

Channel Interaction in Cochlear Implants as a Function of Pulse Rate, Phase Duration, and Stimulation Mode

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Introduction

Multichannel cochlear implants stimulate auditory nerves at different locations along the cochlea. It is widely assumed that good speech recognition requires independent activation of distinct tonotopic regions with no interactions between electrodes; interactions between electrodes can produce a result similar to spectral smearing. The electrical pulses produced by multiple electrodes can interact both spatially and temporally. However, little is known about the effect of basic electrical stimulation parameters on the degree of electrode interaction. It is possible that high stimulation pulse rates could improve the temporal representation of the signal but reduce the spatial (tonotopic) resolution due to increased electrode interaction. Differences in electrode stimulation configuration (monopolar (MP) or bipolar (BP)), pulse phase duration, pulse amplitude, and stimulation rate could change the level of electrode interaction. The present study used forward masking to measure electrode interaction patterns as a function of the stimulating pulse phase duration and the stimulation rate. A masker was placed on one electrode and the threshold elevation of the following probe signal was measured as a function of cochlear location.

Subjects

Two Clarion II users participated in the study. Both subjects were deafened postlingually and have very good speech recognition with their implants. Subject 1 was implanted with HiFocus II electrode array with the positioner in 2001. Subject 2 was implanted with HiFocus I electrode array with the positioner in 2002.

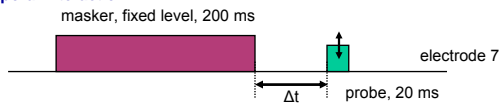
Experimental Conditions

stimulation mode	phase duration (µsec)	pulse rate (pps)	level	masker electrode location
monopolar (MP)	50 (MP)	1k (MP,BP+2)	20% DR	apical (MP)
bipolar (BP+2)	60 (BP+2)	8k (BP+2)	50% DR	middle (MP,BP+2)
	450 (MP,BP+2)	10k (MP)	80% DR	basal (MP)

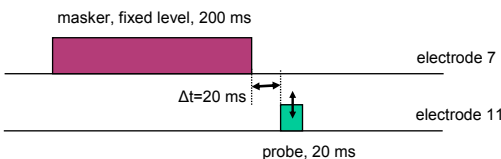
Stimuli

Trains of biphasic pulses (with anodic phase leading and no interphase gap between phases) were used. The masker and probe durations were 200 msec and 20 msec, respectively. Before the actual data collection MCL and THR levels were determined for each subject and for each experimental setup. MCL and THR were used to set the masker level equally loud for each condition as well as to normalize the masked threshold of the probe as percent dynamic range (DR). The probe started after the offset of the masker by the time delay Δt . Temporal interaction was measured with the release of masking on the same electrode where the masker and the probe were on the same electrode while Δt changed. Spatial interaction pattern was determined by measuring the masked thresholds of the probe at different electrodes while Δt was fixed at 20 msec.

Temporal interaction:

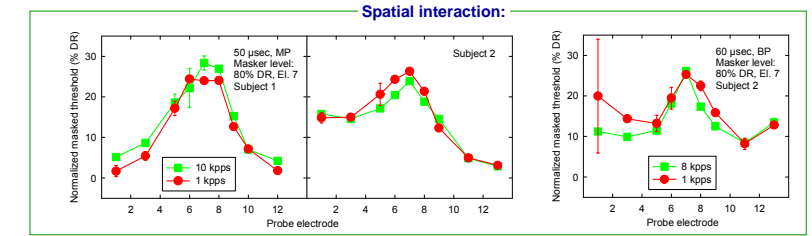
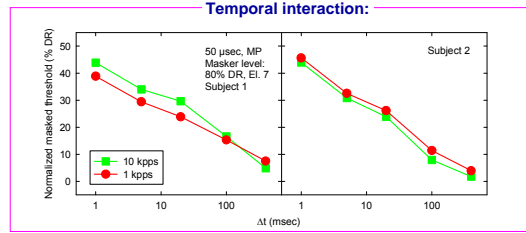


Spatial interaction:

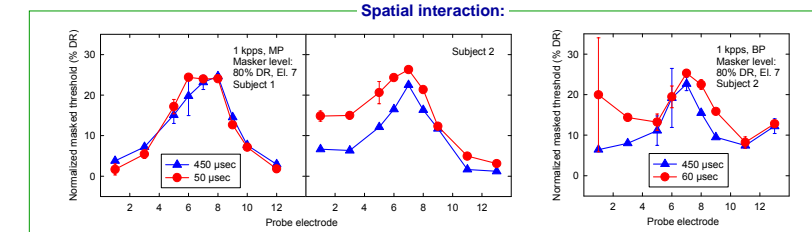
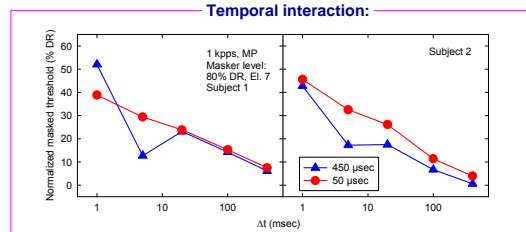


Results

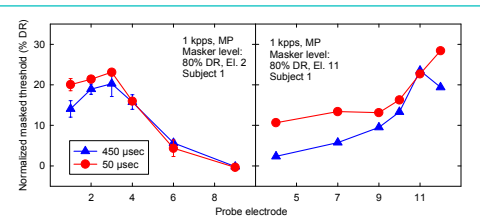
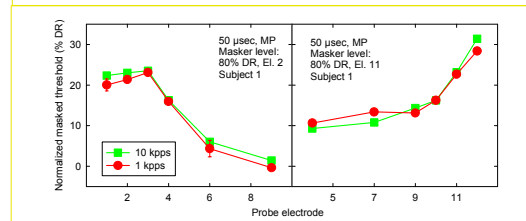
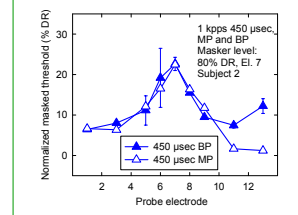
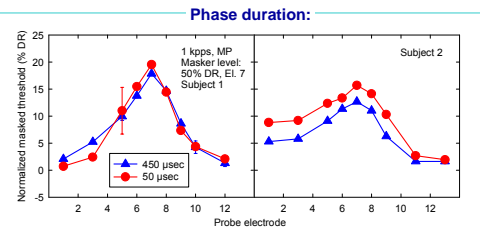
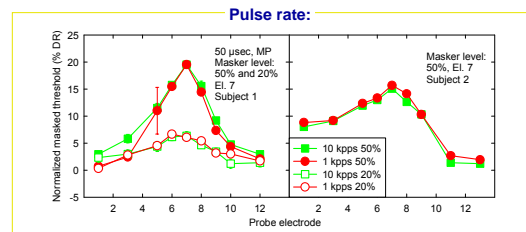
Pulse Rate: No significant difference in channel interactions with pulse rates of 1 kpps and 10 kpps (8 kpps for BP) temporally or spatially.



Phase Duration: No significant difference in patterns from phase duration of 50 µsec to 450 µsec temporally or spatially.



Masker Level: Similar effects are observed at masker levels of 50% and 20% DR.



Stimulation Mode:

Once normalized to percent DR, the spatial spread of activation is the same for MP and BP configurations.

Masker Location:

Masker is on electrode 2 or electrode 11. Generally, the effect of increasing pulse rate or phase duration is minimal.

Conclusion

There was no significant effect of the stimulation rate or pulse phase duration on channel interactions, once the masker level was set at a fixed percent dynamic range (i.e., loudness balanced across conditions) and the masked thresholds of the probe were similarly plotted as percent dynamic range. This was true for a wide range of masker levels and masker locations in the cochlea. Similarly, for pulse trains with 450 µsec phase duration and 1 kpps stimulation rate MP and BP configurations produced same spatial spread patterns, once masked thresholds were normalized to DR.

Acknowledgement

Work supported by NIDCD Grant R01-DC-01526. The speech processor and software were provided by Advanced Bionics. We thank Leonid Litvak for his help with the direct stimulation software BEDCS and Monita Chatterjee for valuable input in the study.