NUROTRON

诺尔康文摘

NURIOTRON DIGEST

2019年第1期 总第10期

首届人工智能听力跨界研讨会专刊

浙江诺尔康神经电子科技股份有限公司
NUROTRON BIOTECHNOLOGY., Ltd.

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出版日期：2019年6月30日

主办单位：
浙江诺尔康神经电子科技股份有限公司

地址：浙江省杭州市余杭区龙潭路17号
邮编：311121
电话：4006 222 571
传真：0571-88179905
邮箱：service@nurotron.com
网址：http://www.nurotron.com

首届人工智能听力跨界研讨会（中国 杭州）

First Artificial Intelligent Auditory Crossover Forum (Hangzhou, China)

1st AIACF

于 2019 年 4 月 12 日，由美国加州大学洛杉矶分校、华南理工大学及诺尔康听力言语医学研究院联合主办的首届人工智能听力跨界研讨会在诺尔康神经电子研发生产基地顺利举办。本次跨界研讨会旨在跨学科探讨如何突破现有技术桎梏，解决目前人工耳蜗（Cochlear Implant, CI）、听性脑干植入（Auditory Brainstem Implant, ABI）等人工听觉装置仍未攻克的难题，为听障人士提供人工智能听力，还原最真实的有声世界。

作为中国自主研发人工听觉植入装置的代表，诺尔康人工耳蜗自 2009 年开始应用于临床，现已有超过 10,000 名植入者；2016 年，中国大陆首例听性脑干植入（诺尔康）开机成功，解决了如听神经瘤、耳蜗严重畸形等人工耳蜗无法克服的听觉障碍，填补了国内的技术空白，标志着中国人自主研发的人工听觉植入产品和技术已经跻身世界前列。

然而，与人耳自然听声相比，目前的人工听觉技术仍然存在诸多局限，比如人工耳蜗植入者在音乐欣赏、噪声下的聆听仍存在困难，听性脑干植入患者目前普遍只能达到听声辨别，而言语识别仍存在困难，需要借助唇读等等。近几十年来，人工听觉植入装置虽然不断推陈出新，但其材料、核心技术等一直未有突破性的进展，如何使得人工听觉更智能、更真实？确实，技术革新迫在眉睫。

本次研讨会就这些议题展开了热烈的讨论，研讨会邀请到了医学、听力学、言语康复、心理声学、语音学、信号处理、工艺设计等多学科领域的专家教授共同参与，摩擦碰撞出了人工智能的科技火花，也相信未来通过我们共同的努力能够使得中国人工听觉科技打破国外垄断，突破现有瓶颈，让更多的人聆听智能中国声！

首届人工智能听力跨界研讨会（中国 杭州）

First Artificial Intelligent Auditory Crossover Forum (Hangzhou, China)

1st AIACF

2019 年 4 月 12 日（周五）

时间	议程	主讲人	主持人
09:00—12:00	人工智能听力高峰论坛	全体跨界专家	屠文河
12:00—13:00	午餐		
13:00—14:00	诺尔康研发生产基地参观	银力	屠文河
14:00—17:30	圆桌讨论会	全体跨界专家	银力

会议主办单位及特邀嘉宾：

- 美国加州大学洛杉矶分校（University of California at Los Angeles）；
  特邀嘉宾：傅前杰（教授）
- 诺尔康听力言语研究院（Nurotron Hearing, Speech and Medical Science Institute）；
  特邀嘉宾：银力（院长）
- 华南理工大学（South China University of Technology）；
  特邀嘉宾：孟庆林（博士、讲师）

会议地点：浙江诺尔康神经电子科技股份有限公司（杭州市余杭区龙潭路 17 号）

Listening AI
Sensing Sound for Hearing Impaired

Qian-Jie Fu, Ph.D.

Signal Processing and Auditory Perception Laboratory
Department of Head and Neck Surgery
David Geffen School of Medicine UCLA
2100 W 3rd Street, Los Angeles, CA 90057

David Geffen School of Medicine　UCLA Health

Artificial Intelligence (AI)

- Artificial intelligence (AI), defined as intelligence exhibited by machines.
- **Weak AI**: also known as narrow AI, the form of AI where programs are developed to perform specific tasks (one narrow task), that is being utilized for a wide range of activities.
- **Strong AI**: a machine with consciousness, sentience and mind or artificial general intelligence (a machine with the ability to apply intelligence to any problem, rather than just one specific problem).

