

Possibilities for a Closer Mimicking of Normal Auditory Functions with Cochlear Implants

Blake S. Wilson et al.



Contents

- Abstract
- A General Approach for Closer Mimicking
- Implementations of “Closer-Mimicking” Processors
- n-to-m Approaches
- Combined Use of Dual-Resonance, Nonlinear Filters and Virtual Channels
- Discussion of Findings to Date
- Conclusion

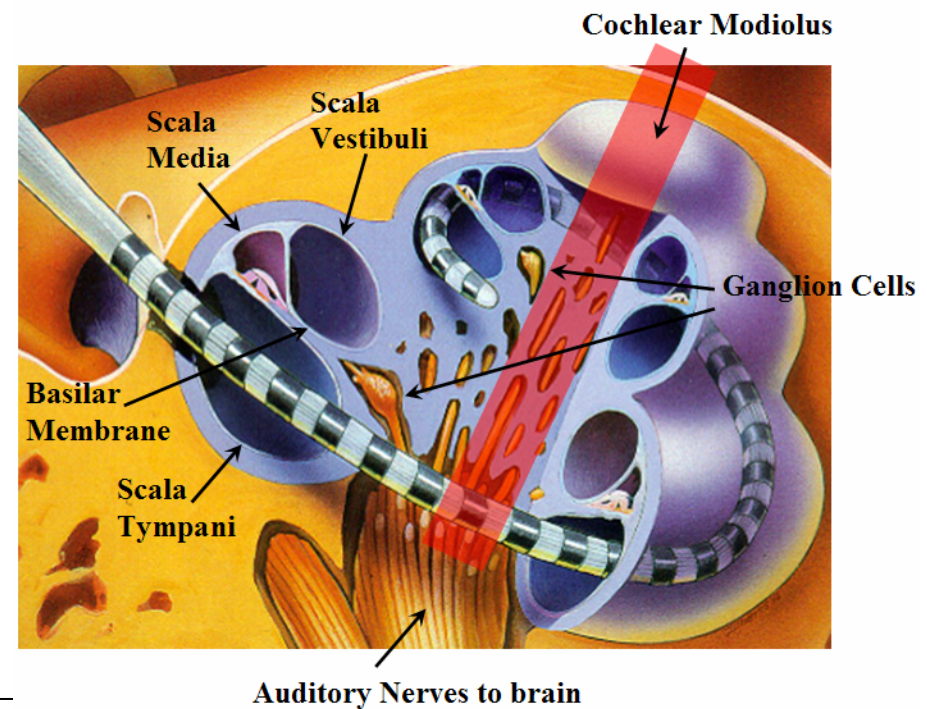


Abstract

Advances in Cochlear Implants

Present Processing Strategies vs. Intact Cochlea
Perceptual limitations of implant patients

- Perimodiolar Placements of Electrodes
- High Rate Carriers or High Rate Conditioner Pulses
- Virtual Channel



Abstract

Advances in Cochlear Implants

Present Processing Strategies vs. Intact Cochlea

Perceptual limitations of implant patients

Present Processing Strategies	Intact Cochlea
•Linear Band pass Filter	•Highly Nonlinear and coupled filter
•Single Nonlinear Mapping Function	•Multiple Mapping Function
•Instantaneous Compression	•Noninstantaneous Compression, with Large Adaptation Effects



