Directional Responses to Sound in the Central Nervous System of the Cricket *Teleogryllus commodus* (Orthoptera: Gryllidea)

II. A Descending Interneuron

G.S. Boyan*

Department of Neurobiology, Research School of Biological Sciences, Australian National University, Canberra City, A.C.T. 2601, Australia

Accepted December 18, 1978

Summary. 1. The D neuron is one of several auditory interneurons which descend from the prothoracic ganglion in the ventral nerve cord of the cricket *Teleogryllus commodus* and is characterised by the response properties below.

2. The D neuron has two sensitivity peaks – at 4 kHz (near the conspecific song frequency) and at 900–1,000 Hz. At 4 kHz the ipsilateral intensity-response curve of the D neuron is sigmoid with a dynamic range of 15 dB.

3. The D neuron encodes stimulus durations of up to 80 ms with increases in both the duration of the response and spike numbers per response; but with longer stimulus durations the number of spikes in each response declines. The D neuron follows pulses presented at biologically relevant rates and may therefore provide information on temporal characteristics of the species’ song.

4. Directional sensitivity in the D neuron is a maximum at 4 kHz and there is no directional response at 900–1,000 Hz. At low intensities the directivity pattern plotted on polar coordinates is cardioid, with a maximum sensitivity at 90° on the ipsilateral side; but at high intensities the response becomes omnidirectional.

5. Removal of contralateral neural input results in a small but consistent reduction in sensitivity to ipsilateral and contralateral sound over a narrow frequency band around 4 kHz. At suprathreshold intensities, however, ipsilateral spike numbers decrease and contralateral spike numbers increase, with the effects becoming more apparent at high intensities. Both excitatory and inhibitory inputs across the ganglion determine the response. The directionality of the D neuron is abolished when the prothoracic tracheal system is blocked, but the tuned response is not affected.

6. Simultaneous recording of the D neuron, and S and L neurons in the ascending auditory pathway, shows that auditory thresholds, spike numbers to a given stimulus, and intensity-response characteristics are different in each neuron. The D neuron is not the posterior projection of S or L neurons.

Introduction

In contrast to the many studies on ascending auditory neurons summarised in the preceding paper (Boyan, 1979) few attempts have been made to investigate auditory information descending from the thoracic (Zhantiev and Chukanov, 1972; Rheinlaender and Kalmring, 1973; Zhantiev and Kalinkina, 1977; Boyan, 1978) or head ganglia (Zhantiev and Korsunovskaya, 1977) apart from the T neurons of the Tettigoniidae (Rheinlaender et al., 1972).

The Tettigoniidae and Gryllidae have auditory organs on their forelegs, so auditory information entering the prothoracic ganglion can reach the head without passing through other thoracic ganglia. If the posterior thoracic ganglia are therefore to play a role in auditory behaviour independently of the head ganglia, they must have auditory information specifically sent to them, either in conjunction with the ascending pathway as T-fibres or independently by descending interneurons.

In a preliminary report (Boyan, 1978), a newly described neuron – the D neuron – was found to project auditory information from the prothoracic ganglion to the meso- and metathoracic ganglia in the cricket *Teleogryllus commodus*. The neuron showed directional responses very similar to those...
recorded in the ascending auditory pathway (Hill and Boyan, 1977).

In this paper, the response properties of the D neuron are examined in more detail, particularly at suprathreshold intensities, and the potential significance of these properties for the acoustic behaviour of the cricket considered.

Materials and Methods

Most crickets used in the experiments (Teleogryllus commodus) were caught in the wild near Canberra either as adults or as immatures and then reared to adulthood in the laboratory. In some cases when wild crickets were unavailable, first generation laboratory reared crickets were used after checking that their auditory sensitivities were within the range of those found in wild animals.

Crickets were prepared for experiments as previously described (Boyan, 1979). The prothoracic ganglion was isolated from neural input from the head and posterior part of the body by severing the ventral nerve cord immediately posterior to the suboesophageal ganglion and again posterior to the recording site. This procedure was also followed when recordings were made from connectives posterior to the other thoracic ganglia.

Stimulation of the preparation with sound and recording and analysis of neural responses were carried out using the equipment and procedures described previously (Boyan, 1979). Recordings were made from the D neuron in one of the connectives posterior to the prothoracic ganglion, and the trigger levels of the microprocessor were set in each preparation so as to discriminate the spikes of the D neuron from other ongoing activity.

Since both D neurons were not recorded simultaneously no determination of any asymmetry between them or of a null direction could be made. Crickets were therefore initially aligned with sound incident along the longitudinal body axis (defined as 0°) and all angles are expressed in degrees with respect to 0°.

The convention of referring to sound levels as dB above the threshold of a unit (Boyan, 1979) is continued here. Threshold is defined as an average response of one spike per tone burst over five successive tone bursts to sound incident from 90° on the ipsilateral side.

Results

Several auditory units were consistently recorded in the connective posterior to the prothoracic ganglion. The results presented here however, refer only to the D neuron which has the response characteristics described below.

1. Tuning Properties

(a) Threshold Responses. The threshold curve of the D neuron for ipsilateral and contralateral sound presentation is shown in Fig. 1. The D neuron has two sensitivity peaks — a major one at 4 kHz (near the conspecific song frequency) and another at 900–1,000 Hz. Threshold levels at 4 kHz for ipsilateral sound varied from 52 dB to 67 dB SPL but were rarely lower than 55 dB; sensitivity at 900–1,000 Hz varied from 55 dB to 75 dB SPL and was generally less than, but could equal, that at 4 kHz depending on the preparation. The D neuron is less sensitive to frequencies greater than 10 kHz and often could not be stimulated by sound beyond 12 kHz.