Typical application of AI

AI has been used to develop and advance numerous fields and industries, including finance, healthcare, education, transportation, and more.

- Agriculture
- Education
- Finance
- Human resources and recruiting;
- Job search;
- Marketing;
- Media and e-commerce
- News, publishing and writing
- Algorithmic computer music
- Online and telephone customer service
- Power electronics
- Sensors
- Telecommunications maintenance
- Toys and games
- Transportation
- Heavy industry - robots
- **Hospital and medicine**

AI for Hospitals and Medicine

- **Computer-aided interpretation of medical images**
- Heart sound analysis
- Mining medical records

What AI can do for individuals with hearing impairment?

death from surgical procedures

- Drug creation
- Using avatars for clinical training
- Companion robots for the care of the elderly

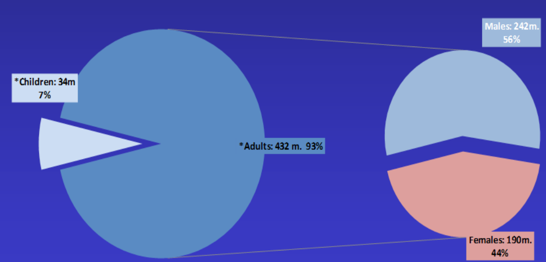
WHO: Disabling Hearing Loss (DHL)

Degree of hearing loss	Hearing loss range (dB HL)
Normal	-10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55
Moderately severe	56 to 70
Severe	71 to 90
Profound	91+

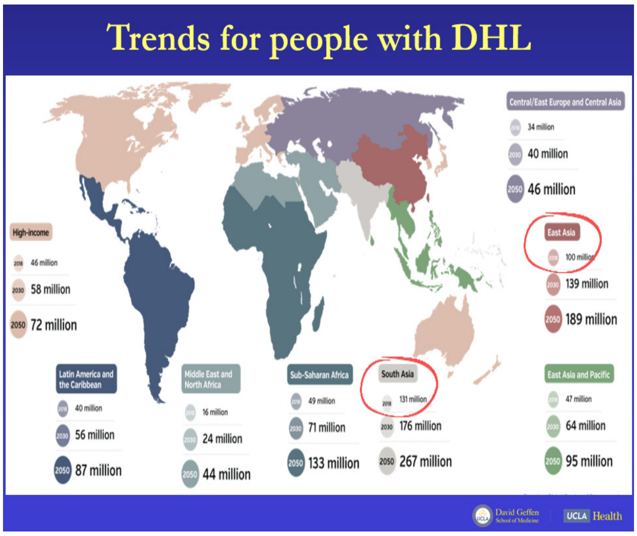
Source: Clark, J. G. (1981). Uses and abuses of hearing loss classification. *Asha, 23,* 493–500.

Disabling hearing loss refers to hearing loss greater than 40 dB in the better hearing ear in adults (15 years or older) and greater than 30 dB in the better hearing ear in children (0 to 14 years).

WHO: DHL Prevalence



In 2018, there are an estimated 466 million people with disabling hearing loss worldwide (over 5% of the world's population). 93% of them are adults and 7% children. Among the DHL adults, there are more males (56%) than females (44%).


