1. Introduction

Computation models have been developed by Carney and colleagues to simulate the responses of auditory nerve (AN) fibers in cat [Bruce et al., 1998; Carney et al., 2003]. The most recent version adds a level-independent instantaneous frequency glide in the basilar membrane (BM) filter, as observed in BM and AN data. This model predicts realistic responses to simple acoustic stimuli but has not applied to the study of AN responses to speech. The Zhang et al. (2001) version of the model has been modified by Bruce and colleagues (JASA 2003) to study the effects of outer and inner hair cell impairment on the ANs representation of speech stimuli. However, the Bruce et al. model has not addressed the instantaneous frequency glides in the impulse response of AN fibers, which may explain the shifts in best frequency (BF) following impairment of outer hair cells or at high intensities in the normal cochlea. In this paper, an improved model has been developed by substituting the BM membrane dynamics of the Bruce et al. model by a chopper filter from the recent version of the model by Carney et al. [2003]. Usually, the motivation for the development of this model is to provide a more accurate description of the representation of AN fibers to speech sounds. It would be valuable in testing the effects of potential hearing-aid speech processing schemes.

2. The Model

The model of Bruce and colleagues is an extended version of the model of Bruce et al. (2003) to include the added feature of level-independent frequency glides in the BM filter of AN fibers. The BM membrane dynamics of the Bruce et al. model by a chopper filter from the recent version of the model by Carney et al. (2003) is modified to a BM membrane filter for a filter with shifting BF. All chopper functions are normalized in such a way that the Chopper function for each frequency filter is calculated based on a real-time equations from auditory nerve fibers. The best frequency to the sounds of the BM filter is slightly different from the BF of the BM filter. With impaired OHC and IHC function, model predictions of BF are within the range of single-fiber responses at several SPLs on a linear frequency axis. The BF for each SPL (unit 86100-25 from Carney and Yin (1988) is decreasing with increasing BF. The new model better predicts the spikes in BF and P2 synchrony is observed in the model.

3. Results

The basic response properties of the model are quite satisfactory, as seen in the figures.

4. Discussions and Conclusions

This model describes a computational model that is accurate enough to be useful in testing the effects of potential hearing aid processing schemes on the neural representation of speech. The adder feature to level-independent frequency glides in the impulse response of AN fibers into BM, Bruce et al. model gives more realistic AN responses for the vowel stimuli. The realization of BF shift in the impaired cochlea or at high intensities in the normal cochlea, this model should describe the loss of synchrony from the second formant to the first at high intensities or in the impaired cochlea. However, the impaired model will not be overestimated to BF2 in the BF region around F2. Also, only AN fibers with high spontaneous rates have been considered here.

The parameters of the Bellman function in the control path shows a significant effect on the behavior of compression which is partly responsible for the loss of synchrony from F2 to F1 at high intensities. We are still working on this new model to be able to more accurately predict the amount of synchrony loss by F2 in the normal and impaired cases. For this, we need to adjust the parameters of the Bellman function and also the BM chopper filter.

One important feature that is not addressed in the component 1/2 component 2 transition. A change in AN responses occurs at high levels that is characterized by an abrupt shift of B180 in the vowel level. It is expected that this shift would be more noticeable at high levels.

References