TRANSIENT AND PERIODICITY CODING IN TWO FIELDS IN AUDITORY CORTEX OF THE CAT

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Periodically modulated sounds are coded temporally in the peripheral auditory system, but this changes gradually into a rate coding for more central nuclei. In the auditory cortex, however, the average firing rate does change very little with modulation frequency or click repetition rate whereas the synchronized firing rate does. Several dramatic differences in the coding of periodic sounds in cortex are observed: first of all the modulation frequencies or repetition rates that can be followed are much lower than in subcortical areas and generally less than 50 Hz, secondly different cortical areas appear to have different abilities to code for modulation frequency. A complication arises because of prominent EEG rhythms in the 8-12 Hz range which tend to interact with stimulus modulation frequencies in that range and limit the capacity to follow higher rates. This suggests that network properties determine to a large extent the preferred modulation frequency.

The procedures have been described in detail in previous publications (e.g., Eggermont, 1994) and we will only repeat those aspects that are important for the interpretation of the results. Cats were under ketamine anesthesia. Stimuli were presented from a speaker placed 55 cm in front of the cat's head. The sound-treated room was anechoic for frequencies above 625 Hz. The recording procedures were similar to those described previously (Eggermont, 1994). Three tungsten micro electrodes were independently advanced into the primary auditory cortex (AI) and anterior auditory field (AAF) using remotely controlled motorized hydraulic microdrives.

Periodicity coding was investigated for single units and local field potentials (LFP) in the middle layers of cat AI and AAF using click trains and amplitude modulated (AM) noise or AM CF-tones (Eggermont, 1994). Modulation frequencies were between 1 and 64 Hz. The click-following and AM-following capacity of the neurons was evaluated from the synchronization modulation transfer functions obtained by Fourier transformation of the period histograms. The best modulating frequency (BMF) was defined as that click rate or AM frequency for which the synchronized firing rate was maximal.

Results are from 62 simultaneous recordings in AI and AAF resulting in 186 multi-unit (MU) records and 186 LFP recordings. Seventy single units with good locking to the periodic click trains were isolated from the MU records. Simultaneous recordings from AI and AAF were used to ensure similar anesthesia conditions. We demonstrate that the best modulation frequency (BMF) for periodic click train stimulation is strongly correlated with the EEG spindle frequency. In contrast to earlier reports (Schreiner and Urbas, 1988), which found that the average BMF for sinusoidally modulated CF-tones was larger in AAF than in AI, no dramatic differences between AI and AAF were found with respect to best click rate. No differences were found in limiting rate, the magnitude of the temporal modulation transfer function is 50% of maximum, either. If anything the BMFs were on average 1-2 Hz higher in AI, but this was not statistically significant.

The previous findings that AAF may be better tuned to sinusoidal CF-tone modulation was further explored. LFP data for simultaneous recording in AI and AAF for three periodic stimuli were compared. We used periodic click trains, exponential-sine AM noise and exponential-sine AM CF-tones. The LFPs in AAF were slightly lower tuned for clicks, responded somewhat less to high AM rates for modulated noise, but were far better responsive (up to modulation frequencies of 32 Hz) to CF carrier tones than the simultaneously recorded LFPs in AI. The same was found for multi and single-unit activity.

Psychophysically, temporal modulation transfer functions obtained for sinusoidally AM noise show an decrease in sensitivity above 30 Hz by about 3-4 dB/oct (Viemeister, 1979) whereas sinusoidal AM of pure tone carriers show a great dependence on the carrier frequency (Fassel and Kohlrausch, 1995). For instance at 1 kHz, the tMTF is low pass with a cut-off frequency (-6 dB) of about 150 Hz, but for a 3 kHz carrier there is an enhanced sensitivity around 200-300 Hz and a cut-off point at about 400 Hz. In these studies the high-frequency slope of the tMTF was about 8-12 dB/oct. This contrasts with the small effect found in electrophysiological studies where the most frequently found BMFs are below 20 Hz, regardless of the carrier used: the highest BMFs are still at least a factor 10 below those found in psychophysical studies. The presently available electrophysiological data thus suggests that the physiological substrate for the psychophysical performance is likely found in subcortical structures.

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