Trends for people with DHL
Central/East Europe and Central Asia
34 million
40 million
2050 46 million
High-income
46 million
2030 58 million
2050 72 million
East Asia
100 million
2030 139 million
2050 189 million
Latin America and the Caribbean
40 million
56 million
2050 87 million
Middle East and North Africa
16 million
24 million
2050 44 million
Sub-Saharan Africa
49 million
71 million
2050 133 million
South Asia
131 million
2030 176 million
2050 267 million
East Asia and Pacific
47 million
64 million
2050 95 million
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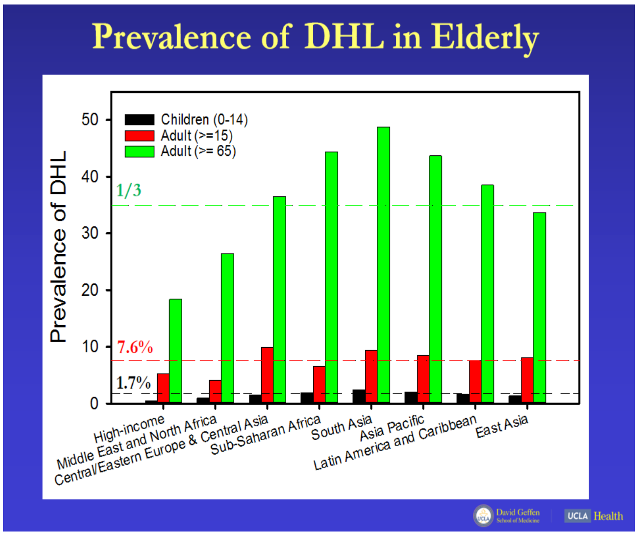
UCLA Health


Prevalence of DHL in Elderly
Prevalence of DHL
Children (0-14)
Adult (>=15)
Adult (>= 65)
1/3
7.6%
1.7%
50
40
30
20
10
0
High-income
Middle East and North Africa
Central/Eastern Europe & Central Asia
Sub-Saharan Africa
South Asia
Asia Pacific
Latin America and Caribbean
East Asia
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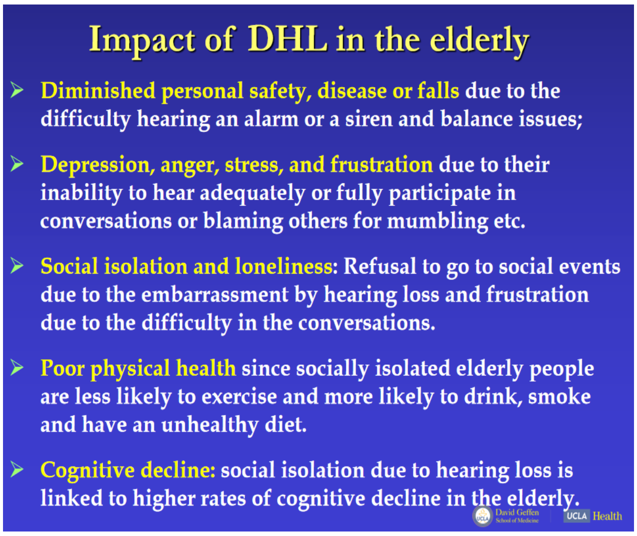
Impact of DHL in the elderly
Diminished personal safety, disease or falls due to the difficulty hearing an alarm or a siren and balance issues;
Depression, anger, stress, and frustration due to their inability to hear adequately or fully participate in conversations or blaming others for mumbling etc.
