SPECTRO-TEMPORAL RECEPTIVE FIELD OF FREQUENCY-MODULATION SENSITIVE NEURONS AFTER ADJUSTMENT FOR RESPONSE JITTER

Tsai-Chang Rong, Pau-Choo Chung
Dept. of Electrical Engineering, National Cheng Kung University
1, University Road, Tainan, Taiwan, R.O.C
pcchung@eembox.ncku.edu.tw

T.W. Chiu, Paul W.F. Poon
Dept. of Physiology, National Cheng Kung University
1, University Road, Tainan, Taiwan, R.O.C
ppoon@mail.ncku.edu.tw

ABSTRACT

Receptive field (RF) represents an important property of central neurons in stimulus coding. In the auditory system, RF is often obtained with random stimuli. Typically, a random acoustic stimulus (e.g., randomly FM tone, or random chord noise) is presented to evoke neural responses from single neurons. Then spike-triggered averaging is used to generate a spectro-temporal receptive field (STRF) showing the time-varying spectral feature that excites or triggers the neuron. Such averaging method invariably aligns the spikes in time and the STRF therefore assumes that the neuron responds to the trigger feature with a fixed latency. But central neurons respond to identical stimuli in a probabilistic way as a result of synaptic transmission. This variability in response, reflected partly as a response jitter, would tend to blur the trigger features in the STRF. In this study, we developed a method to improve the STRF representation by correcting for the response jitter.

We first recorded single unit responses to sounds from the midbrain of urethane anesthetized rats. Two acoustic stimuli were used: (a) random FM tone (generated by low pass-filtering a white noise below 25 Hz, and using it to modulate a sine wave generator) presented continuously, and (b) a family of linear FM sweeps (generated by modulating the sine wave generator with a series of triangular modulating waveforms of frequencies from 5 to 25 Hz) presented repetitively to the animal. Spikes responses from 12 FM sensitive neurons were analyzed. Based on the random FM datasets, STRF of each unit was first generated by the conventional peri-spike averaging of modulating time waveforms. The variance function of modulating waveform (called the original variance time profile VTP) was constructed for a period of 40 msec before the spike. A minimum of VTP was consistently found within 10 to 20 msec before the spike. Minimization of VTP was then performed over systematically varied time segments with centers set at the minimum position of the original VTP. Specifically, a selected pre-spike modulating time waveform was shifted systematically in time and the shifted waveform was again computed with the remaining waveforms to form a new series of VTP. At a characteristic delay, a minimum VTP was found. The selected modulating waveform was then translated to the characteristic delay. This procedure was repeated for all other waveforms. A new VTP was finally calculated with all the characteristic delays. A family of new VTPs was hence obtained with time segments of different durations. The disparity of each new VTP and the original VTP was further estimated by the degree of non-overlap between the two VTPs. A minimum disparity was found at a time segment (called optimum time segment, OTS) about 5-10 msec in duration that reflected the length of the trigger feature. The new STRF after jitter adjustment revealed a much sharper FM feature compared with the original STRF. The adequacy of the jitter adjustment was supported by the following findings. In comparison with the results from the second stimulus, the rate of FM sweep in the new STRF matched closely with the best linear FM sweeps. Also the peri-stimulus time histogram (PSTH) at the best linear FM ramps also matched closely with the jitter adjustment histogram. We also calculated the trigger point of

each unit by a linear regression of response delay in the PSTH against the period of triangular FM waveforms. The trigger point also appeared at the end of the FM feature.

Results showed that the present method could provide a better estimation of the receptive field of auditory neurons especially to random FM stimuli.

Keywords: STRF, midbrain, auditory neuron, FM, trigger feature, response jitter.

References

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