Abstract

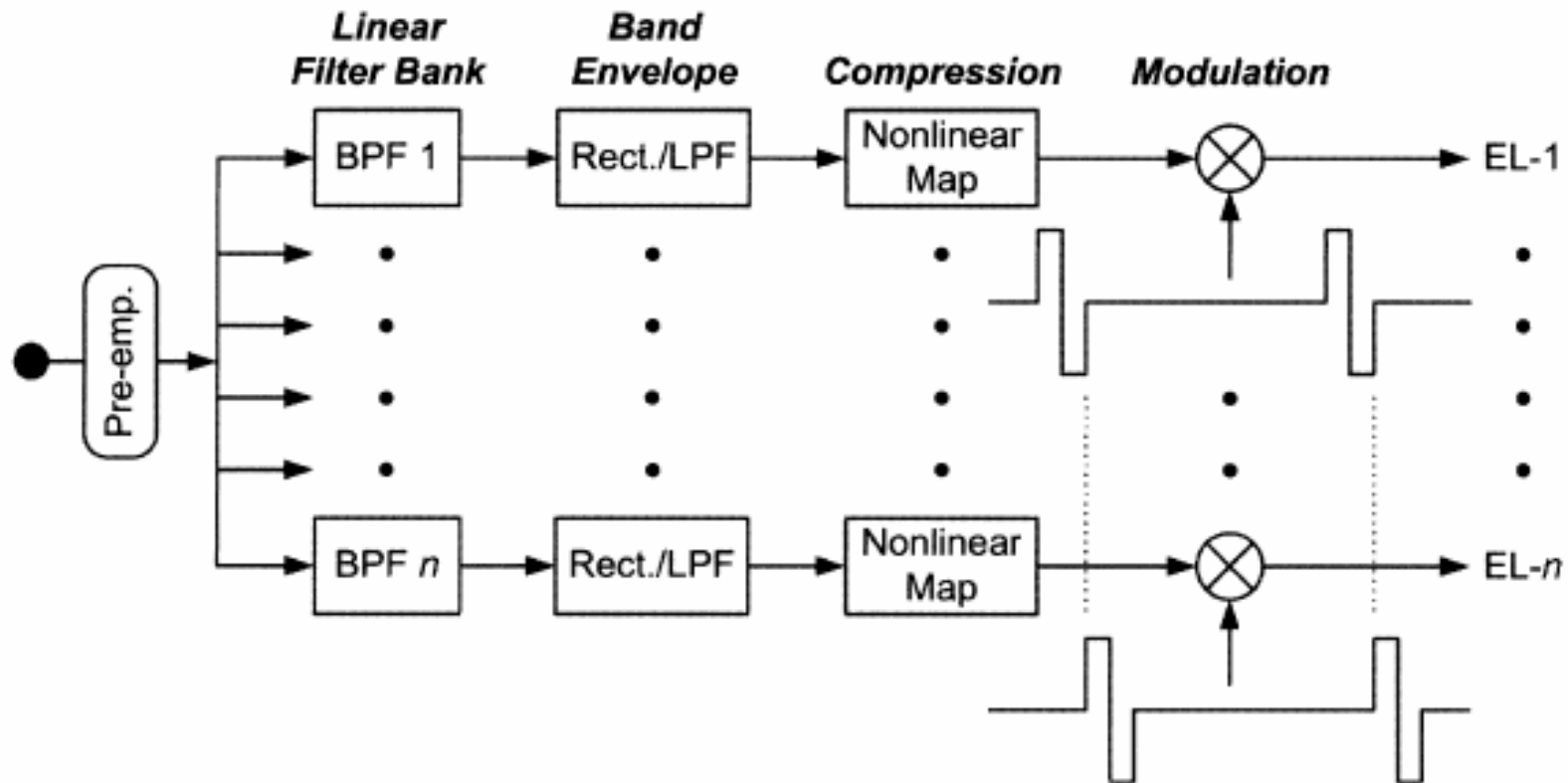
Advances in Cochlear Implants Present Processing Strategies vs. Intact Cochlea **Perceptual limitations of implant patients**

- Nonlinearities in filtering at the BM and associated structures
 - In competition with noise, enhancing neural representation
- An importance of adaptation at the IHC/neuron synapse in representing temporal events, or markers
- For more complex sound, full interplay function of many processing steps is required.



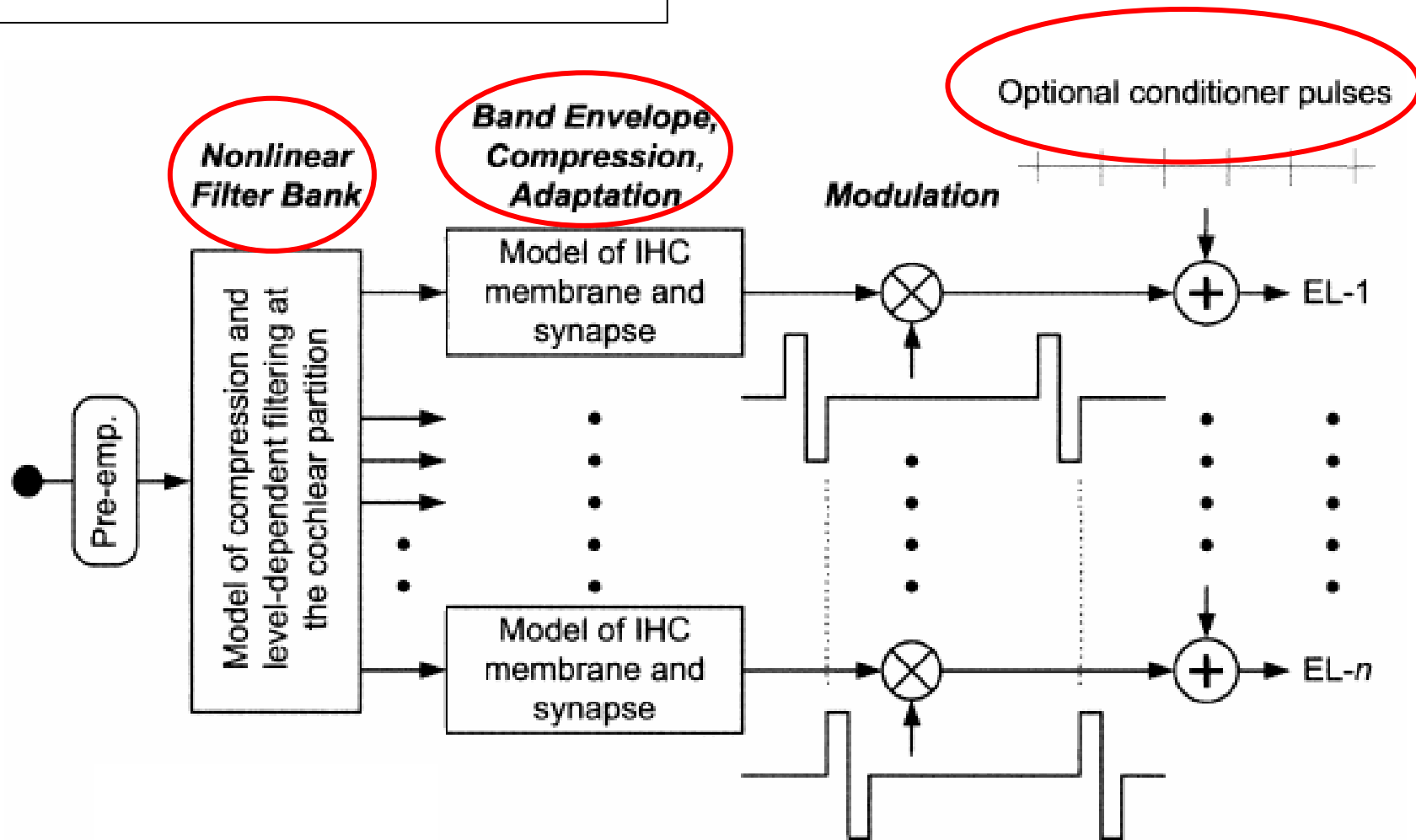
**General Approach
For Closer Mimicking**