Social isolation and loneliness: Refusal to go to social events due to the embarrassment by hearing loss and frustration due to the difficulty in the conversations.
Poor physical health since socially isolated elderly people are less likely to exercise and more likely to drink, smoke and have an unhealthy diet.
Cognitive decline: social isolation due to hearing loss is linked to higher rates of cognitive decline in the elderly.
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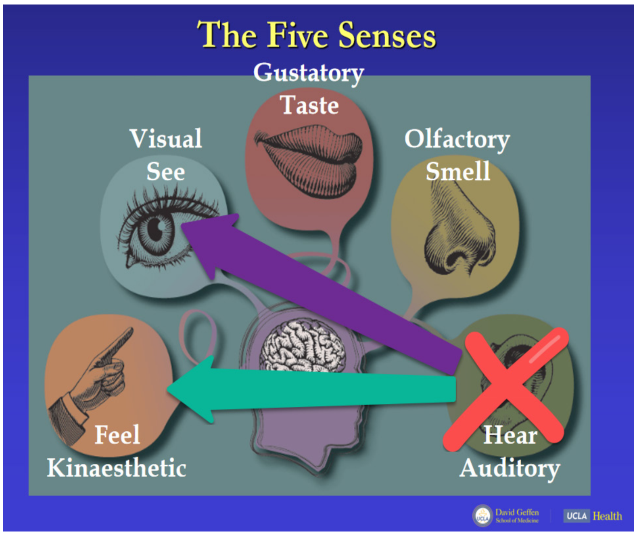
The Five Senses
Gustatory
Taste
Visual
See
Olfactory
Smell
Feel
Kinaesthetic
Hear
Auditory
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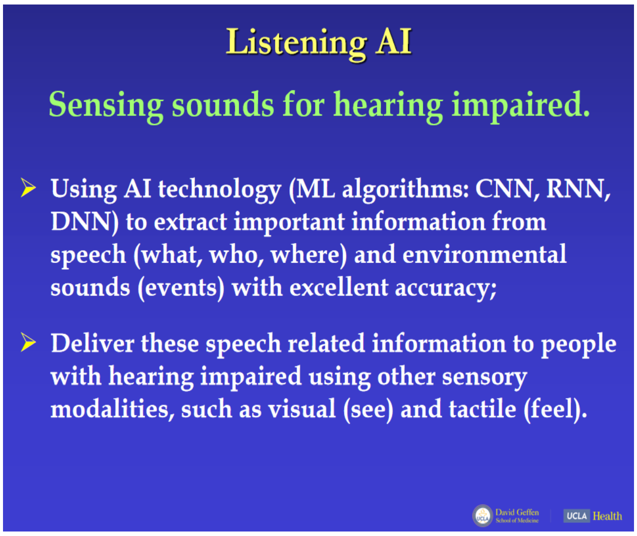
Listening AI
Sensing sounds for hearing impaired.
Using AI technology (ML algorithms: CNN, RNN, DNN) to extract important information from speech (what, who, where) and environmental sounds (events) with excellent accuracy;
Deliver these speech related information to people with hearing impaired using other sensory modalities, such as visual (see) and tactile (feel).
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A True Story
David Geffen School of Medicine
UCLA Health


