Simulating Psychophysical Forward Masking in a Model of Hearing with Cochlear Implants

Xiaowei Xia[1#], *Demi X. Gao*[2,3], *Martin Spencer*[1], *Tim Brochier*[4], *David B. Grayden*[1,2]

[1]Department of Biomedical Engineering and Graeme Clark Institute, The University of Melbourne, Australia
[2]Bionics Institute, Australia
[3]Department of Medical Bionics, The University of Melbourne, Australia
[4]Cochlear Limited, Australia
[#]`xiaowei.xia@student.unimelb.edu.au`

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1. Introduction

The Cochlear Implant (CI) directly stimulates auditory nerve fibres (ANFs) to provide hearing to individuals with hearing loss. The spread of excitation from stimulated electrodes can vary significantly between users, directly impacting their hearing performance.

Psychophysical Forward Masking (PFM) is a method to estimate the extent of spread of excitation of electric fields from electrodes and the potential impact upon the ability to perceive nearby electrodes [1]. PFM measures the increase in the detection threshold of a probe when presented after a masker. While it is hypothesised that PFM involves processes at or more central than the auditory nerve [2], the underlying mechanism remains unclear. This research aims to develop a model to explain these mechanisms using a user-specific computational model and PFM data [1].

2. Methodology

Data from previous PFM experiments with two CI recipients [1] were used to obtain user-specific information, including masker and probe positions, current levels and masking profiles. With a 300 ms masker stimulation at 250 pulses/s on a fixed electrode position at 80% of dynamic range, the masking profile shows how many additional current levels are required in a subsequent 20 ms, 250 pulses/s probe stimulus to perceive the probe.

To study the additional neural activation required to perceive the probe, we used an existing stochastic neural model [3, 4] to obtain neural activations of the masker and probe. The neural activity of 100 ANFs in the model at each electrode position was integrated over a 40 ms moving window to estimate perceived loudness, and the mean and standard deviation of the neural activation during the masker were calculated. The number of activated ANFs was then obtained from the model at each electrode location to determine the masking curves. The probe was considered detected if its maximum loudness exceeded the mean activation during the masker plus twice its standard deviation (d-prime = 2). The neural activations at each probe location during unmasked threshold level stimulation were also obtained.

3. Results and Discussion

Figure 1 shows example simulations of two CI recipient's activated ANFs at different electrode positions during the masker (blue curves), perceivable probes (red curves) and unmasked threshold stimulation (orange bars) for three different masker positions and different probe positions. The model was fitted using the experimental masking levels with the masker and probe on the same electrode using the d-prime criterion.

This is an important first step in creating user-specific CI models that can be used to predict and improve hearing performance. Other factors related to hearing performance will be included in the model to better predict neural activity, such as the proportion of surviving ANFs at each electrode position. While the d-prime measure is suitable for probes on the same electrode as the masker, further research is needed to develop a model of probes on different electrodes and, thus, different perception due to the place coding of sound.

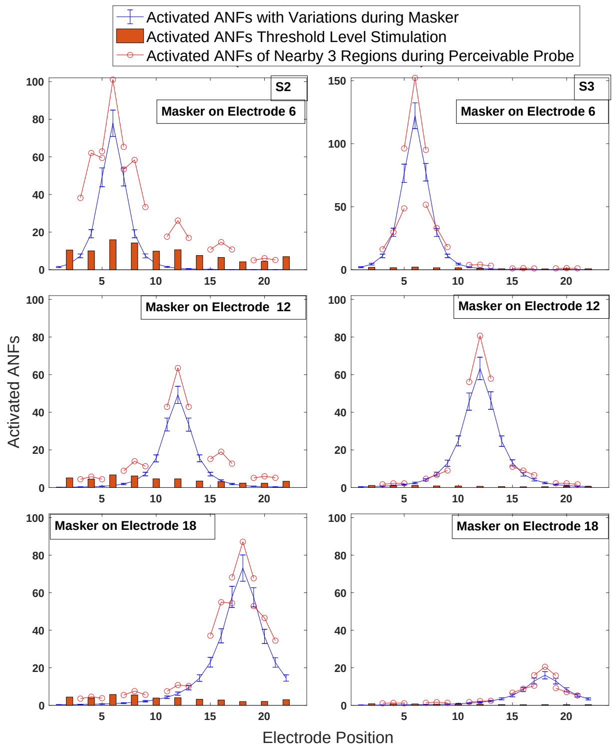

Figure 1: *Example plots of numbers of activated ANFs at different electrode positions. The blue line shows the activated ANFs at different probe electrode positions during the masker. The red lines show the activated ANFs at three nearby probe electrode regions during different perceivable probes. The orange bars show the activated ANFs at probe regions during unmasked threshold sound at different probe locations.*

4. References

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