Continuous Interleaved Sampling (CIS)
New Approach Aimed at Providing a
Closer Mimicking of Normal Cochlea



**General Approach
For Closer Mimicking**

**Continuous Interleaved Sampling (CIS)
New Approach Aimed at Providing a
Closer Mimicking of Normal Cochlea**



**Implementations of
“Closer-Mimicking”
Processors**

**Processors based on general steps
DRNL filter implementation**

- Substitution of a bank of DRNL filters for the bank of linear filters.
- Substitution of the Meddis IHC model for the envelope detector and nonlinear mapping table.
- Fine tuning of the interstage gain and compression



**Implementations of
“Closer-Mimicking”
Processors**

**Processors based on general steps
DRNL filter implementation**

- Substantial compression is provided by the DRNL filters.
- Uniform compressions at the center frequencies is provided by setting filter parameters.
- Sharper frequency responses than Butterworth filters.
- Could cause “picket fence” effect, which degrade performance.

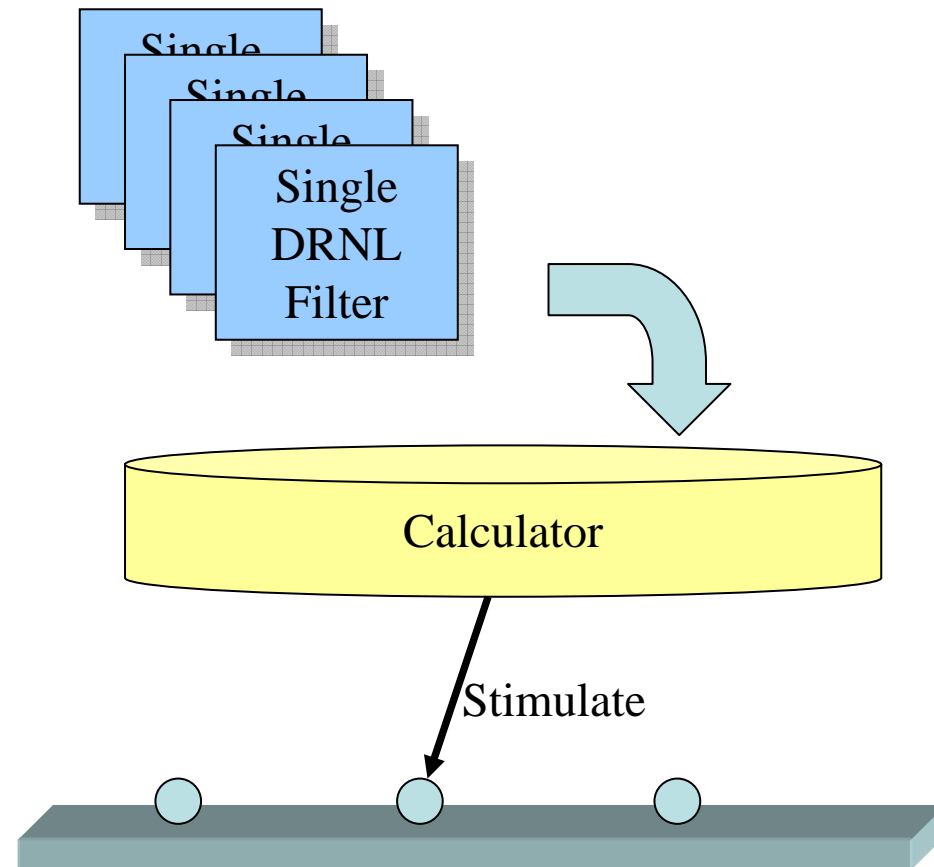


“n-to-m” Approaches

Concept

Specifying n-to-m Approaches
Possibilities for improvement

- More than one channel of DRNL processing is assigned to each stimulus site.
- Average or maximum of outputs from the multiple channel is calculated.
- Average or maximum is used to determine the amplitude of a stimulus pulse for a particular electrode

