TEMPORAL PROCESSING IN THE YOUNG AND OLD AUDITORY CORTEX

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A common complaint among the elderly is a difficulty in understanding speech. One central factor that may contribute to this difficulty, is a deterioration in the ability to process the dynamic aspects of speech such as the formant transitions. Formant transitions, which are characterized by a change in frequency over time, enable us to discriminate one consonant sound from another. A number of investigators have suggested that processing speed deteriorates with age. For the aging auditory system, this deterioration may be manifest as a deficit in processing time-varying sounds that contain rapidly changing sounds, such as the formant transitions. Thus, if temporal processing deteriorates with age, then our ability to recognize speech could be seriously affected. Unfortunately, the nature of temporal processing in the aged auditory system, has not been explored very extensively, particularly in relation to speech comprehension. Thus, the primary goal of this study was to explore one aspect of the neural mechanisms underlying the effects of aging on temporal processing. A stimulus which lends itself well to studying this type of processing is the frequency modulated (FM) sweep which in many respects, FM sweeps resemble formant transitions found in a variety of communication signals.

METHODS. Experiments were conducted on 12 young (3-4 months) and 3 old (24-30 months) male Long Evans hooded rats. Rats were anaesthetized and maintained at a surgical level of anaesthesia throughout the experiment with Equithesin (3 mg/kg i.p.). Animals were placed in a modified head holder and a craniotomy performed. Earphones connected to speculae were placed within 3 mm of the tympanic membranes. All extracellular single unit recordings were conducted in a sound attenuating chamber.

Rats were initially stimulated monaurally through the contralateral ear with tone bursts (100 ms duration with a 10 ms rise/decay time, 700 msec interstimulus interval) to determine characteristic frequency (CF) and threshold, followed by linear FM sweeps ranging from 150 Hz to 45.0 kHz (upward-directed) and 45.0 kHz to 150 Hz (downward-directed) at speeds of 0.8, 0.3, and 0.05 kHz/msec. All stimuli were generated and data collected by a Macintosh computer using the MALab system.

RESULTS. A total of 60 units were studied of which 40 were recorded from young rats and 20 from old rats. The average CF was 14.2 kHz for cells recorded from young rats and 11.0 kHz for those tested in old rats.

The results show that the majority of units in both age groups (Y: 37/40, O: 17/20) were selective for the direction and/or speed of FM sweep. There were 3 units in each age group that did not appear to be sensitive to FM sweeps and thus, were excluded from further analysis.

Preferred Speed. All of the FM-sensitive units examined were sensitive to speed of frequency modulation. Perhaps the most striking result observed was a significant difference in the distribution of preferred speed between young and old animals. In the young animals, the largest number of cells (43%; n=16) responded most vigorously to the fast speed while the preferred speed of the remaining units was more evenly distributed between the medium (27%; n=10) and slow speed (30%; n=11). In contrast, the majority of units (59%; n=10) recorded from the old animals responded best to the slow speed while relatively few units preferred the fast speed (12%; n=2).

Direction Selectivity. Using a criterion where the cell \ responded at least twice as vigorously in one direction as in the opposite direction, almost half (49%) of the units recorded from young rats showed no preference for the direction of FM sweep. Of the cells that exhibited direction selectivity, all of them preferred upward-directed sweeps. For the old rats, the majority of units (71%) were direction-selective with 58% of these units preferring upward-directed sweeps.

DISCUSSION. The results of the present study provide one of the first demonstrations of a difference between young and old animals in cortical temporal processing speed of dynamic stimuli. The difference in FM speed preferences observed between the neurons recorded from young and old rats may reflect a deterioration of temporal processing speed in the aging auditory cortex.