PS-229

Synchronizing bilateral cochlear implants: Preliminary findings using the UT-Dallas Cochlear Implant Personal Digital Assistant research platform

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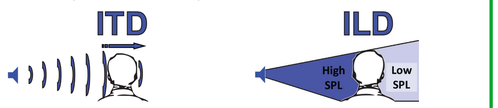
INTRODUCTION

Binaural Processing

- Integration of acoustic information at the two ears
- Encodes two important acoustic spatial cues:



Interaural Time Difference | Interaural Level Difference

Facilitates

Spatial Hearing Abilities

1) Sound localization

- Identifying the location of a sound source of interest
- For broadband signals, such as speech, ITDs are the dominant cue[1]
- More difficult in reverberant and multi-source acoustic environments

2) Speech reception in background noise

- Spatial release from masking (SRM)
  -Speech intelligibility improves when target speech and competing sounds are spatially separated[2]
- Selectively attend to source of interest and ignore masking sources

The PROBLEM for Bilateral Cochlear Implant (BiCI) Users

1) Sound localization

- Users report difficulty identifying where sounds are coming from
- Larger localization errors compared to normal hearing (NH) listeners[3,4]

2) Speech reception in background noise

- Users report difficulty listening in noisy places (i.e., restaurants, classrooms)
- Speech reception thresholds (SRTs) for spatially separated target and maskers are significantly elevated compared to NH listeners[5,6,7]
- Receive minimal benefit from SRM[6,7]

Binaural limitations of current BiCIs

- Current devices operate independently of one another
- Stimulation between implants is not coordinated
- As such, transmission of acoustic ITDs is not done effectively, or at least not in a way that can be perceived reliably by BiCI users
- No intelligent (binaural) signal processing can be implemented, because the devices are not linked

CiPDA RESEARCH PLATFORM[8]

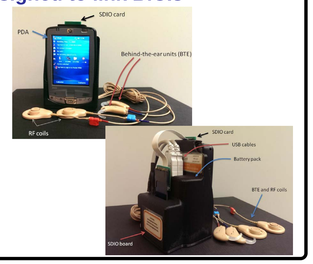
Experimental device designed to link BiCIs

Capabilities

- Single processor drives both implants
- Synchronized bilateral stimulation
- Works with Cochlear Nucleus® devices

Features

- Real-time ACE processing
- Mimics clinical processors
- Use patient's clinical maps
- May provide better ITD transmission:
  -Envelope ITDs
  -**Not** Temporal Fine Structure ITDs



The current study aimed to:

1.) Evaluate the CiPDA research platform for free-field psychoacoustic testing

2.) Assess spatial hearing benefits of synchronized bilateral stimulation

PARTICIPANTS

Listeners

- 8 post-lingually deafened BiCI Cochlear Nucleus users

Table 1. Listener profiles and etiology

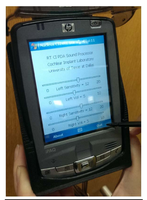
ID	Age	Sex	Years of Bilateral CI Experience	Etiology
IAZ	76	M	3	Hereditary
ICF	70	F	1	Bilateral otosclerosis
ICO	32	F	1	Etiology unknown
IBK	71	M	2	Hereditary / Noise
IBY	48	F	8	Etiology unknown
ICJ	63	F	3	Illness
ICB	61	F	6	Hereditary
IBF	59	F	3	Hereditary

PROCEDURES

Getting Started

- Load patient's clinical maps onto the CiPDA
- Place RF coils onto patients
- Turn device on and start real-time processor
- Ensure that patient can hear tester speaking*
- Find comfortable loudness for listening

Parameters from the patient's clinical MAP used by the CiPDA



Screen for CiPDA sensitivity and volume adjustments

Loudness Matching

1) Start with CiPDA default settings and clinical processors in the patient's everyday program
2) Adjust (lower) CiPDA sensitivity to reduce background noise**
3) Adjust CiPDA left and right volume to ensure a perceived centered auditory image for a stimulus played from 0° azimuth.
4) Wear one CiPDA and one clinical processor, and adjust CiPDA volume to match loudness of clinical processor
5) Repeat for the other ear
6) Loudness matching and auditory image centering was also done for the clinical processors

All patients reported that: **voices sounded "tinny" or "as if person speaking was inside a well"*
***a background noise or "hum" was heard upon activation of CiPDA*

EXPERIMENTS

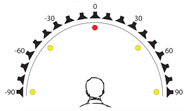
LOCALIZATION PERFORMANCE

Stimuli

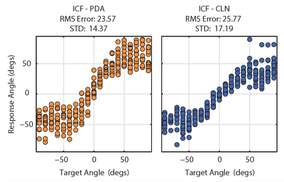
- Train of four pink noise bursts (each 170ms)
- Inter-stimulus-interval (ISI) = 50 ms