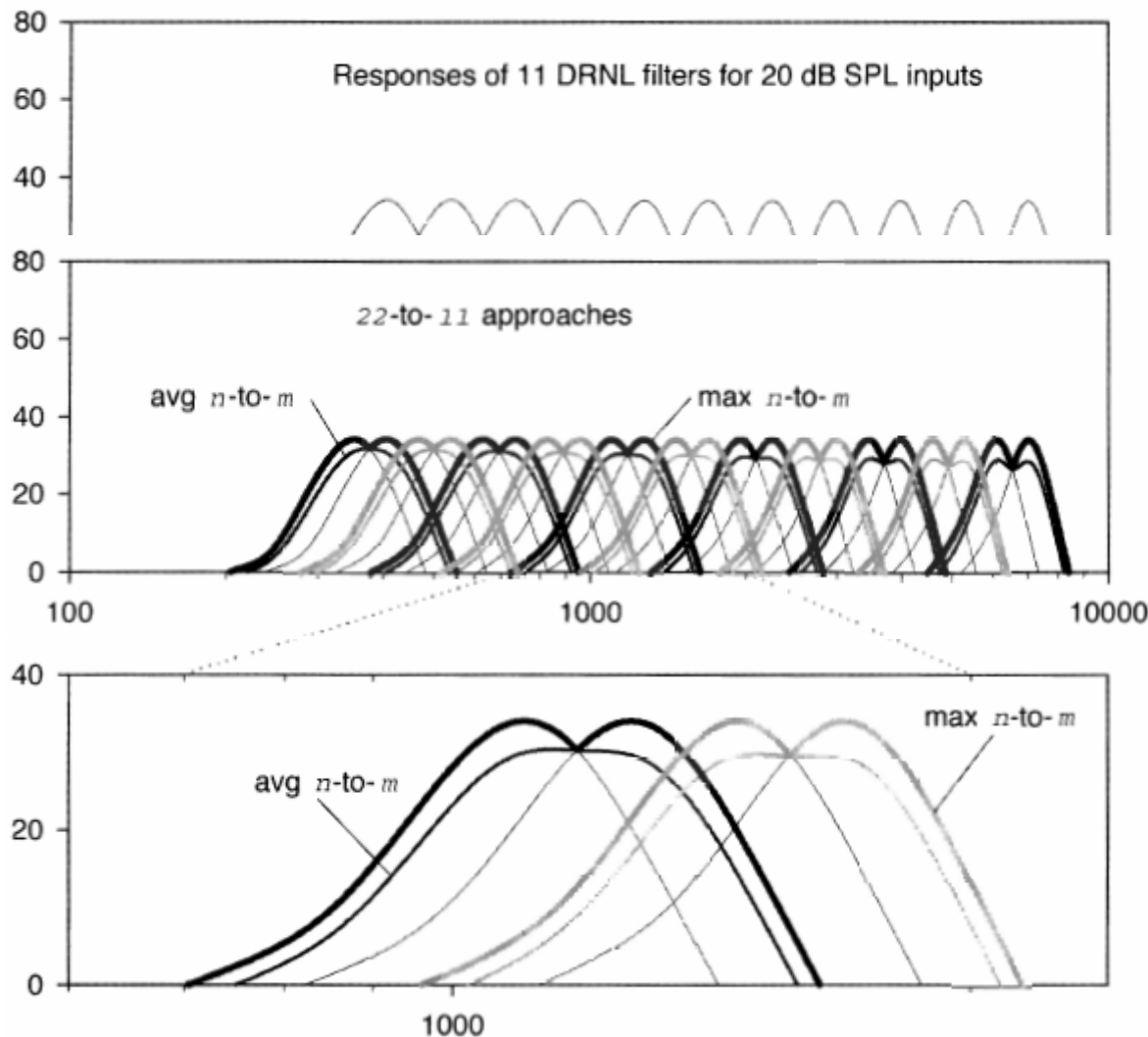


“n-to-m” Approaches

Concept

Specifying n-to-m Approaches

Possibilities for improvement



- A 1-to-1 assignment of filter outputs to 11 intracochlear electrodes
- Average and Maximum 22-to-11 approaches for combining the outputs of 22 DRNL filters and directing the combinations to 11 electrodes
- Expanded display that the average and maximum combinations of their outputs.



“n-to-m” Approaches

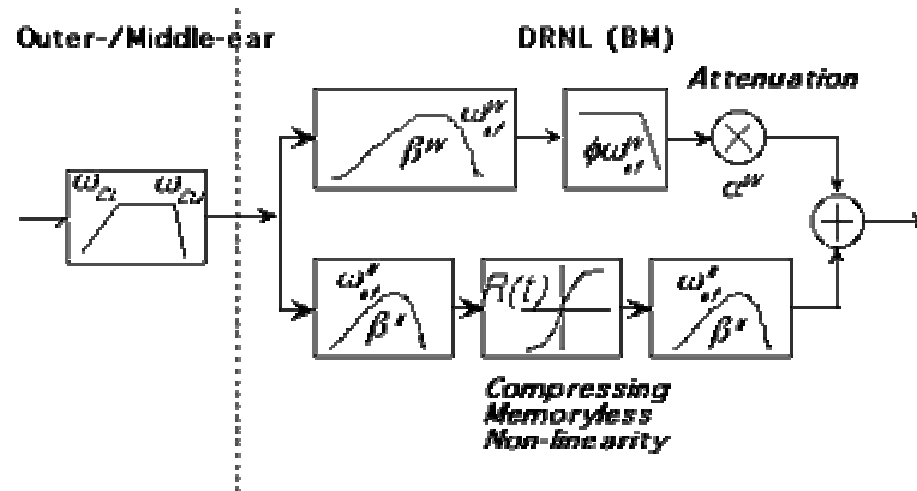
Concept Specifying n-to-m Approaches **Possibilities for improvement**

- Further adjustment and testing of the many parameter values in DRNL filters
- Combination or selection of DRNL filter outputs, rather than the DRNL channel outputs, in designs using n-to-m approaches.
- Using the same number of filters as stimulus sites, but with a high number of stimulus sites.



