

# Optimizing electric stimulation to suppress tinnitus

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- Introduction
- The subject: CINH001
- Optimization
- Mechanisms and treatment



# Introduction

- A significant problem
- Unclear Mechanisms:

- correlated to hearing loss;
  - peripheral and central origins

- Unproven Therapy?

- Drugs;
  - Surgeries
  - Tinnitus retraining therapy
  - Masking devices

- Electric stimulation:

- Brackmann DE. Reduction of tinnitus in cochlear-implant patients.

- J Laryngol Otol Suppl. 1981;(4):163-5.

- Rubinstein JT, Tyler RS, Johnson A, Brown CJ. Electrical suppression of tinnitus with high-rate pulse trains. Otol Neurotol. 2003;24(3):478-85.

# CINH001

## ➤ **Audiological info:**

- 46-years-old male;
- unilateral sudden hearing loss (right ear) in 2004
- normal hearing in the left ear

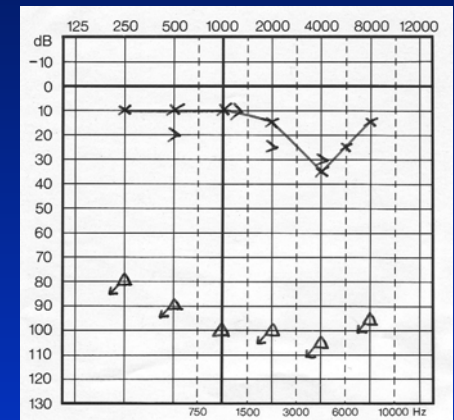
## ➤ **Cochlear implant:**

- received Clarion HiRes 90k at Stanford
- CIS strategy; HINT=40-75%

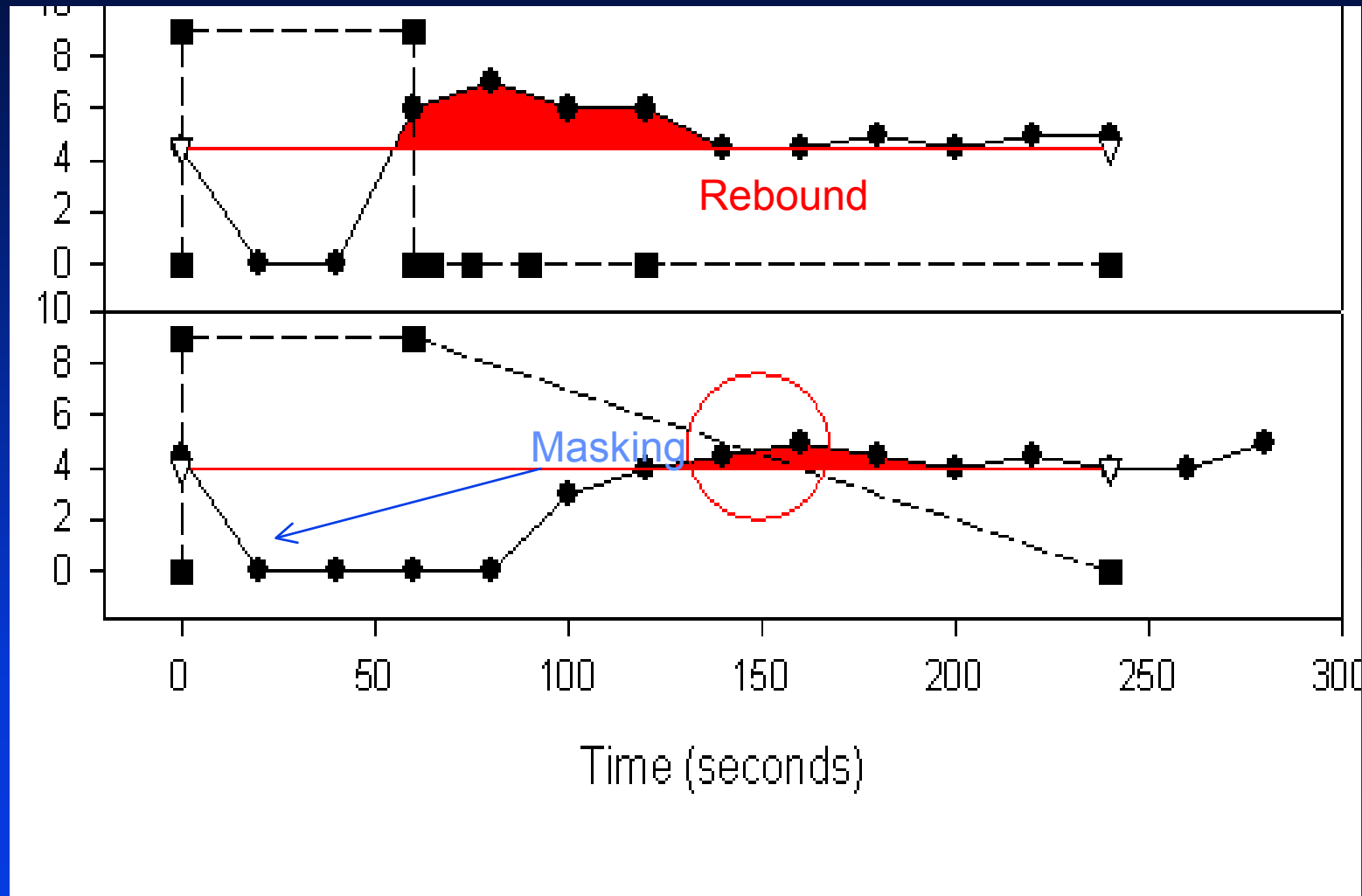
## ➤ **Psychophysics of tinnitus:**

- most of the time: 5-7 out of 10 in loudness
- attacks can occur and develop in to migraine
- matched to the following sounds:

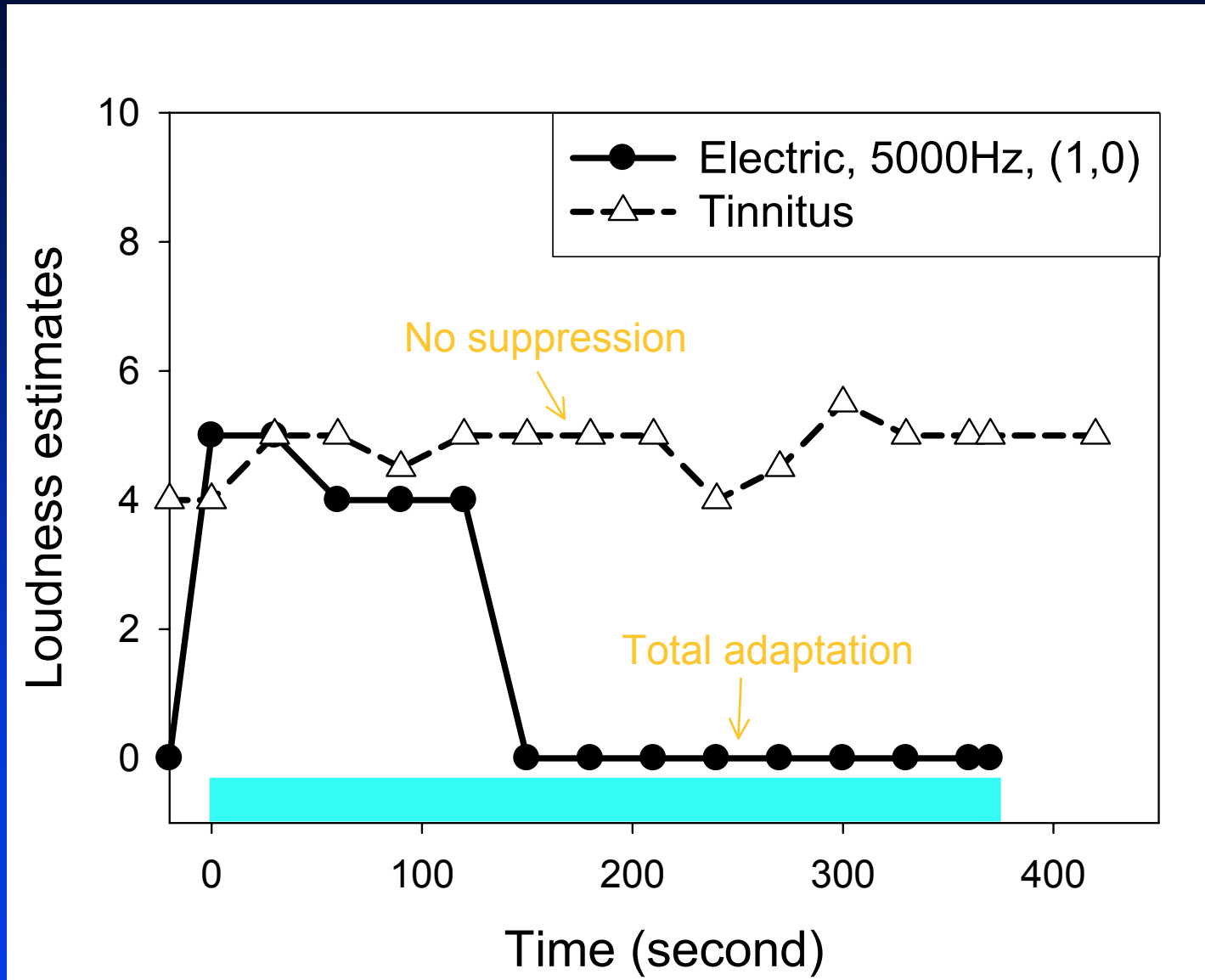
1. 4000 Hz at 73 dB
2. 500-8000 Hz noise at 70-90 dB
3. 4000-8000 Hz 90 dB



