Temporal properties of dendritic processing in octopus cells of the posteroventral cochlear nucleus

M.J. Spencer,[1,2] I.C. Bruce,[1,3,4] D.B. Grayden,[1,4] H. Meffin[1,2] and A.N. Burkitt,[1,4] [1]Department of Electrical and Electronic Engineering, University of Melbourne, VIC 3010, Australia, [2]National ICT Australia, University of Melbourne, VIC 3010, Australia, [3]Department of Electrical and Computer Engineering, McMaster University, Hamilton, Ontario L8S 4K1, Canada and [4]Bionic Ear Institute, Fitzroy, VIC 3065, Australia.

Octopus cells in the posteroventral cochlear nucleus detect broadband auditory events by performing a coincidence detection across many (>60) Auditory Nerve Fibres (ANFs), covering ~1/3 of the ANFs' tonotopicity. It has been suggested that octopus cell dendrites introduce a delay to compensate for systematic variation in ANF spike latency, which is a known function of Characteristic Frequency (CF). In this study, numerical modelling (in NEURON and MATLAB) was used to calculate the Post-Synaptic Potential (PSP) propagation delay in octopus cell dendrites. The model's parameters were based on published experimental results from a number of papers dealing with cats, although the results are relevant for most mammals including humans. This study showed that an octopus cell dendrite with typical morphology could provide a PSP delay of 0.5 ± 0.2 ms. The resulting compensation would allow coincidence detection of 0.2 ± 0.1 octaves of the lowest CF ANFs, or 3 ± 0.5 octaves of the highest CF ANFs. The uncertainty intervals are dominated by the imprecise knowledge of membrane properties of the dendrites of octopus cells and of the exact functional relationship between CF and spike latency in ANFs. These results support the hypothesis that the dendrites are providing a compensatory delay, however, the delay is not enough to allow for coincidence detection across 1/3 of the tonotopicity at low CF ANFs.