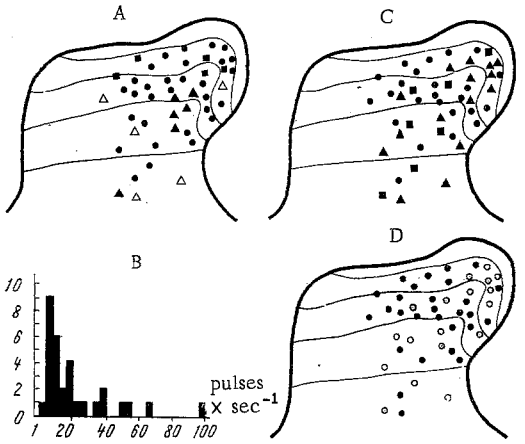


Fig. 1. Character of single unit background activity in posterior horn in relation to localization of neurons. A) Distribution of neurons with different firing rates (circles, rate 1-20/sec, squares 20-40/sec, black triangles 40-60/sec, white triangles 60-100/sec or more) on diagram of cross section of segment L7 of the spinal cord; B) frequency histogram of background activity of units located in region of substantia gelatinosa. Ordinate, number of units; abscissa, frequency (pulses/sec); C) distribution of units with different types of background unit activity (circles – irregular discharges, triangles – regular discharges, squares – grouped discharges); D) distribution of units with different types of function of expected density (black circles – regular, white circles – irregular).

TABLE 1. Functions of Expected Density for Units with Different Frequencies, Localizations, and Types of Activity

| Function of expected density | Frequency of discharges (pulses/sec) | Number of units located in different layers of gray matter of spinal cord* | | | | Type of distribution of discharges (number of units) | | |
|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV-V | regular | irregular | grouped |
| Regular | 3-65 | – | 8 | 11 | 9 | 6 | 22 | – |
| Irregular | 2-42 | – | 6 | 4 | 8 | 9 | 2 | 7 |

* The layers of the gray matter of the spinal cord are identified from Rexed's atlas [13].

cells in the substantia gelatinosa by frequency (Fig. 1B) that units with identical mean firing rate are concentrated in certain zones of the posterior horn. Most units of the substantia gelatinosa possessed spontaneous activity with a frequency of 1-20/sec.

Neurons of the posterior horn differed in the temporal distribution of their background discharges. The type of discharge, i.e., the structure of SUBA, was defined on the basis of intervals between spikes [5]. On this basis, the SUBA was subdivided into "regular," "irregular," and "grouped." The distribution of units with different types of background discharges in the transverse section of the posterior horn is shown in Fig. 1C. The results show that for most neurons located within the substantia gelatinosa, the SUBA was characterized by irregular discharges (18 units). Regular discharges were found in 9 neurons, 6 of which were located in the dorsolateral part of the posterior horn. Units with grouped discharges were comparatively rare (three neurons). Similar results regarding the types of SUBA in the substantia gelatinosa have been described by other workers [3, 5]. No relationship could be detected between the mean frequency of the SUBA and the type of background discharges.