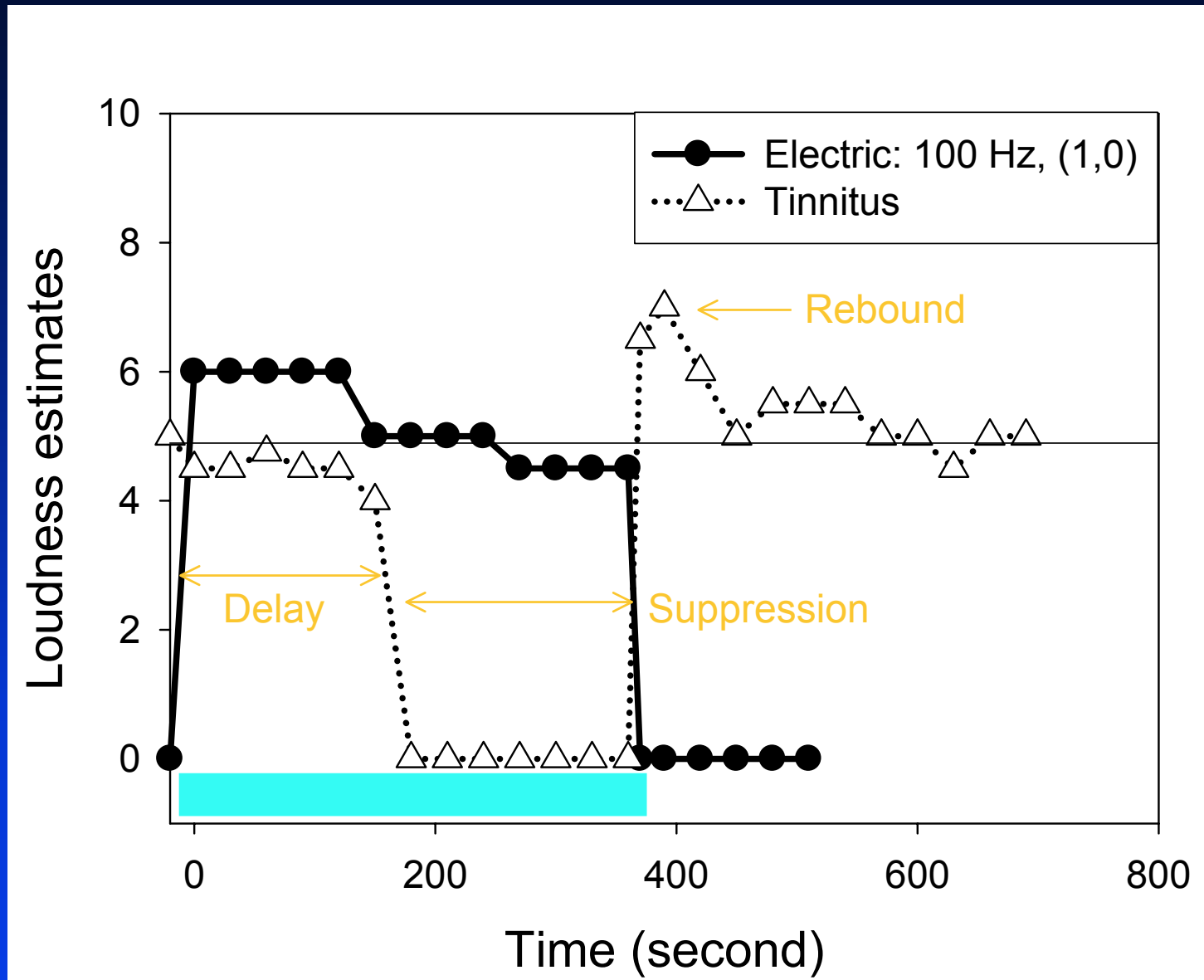
# Acoustic stimulation: Masking but too much