The Dual Resonance Non-linear Filter

The DRNL filter contains five basic elements: three gamma tone filters a (Butterworth) low-pass filter and a compressive non-linearity. The DRNL filter-elements are grouped into two parallel filter paths, one sensitive and sharply tuned-designated as the narrow filter path, and the other less sensitive and broadly tuned-the wide filter path. There is no feedback loop in the DRNL filter, so the model is inherently stable

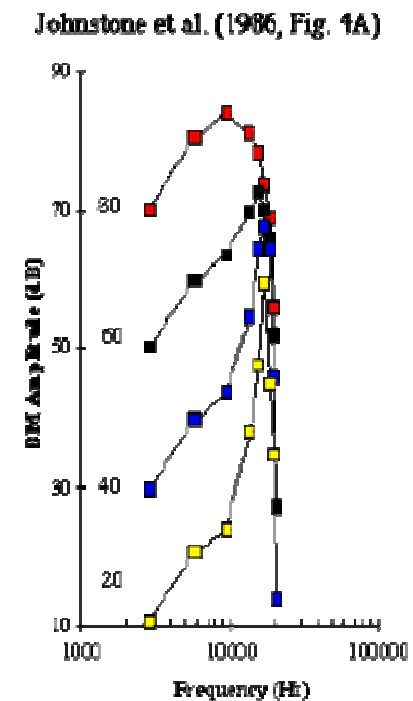
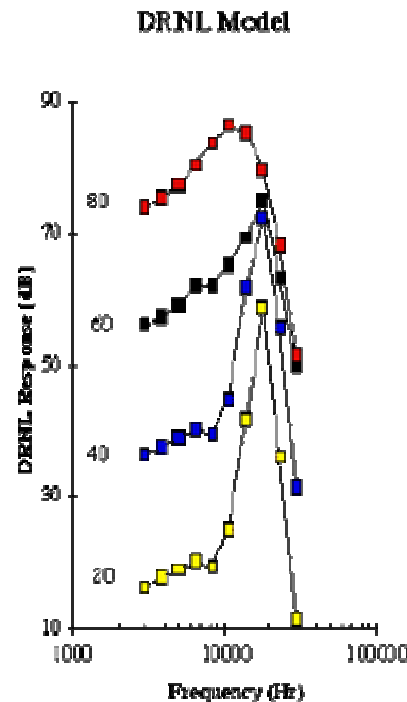


The Non-linear BM

Johnstone et al. (1986) showed how the BM response becomes more broadly tuned and peaks at lower frequencies as stimulus intensity is raised.

Broadening occurs as the wide filter path contribution to the model output increases, relative to that of the narrow filter path-the narrow filter path response is subject to compression at high signal levels.

The lower BF at higher intensities is also caused by the wide filter path response overwhelming the narrow path response. The wide filter path has a lower centre frequency.



Contents

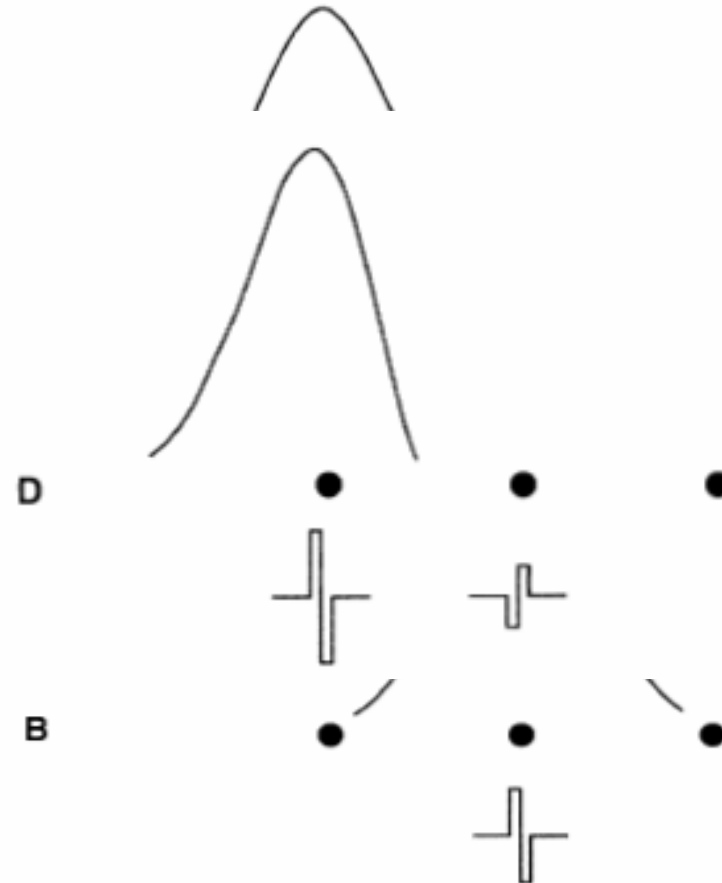
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Combined Use of DRNL and VC

