AGE-RELATED EFFECTS ON TEMPORAL PROCESSING SPEED IN THE INFERIOR COLLICULUS (IC)

Julie R Mendelson, H Jin Lee* and Tasneem Wallani****
*Department of Speech-Language Pathology - **Institute of Medical Science
University of Toronto, 6 Queen's Park Cres. W., Toronto, Ontario, M5S 3H2

Difficulty in understanding speech is one of the most common problems afflicting the elderly population. One factor that may contribute to this is a deterioration in the ability to process dynamic aspects of speech such as the formant transitions (components of speech in which frequency and amplitude vary over time). Underlying this deterioration may be an age-related decline in temporal processing speed in the central auditory system. 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 speed deteriorates with age, then our ability to recognize speech could be seriously affected.

A stimulus which lends itself well to studying this type of processing is the frequency modulated (FM) sweep which, in many respects, resembles formant transitions found in a variety of communication signals. We have recently shown that auditory cortical cells recorded from young animals responded best to fast FM sweeps while those recorded from aged animals preferred slower sweeps (Mendelson & Ricketts, 2001). These results suggest that there is a difference in temporal processing speed at the level of the cortex. The next question we asked was whether or not this aging effect was exclusive to the cortex or if it was apparent in subcortical structures such as in the inferior colliculus (IC), an important auditory integration centre in the central auditory system.

METHODS

Experiments were conducted on 18 young (3-4 months) and 12 old (24-30 months) male Long Evans hooded rats. Rats were anaesthetized and maintained at a surgical level of anesthesia throughout the experiment. Animals were placed in a modified head holder and a craniotomy performed over the occipital cortex overlying the IC. Earphones connected to speculate were placed within 3 mm of the tympanic membranes. All extracellular single unit recordings were conducted in a sound attenuating chamber. Following the recording of a unit, a lesion was made (6 mA for 6 sec) for histological verification.

Rats were initially stimulated monaurally through the contralateral ear with pure tone burst stimuli (100 ms duration with a 10 ms rise/decay time, 700 msec interstimulus interval) to determine characteristic frequency (CF) and threshold. Following this, 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, 0.05 and 0.03 KHz/msec were presented at 30 dB above threshold. All stimuli were generated and data collected by a Macintosh computer using the MALab system.

RESULTS

A total of 131 units were examined of which 68 were recorded from young animals and 63 from old animals. The average CF for cells recorded from young animals was 12.3 kHz (range: 2.0-20.5 kHz) and 12.3 kHz (range: 2.0-21.0 kHz) for aged animals. With the exception of 4 units from young rats and 3 units from old rats, all units showed FM speed and/or direction selectivity. These seven units were subsequently eliminated from further analysis.

There was no significant difference between the two age groups for threshold intensity of CF (Young = 49.34 + 1.17 dB; Old = 51.57 $\pm$ 1.01dB: p = 0.15), first spike response latency at threshold CF (Young = 25.46 $\pm$ 1.47 ms; Old= 24.34 $\pm$ 1.58 ms: p = 0.61), or Q_{10dB} value (Young = 1.97 $\pm$ 0.17; Old = 1.88 $\pm$ 0.44: p = 0.85).

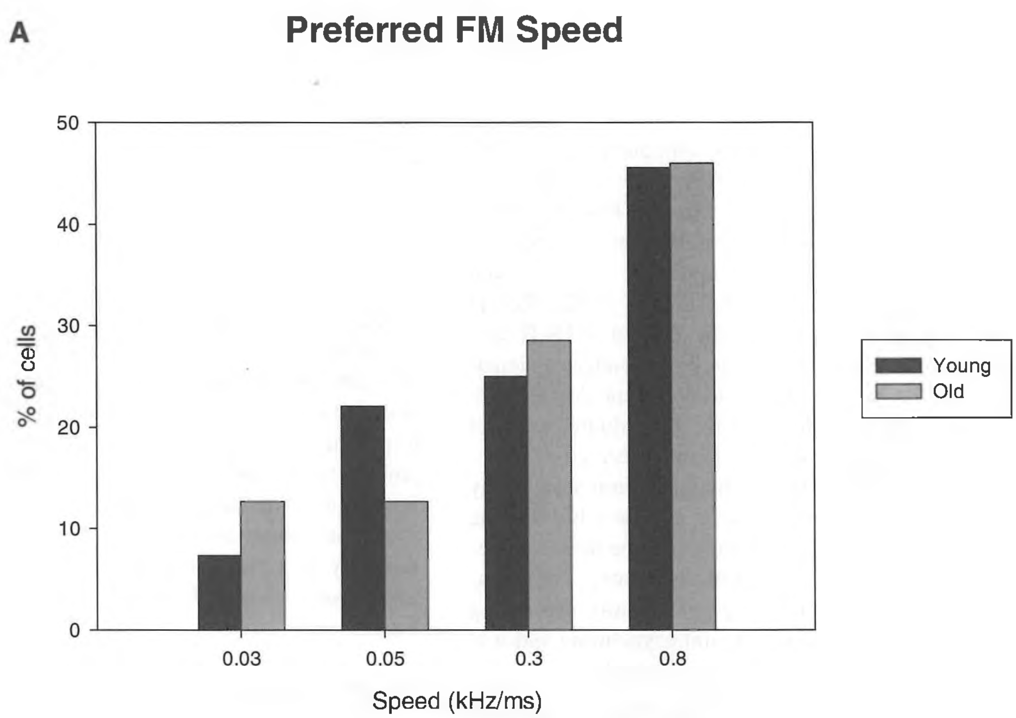
Figure 1A shows the comparison of the distribution of preferred speed responses for young and old animals. There was no significant difference in speed preference between the two age groups (c^2 3 d.f.= 3.34, p = 0.43). The majority of units recorded from both age groups preferred the fast and medium speeds while relatively few cells preferred the slower speeds.