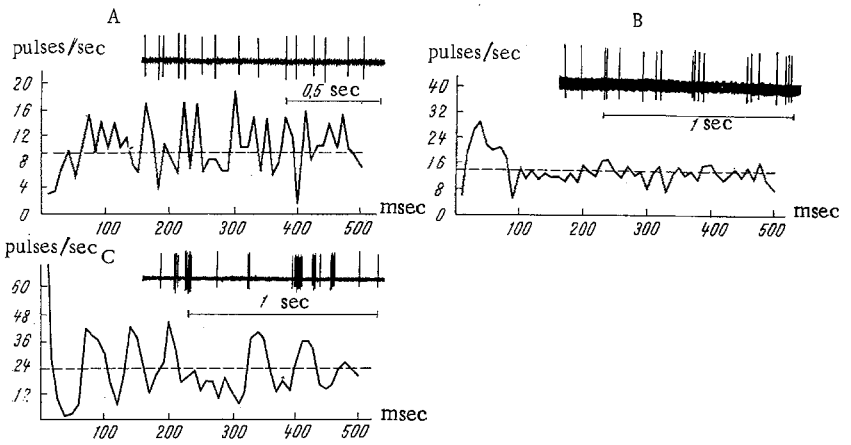


Fig. 2. Graphs of function of expected density of distribution of discharges after each preceding discharge and single unit background activity in the posterior horn. A) Regular function of expected density; B) function of expected density with one initial wave; C) function of expected density with several periodic waves. In all graphs, ordinate, firing rate (pulses/sec), abscissa, time (in msec). Broken line shows level of mean firing rate. Above each graph a fragment of the record of activity of that unit is shown. Time calibration: A) 0.5 sec, B, C) 1 sec.

To determine whether definite forms of statistical correlation exist in the background discharges or whether their character is a random (independent) distribution of the Poisson type, the FED of distribution of the discharges was determined for each unit. The method of statistical analysis was chosen as one of the easiest, for as a rule a computer is required to obtain the other criteria of statistical dependents. On the basis of their FED, all the units were subdivided into two groups (Table 1).

In the first group of units (28) the FED was represented by a curve parallel to the abscissa at the mean frequency level, with deviations from the mean level arising without any particular order (Fig. 2A). This "regular" FED was found in most units of the substantia gelatinosa (Table 1, Fig. 1D). As Table 1 shows, a "regular" FED was more characteristic of units with an irregular type of background discharges, but it could also be found (6 units) in cases of regular activity.

The FED for the second group of neurons located in the substantia gelatinosa (10) and at the base of the posterior horn (8) was reflected graphically as a curve with periodic wave-like deviations from the mean frequency level. A deviation of the FED was taken as significant if the amplitude of the wave exceeded the mean level by twice the basic deviation (2S), given by $S = \sqrt{n}$, where n is the number of spikes in a particular unit of the matrix [1].

For some neurons only an initial maximal deviation lasting 20-40 msec was detected (Fig. 2B). In other cases two or three regular waves, from 50 to 200 msec in duration, were found (Fig. 2C). This "irregular" type of FED was found in neurons with different firing rates (5-55 pulses/sec). However, an "irregular" FED was found considerably more often in units with "regular" and "grouped" types of SUBA (Table 1).

In accordance with the theory of the FED [11], it is assumed [1] that the presence of two or three periodic waves in the graph of the function is evidence of the statistical dependence of distribution of the intervals both within the groups of spikes as well as between separate (2-3) groups of discharges. This statistical dependence is probably characteristic of neurons subjected to powerful synchronous synaptic bombardment, at the apex of which action potentials are generated [2, 8]. As the results given in Fig. 1D show, units of the substantia gelatinosa with "irregular" FED are located in those parts of the posterior horn (layers II-III) where numerous cutaneous fibers terminate [9].

The "irregular" character of the FED is evidently due to the independent, random distribution of the discharges arising as the result of asynchronous synaptic bombardment [1, 11].

These results thus show that the neurons in the dorsal part of the posterior horn differ in the character of their SUBA and can be distinguished essentially by the frequency and type of distribution of their discharges; units possessing a uniform type of spike activity and a similar frequency have a definite localization in the posterior horn, possibly on account of the morphological features distinguishing these neurons and the organization of their connections.

However, differentiation of the SUBA purely by the type of distribution and frequency of the discharges does not reflect the pattern of onset of spike activity in these units. Methods (such as analysis of the FED) by which the presence of a random and dependent distribution of discharges, which in turn is associated with an unequal intensity and synchronization of the synaptic bombardment, can be established must be used for this purpose.

The "irregular" FED, the one most commonly found in neurons located in the lateral region of the posterior horn, evidently indicates the existence of certain specific pathways for their activation, influences from which have the form of periodic, powerful, and synchronous volleys.

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