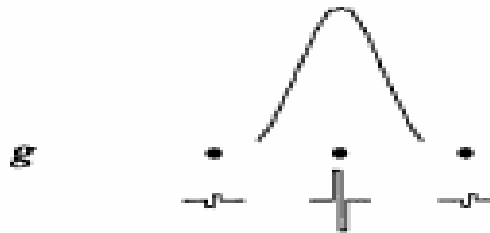
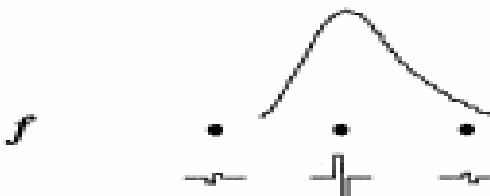
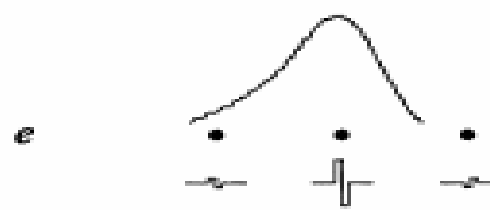
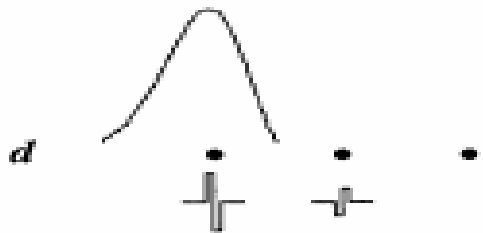
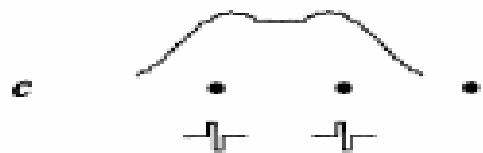
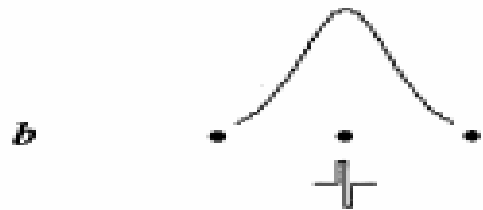
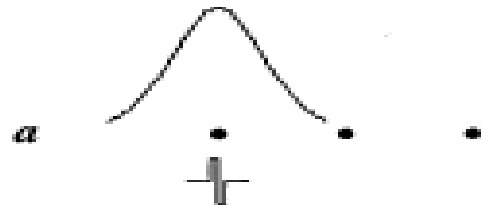
*2 Alternative Forced Choice – 2AFC
Briefing on Processors
Performance*

- Being stimulated alone
- Stimulating the two electrodes together with identical, in-phase pulses.
- Reversing the phase of one of the simultaneous pulses



Combined Use of DRNL and VC

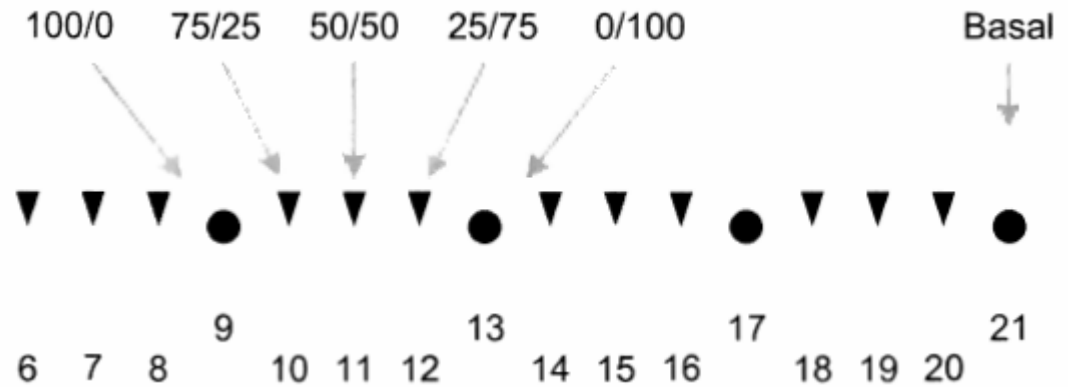
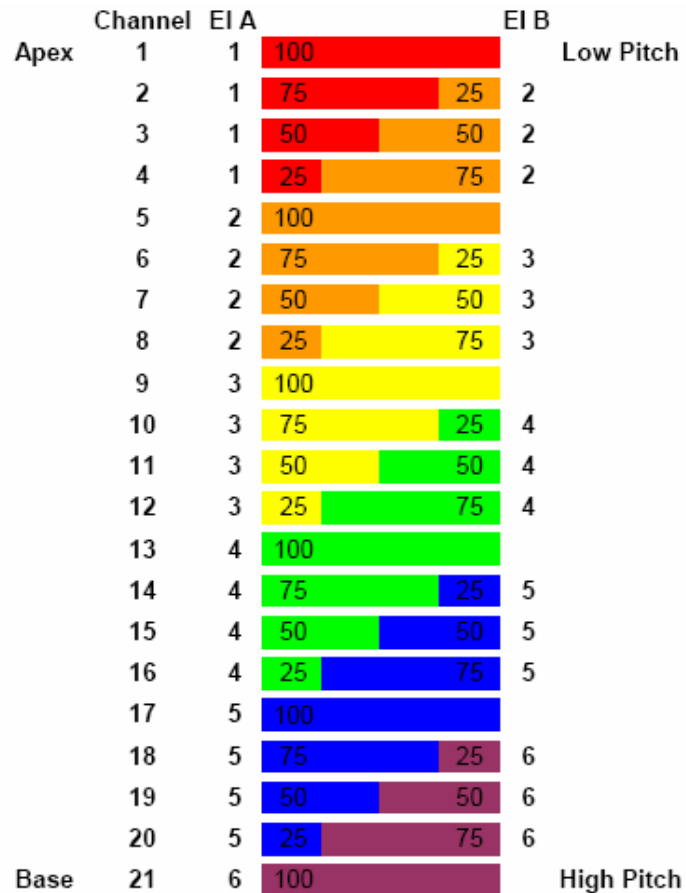
*2 Alternative Forced Choice – 2AFC
Briefing on Processors
Performance*