For direction selectivity, again there was no significant difference between the two groups of animals (c^2 2 d.f.= 0.064, p=0.97). The majority of cells in both groups were nondirection-selective (Fig. 1B).

For both age groups, preferred speed was independent of CF (Young: r = 0.198, p > 0.05; Old: r = -0.080, p > 0.05). However, for direction selectivity, there was a significant correlation with CF for young (r = -0.338, p < 0.02) but not aged animals.

DISCUSSION

The results from the present study indicate that aging does not seem to affect FM speed selectivity at the level of the IC. Recently, Palombi et al., (2001) found no age-related effect in responses to sinusoidal amplitude modulate stimuli. Collectively, these studies suggest that the locus for an age-related effect in temporal processing speed occurs higher up in the auditory pathway. While we know that temporal processing speed is affected by age at the level of the auditory cortex (Mendelson & Ricketts, 2001), it is unclear if, and to what extent, this function may be affected at the thalamic level which lies between the IC and the cortex. Studies are currently underway to ascertain if there is an age-related effect on processing speed in the medial geniculate nucleus.



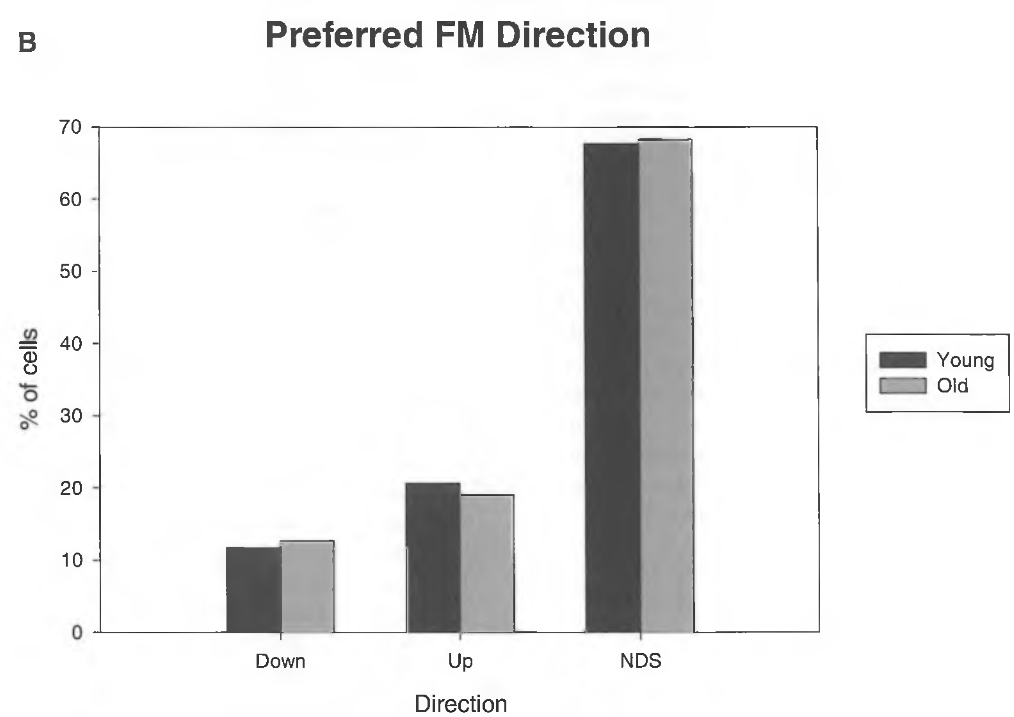


Figure 1. Distribution of preferred speed (1A) and preferred direction (1B) responses for old animals. For preferred speed, the majority of cells (75% or 47/63) preferred the fast and medium speeds. For preferred direction, 68 % of the cells were nondirection-selective.