# High rate stimulation: Adaptation but no suppression



# Low rate stimulation: No adaptation but suppression



# Explore the parametric space #1: Critical rate

	Stimulation rate (Hz)	Trial 1	Trial 2	Trial 3	Trial 4	Trial5
Pulse trains	<b>25</b>	<b>20%</b>	<b>X</b>			
	<b>40</b>	<b>40%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>50%</b>
	<b>50</b>	<b>100%</b>	<b>25%</b>	<b>25%</b>		
	<b>80</b>	<b>100%</b>	<b>60%</b>	<b>X</b>	<b>67%</b>	<b>X</b>
	<b>100</b>	<b>100%</b>	<b>100%</b>	<b>X</b>	<b>X</b>	<b>100%</b>
	<b>137</b>	<b>X</b>	<b>X</b>	<b>X</b>		
	<b>200</b>	<b>X</b>	<b>100%</b>	<b>X</b>		
	<b>400</b>	<b>60%</b>	<b>X</b>			
	<b>600</b>	<b>X</b>	<b>X</b>			
	<b>1000</b>	<b>X</b>	<b>X</b>			
	<b>5000</b>	<b>X</b>	<b>X</b>	<b>X</b>		
Sinusoids	<b>100</b>	<b>100%</b>	<b>100%</b>	<b>X</b>		
SAM	<b><i>Fm = 100</i></b> <b><i>Fc = 1855</i></b>	<b>X</b>				
	<b><i>Fm = 200</i></b> <b><i>Fc = 1855</i></b>	<b>X</b>				

# Explore the parametric space #2: Critical place

	Stimulation Place	Trial 1	Trial 2	Trial 3	Trial 4	Trial5
50Hz	<i>El(1,0)</i>	100%	25%			
	<i>El(4,0)</i>	X	100%			
100Hz	<i>El(1,0)</i>	100%	100%	X	X	100%
	<i>El(2,0)</i>	X	X			
	<i>El(3,0)</i>	X	X			
	<i>El(4,0)</i>	40%	X			
	<i>El(5,0)</i>	X	X			
	<i>El(9,0)</i>	X				
	<i>El(16,0)</i>	X				
500Hz	<i>El(4,0)</i>	X				
5000Hz	<i>El(1,0)</i>	X	X	X		
	<i>El(16,0)</i>	X	X			