Combined Use of DRNL and VC

Virtual Channel

Briefing on Processors Performance



Combined Use of DRNL and VC

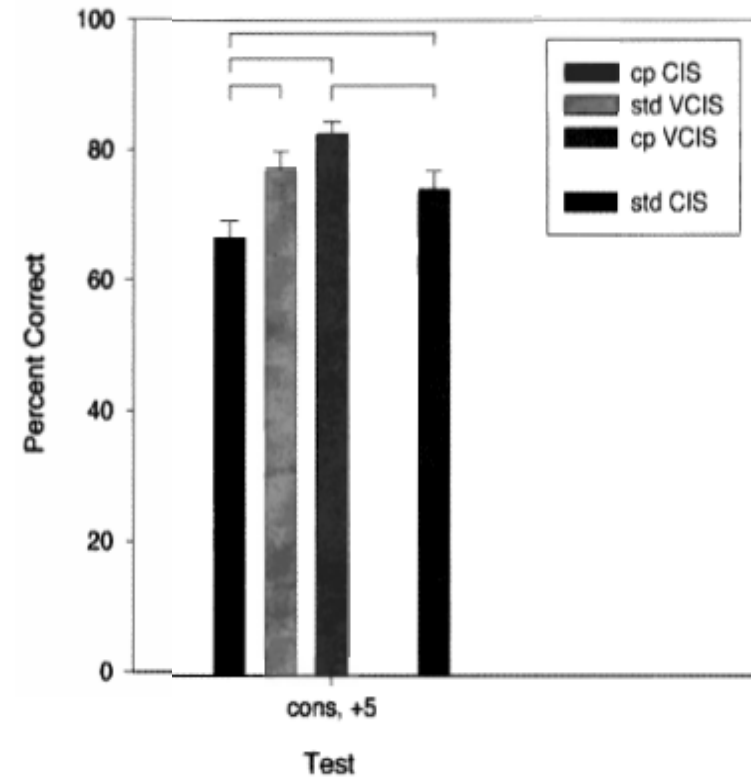
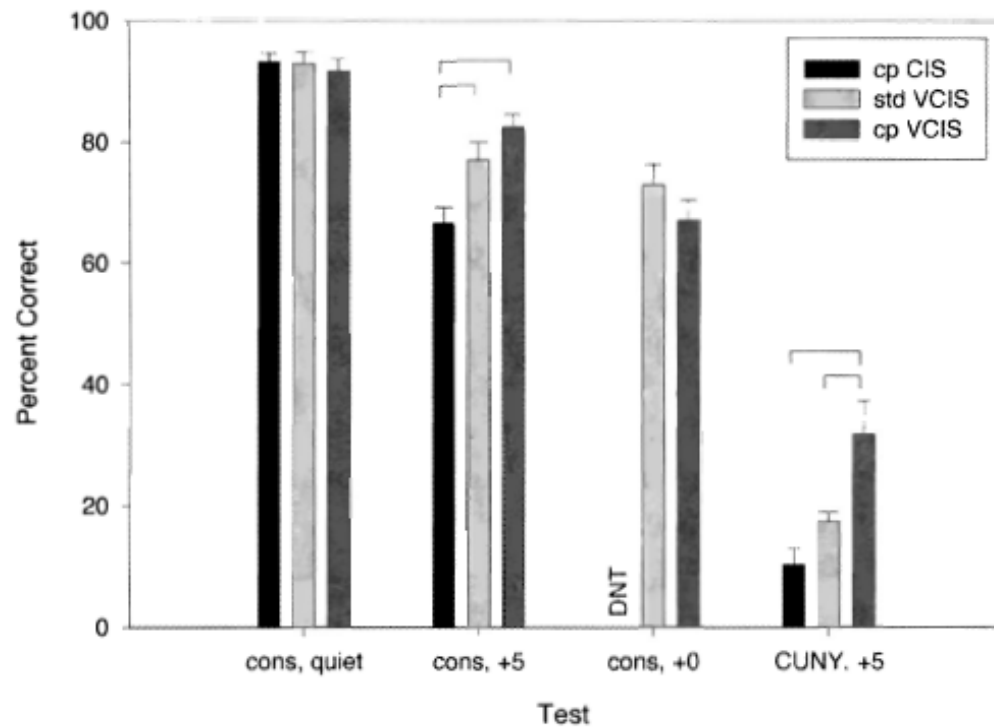
Virtual Channel
2 Alternative Forced Choice – 2AFC
Performance