Procedure

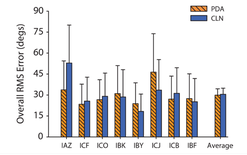
- For each trial, stimuli were randomly presented from each of the 19 locations 5x each
- 60 dBA and ±4dB SPL level rove
- Patients indicated response on computer screen
- Three trials for each condition



Experiment setup



Raw sound localization performance. Patient response as a function of target location for participant ICF with CiPDA (PDA, left) and clinical processors (CLN, right).



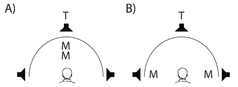
Overall localization errors. Root-mean-square (RMS) difference between target and response was calculated across all trials. On average, both processors produced similar sound localization performance

SPEECH-IN-NOISE PERFORMANCE

Stimuli

Target
- Male speaker
- Mono-syllabic words

Maskers
- Two female speakers
- IEEE sentences

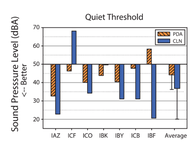


Procedure

- Target and masker presented in two conditions: (A) co-located or (B) symmetric separation
- Patients selected perceived word from a list of 50 words
- Maskers fixed at 50 dBA and target level adjusted
- Adaptive tracking used to determine SRT at 50% correct
- Four total adaptive tracks were measured for each listening condition.
- 7 subjects (no data for ICJ)

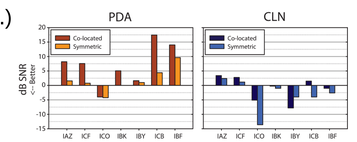
Experiment setup

A.)



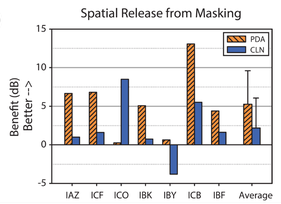
Speech reception thresholds (Quiet). Target started at 50dB SPL and was adjusted based on response.

B.)



Speech reception thresholds (Noise). Maskers were fixed at 50 dB SPL and target SPL was adjusted based on response.

C.)

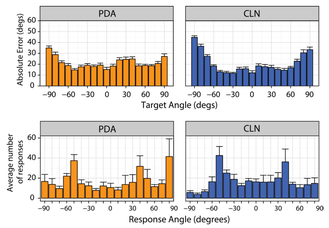


Benefit of spatial release from masking (SRM). SRM was calculated by subtracting the symmetric SRT from the co-located SRT.

SUMMARY

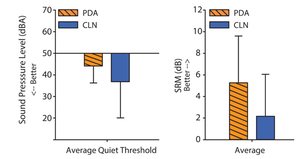
1) Sound localization

Sound localization with CiPDA resulted in comparable overall performance as that measured with the patient's clinical processors



- Group comparison revealed no difference in RMS errors between listening conditions
- Subtle differences in localization error patterns (top panels) and response distributions (bottom panel) across target locations were observed. On average, localization errors for more lateral locations were lower in the PDA listening condition.

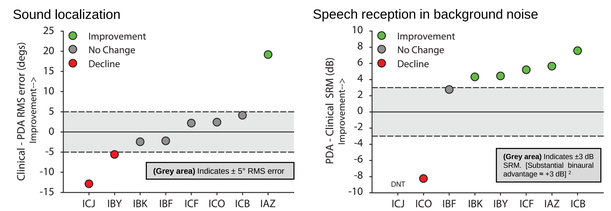
2) Speech reception



Patient's had increased listening benefit in the spatially separated condition with the CiPDA compared to their clinical processors

- SRTs in quiet were elevated for the CiPDA compared to listening with clinical processors.
- However, listening with the CiPDA provided on average ~3-4 dB ***more*** SRM than was measured with clinical processors.

3) Individual Performance Change



Patients had minimal sound localization improvement, but most exhibited an increase in SRM when listening with the CiPDA

CONCLUSIONS

- The CiPDA research platform is effective for testing spatial hearing in the free field.
- The CiPDA can acutely produce comparable listening performance as provided by the patient's clinical processors.
- Synchronizing pulsatile stimulation across the ears alone does not result in improved sound localization performance.
- However, novel strategies aimed at improving sound localization can be implemented and tested using the CiPDA.
- Spatial release from masking was observed when listening with the CiPDA suggesting that coordinated stimulation may provide useful information for segregating spatially separated sound sources.

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