# Explore the parametric space #3: Critical level

	Stimulation Level	Trial 1	Trial 2	Trial 3	Trial 4	Trial5
40Hz	<b>6</b>	<b>100%</b>				
	<b>5</b>	<b>100%</b>				
	<b>4</b>	<b>40%</b>				
	<b>2</b>	<b>100%</b>				
	<b>1</b>	<b>50%</b>				
50Hz	<b>6</b>	<b>100%</b>	<b>25%</b>	<b>25%</b>		
	<b>5</b>	<b>25%</b>				
80Hz	<b>6</b>	<b>100%</b>	<b>60%</b>	<b>X</b>	<b>67%</b>	<b>X</b>
	<b>4</b>	<b>25%</b>	<b>X</b>			
	<b>3</b>	<b>29%</b>				
100Hz	<b>6</b>	<b>100%</b>	<b>100%</b>	<b>X</b>	<b>X</b>	<b>100%</b>
	<b>3</b>	<b>100%</b>				
	<b>1</b>	<b>X</b>				



before CI stimulation

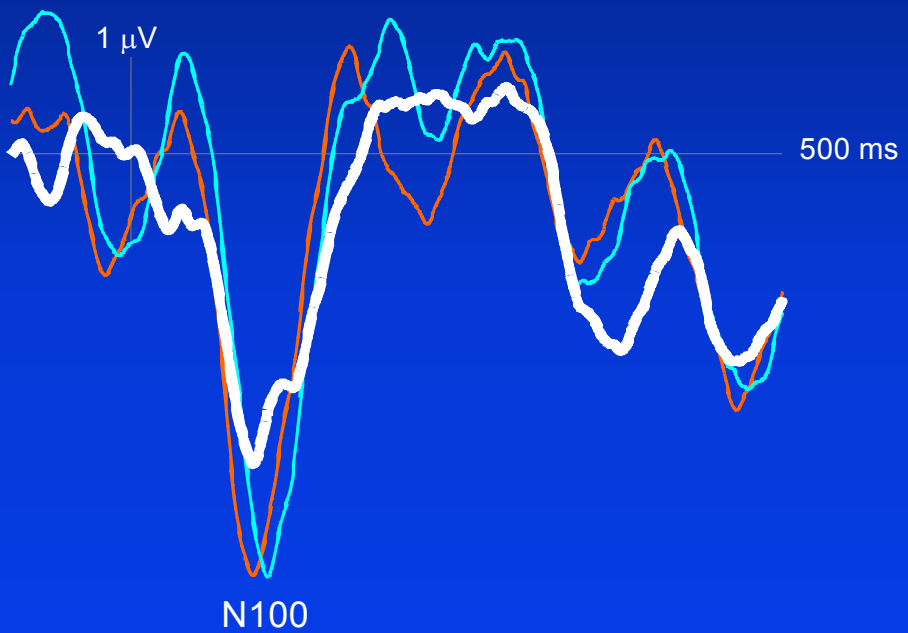
during CI stimulation

after CI stimulation

↑ tinnitus