- **cp CIS**
 - Maximum 24-to-6 processor using DRNL filters
- **std VCIS**
 - 21-site VCIS processor using Butterworth filters
- **cp VCIS**
 - 21-site VCIS processor using DRNL filters



Combined Use of DRNL and VC

*Virtual Channel
2 Alternative Forced Choice – 2AFC
Briefing on Processors*



Discussion of Findings to Date

The Next Step

- Relatively high number of stimulus sites may be needed for effective use of DRNL filters.
- Mapping a high number of DRNL channel outputs to a small number of stimulus sites may not be as effective. However, use of outputs from the DRNL filters, as opposed to the DRNL channels may reduce distortions and thereby improve the performance of n-to-m approaches.
- cp VCIS processor produced the best performance.



Review

Discussion of Findings to Date

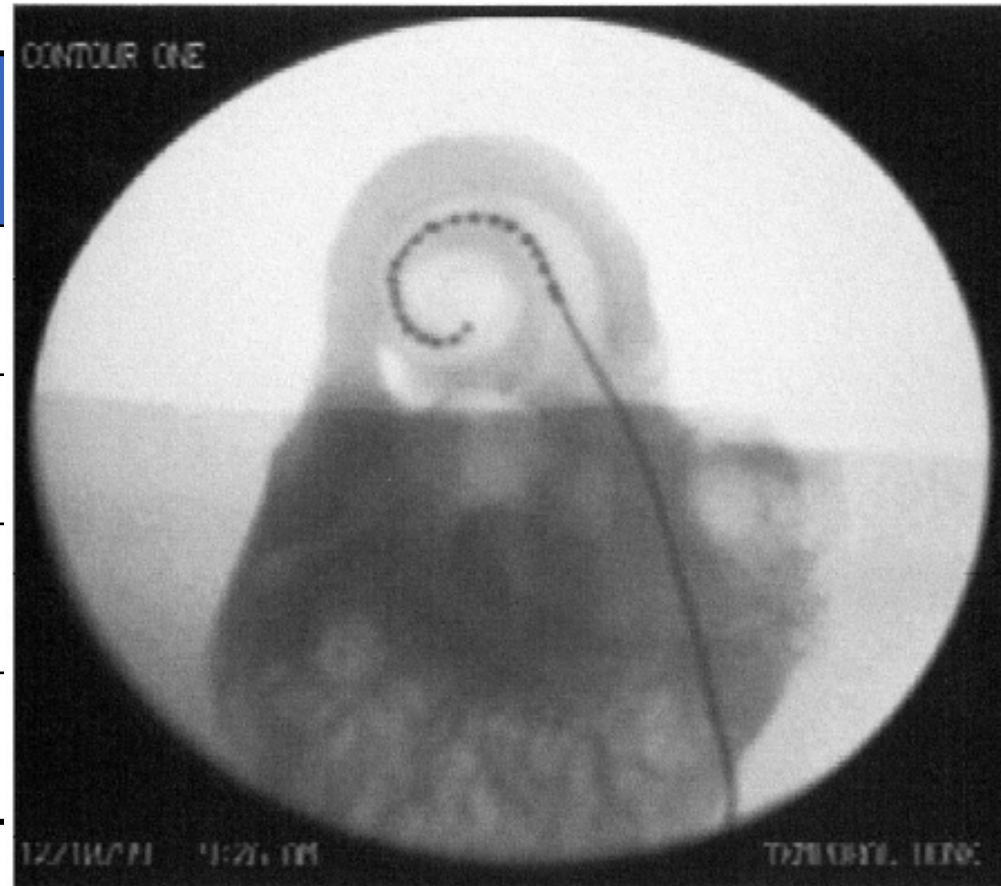
- Two possibilities
 - More than 21 sites may be available using the VCIS approach.
 - Alternative ways to provide a high number of sites should be investigated.
- Nucleus electrode array with 22 intracochlear electrodes and up to 22 discriminable pitches for some subjects.
- Bilateral cochlear implants



Discussion of Findings to Date

Review

System	Company
CII	Clarion
HiResolution 90K	Clarion
PULSAR	Med-El
Contour	Nucleus



How can we Maximize the number of discriminable sites with cochlear implants?



Neural Prosthesis

Conclusion

- *Processors using n-to-m approaches have in general supported speech reception performance that is immediately on a par with that of the standard CIS processors.*
- *A processor using DRNL filters in combination with virtual-channel stimulation supported significantly better performance than the standard CIS processor.*
- *Further studies are needed to evaluate the generality of these preliminary findings and to optimize the incorporation of DRNL filters in speech processor designs.*
- *Substitution of the IHC membrane and synapse model for the standard envelope detector needs to be evaluated separately and in combination with a DRNL filter bank.*

