MODELLING AND ESTIMATION OF INFORMATION TRANSMISSION IN AUDITORY NERVE FIBRES WITH APPLICATIONS TO COCHLEAR IMPLANTS

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ABSTRACT

Functional hearing of profoundly deaf people can often be partially restored by direct electrical stimulation of the cochlear nerve by a cochlear implant. An obvious approach to cochlear implant design would be to devise a coding (stimulation) scheme that evoked the same pattern of nerve activity with electrical stimulation that are evoked in the normal ear with acoustic stimulation. However, this can never be achieved - partly because of the reduced number of healthy nerve fibres present in a damaged cochlear nerve and partly due to the limited number of electrodes (typically 16-22) that can be surgically implanted into the cochlea.

This has led us to propose an alternative design strategy based on maximization of the information transmitted along the cochlear nerve [1]. The principal idea behind this strategy is to exploit a newly discovered form of stochastic resonance, termed suprathreshold stochastic resonance (SSR) [2], to optimally enhance information transmission. To this end, we have developed a computational model of a cochlear nerve fibre that can be used to make estimates of the transmitted information. The model is based on single fibre data obtained from the sciatic nerve of the toad *Xenopus laevis.* The use of this preparation as a physiological model of cochlear nerve fibres has already been established [3].

In this presentation, details of the computational model are discussed and estimates of the information transmitted, obtained from the model, are presented. Estimation of information transmission based on physiological experiments will be discussed elsewhere [4]. Our model is based on the leaky integrate-and-fire (LIF) model [5]. However, non-standard modifications of the LIF model were introduced to enable accurate modelling of refractory effects. Specifically, accommodation effects observed in the experiments were found to dominate the dynamics at low stimulus frequencies. It was possible to model the accommodation effects by including a second integrating equation based on the dynamics of sodium inactivation in the Frankenhaeuser-Huxley equations.

Results for the information transmitted in a population of modified LIF neurones are presented. The information and information rate were estimated using a variety of methods, including uni- and multivariate techniques and the application of Gaussian channel theory. We demonstrate that all these estimates can be optimised by a non-zero level of internal neuronal noise. The implications of these results for coding in neural populations and to the development of improved cochlear implant coding strategies are discussed.

References

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