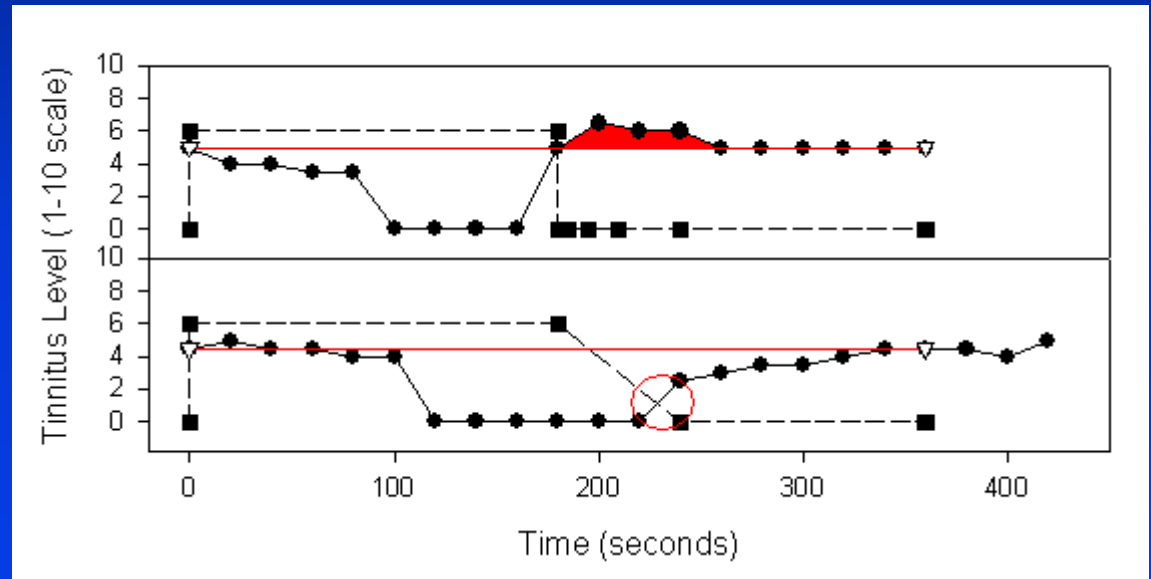
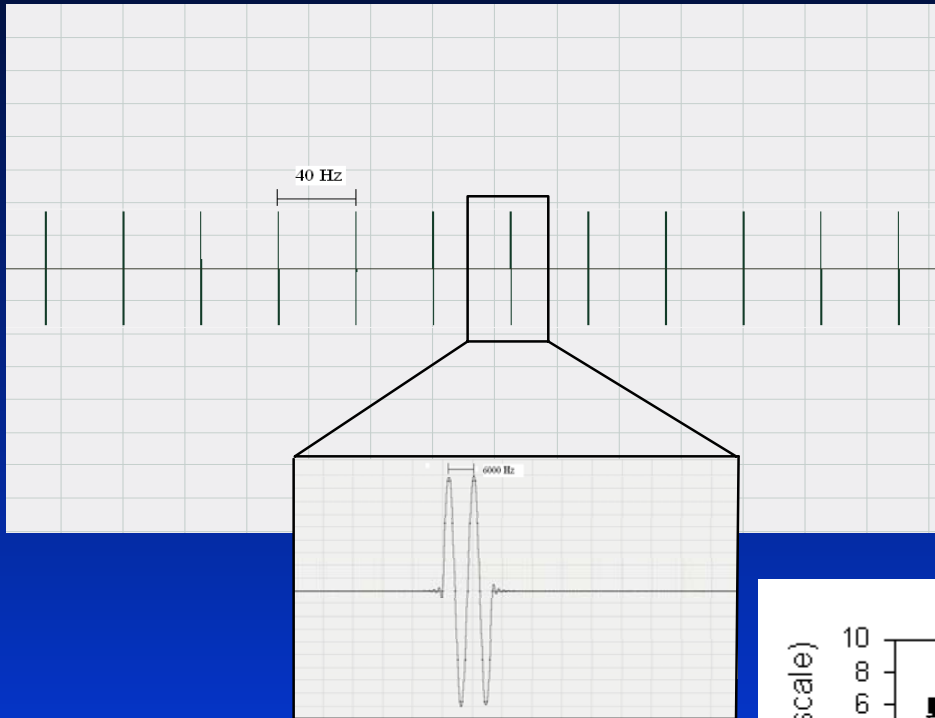
↓ tinnitus

↑ tinnitus



Electrophysiological signature

# Find a clinical solution: Pulse tone bursts with ramps



# Discussion and Conclusions

- **Mechanisms: Not masking but what?**
  - Contralateral loud white noise can mask it
  - Takes 1-2 minutes to suppress
  - Effective stimulus and tinnitus are very different
- **Mechanisms:**
  - Adaptation related mechanism?
  - Balanced input?
- **Take home points:**
  - Electric stimulation can be effective but require fine tuning
  - The best suppressor may not be the best masker
  - Acoustic stimulation?
  - Objective measures of tinnitus?