Other Alerting Needs for Deaf People
Dog Barking?
my DOG?
Phone Ringing?
My Phone Ringing?
Moving Away?
Door Bells?
My Door Bells?
Moving Closer?
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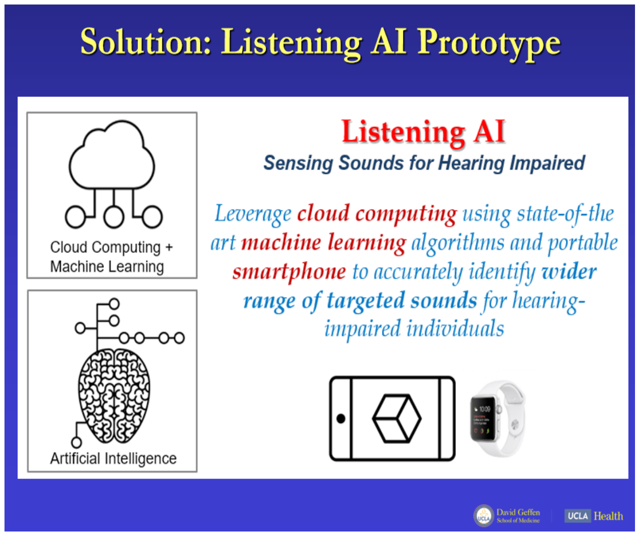
Solution: Listening AI Prototype
Cloud Computing + Machine Learning
Artificial Intelligence
Listening AI
Sensing Sounds for Hearing Impaired
Leverage cloud computing using state-of-the art machine learning algorithms and portable smartphone to accurately identify wider range of targeted sounds for hearing-impaired individuals
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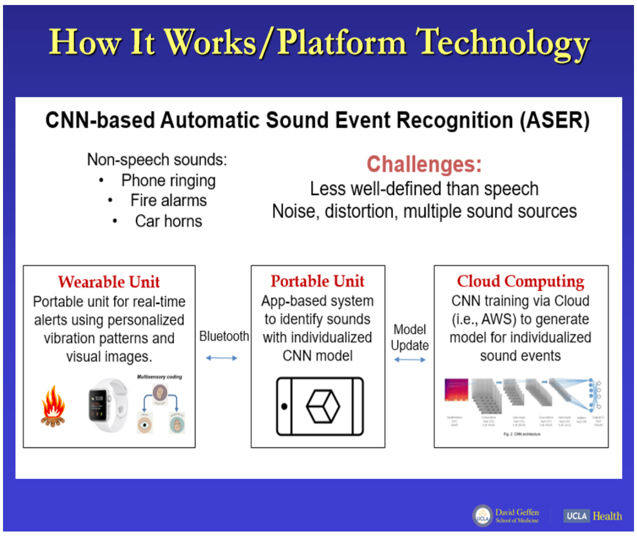
How It Works/Platform Technology
CNN-based Automatic Sound Event Recognition (ASER)
Non-speech sounds:
• Phone ringing
• Fire alarms
• Car horns
Challenges:
Less well-defined than speech
Noise, distortion, multiple sound sources
Wearable Unit
Portable unit for real-time alerts using personalized vibration patterns and visual images.
Bluetooth
Portable Unit
App-based system to identify sounds with individualized CNN model
Model Update
Cloud Computing
CNN training via Cloud (i.e., AWS) to generate model for individualized sound events
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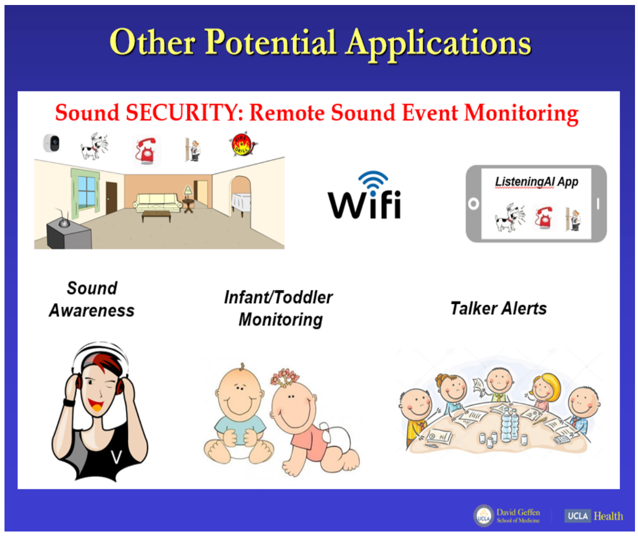
Other Potential Applications
Sound SECURITY: Remote Sound Event Monitoring
Wifi
ListeningAI App
Sound Awareness
Infant/Toddler Monitoring
Talker Alerts
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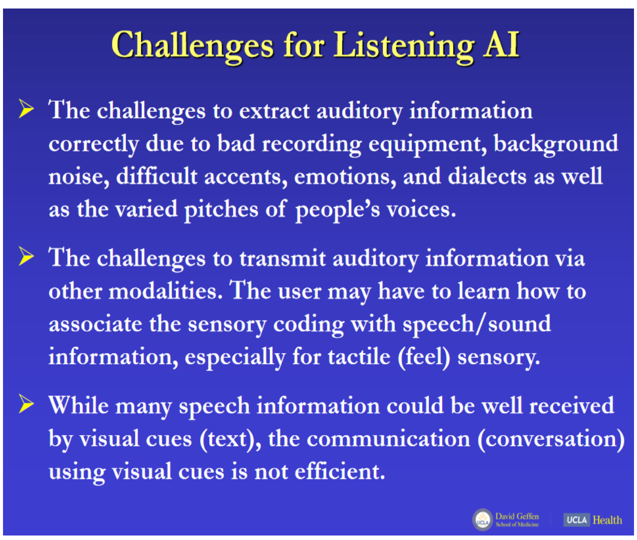
Challenges for Listening AI
➢ The challenges to extract auditory information correctly due to bad recording equipment, background noise, difficult accents, emotions, and dialects as well as the varied pitches of people's voices.
➢ The challenges to transmit auditory information via other modalities. The user may have to learn how to associate the sensory coding with speech/sound information, especially for tactile (feel) sensory.
➢ While many speech information could be well received by visual cues (text), the communication (conversation) using visual cues is not efficient.
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Better Way to Restore Hearing
➢ Using other modalities may not be the best approach to deliver auditory information to hearing impaired people.
➢ Advance in technology development, hearing aids and/or cochlear implant device has become a better option to restore hearing for hearing impaired, especially for those with severe or profound hearing loss.
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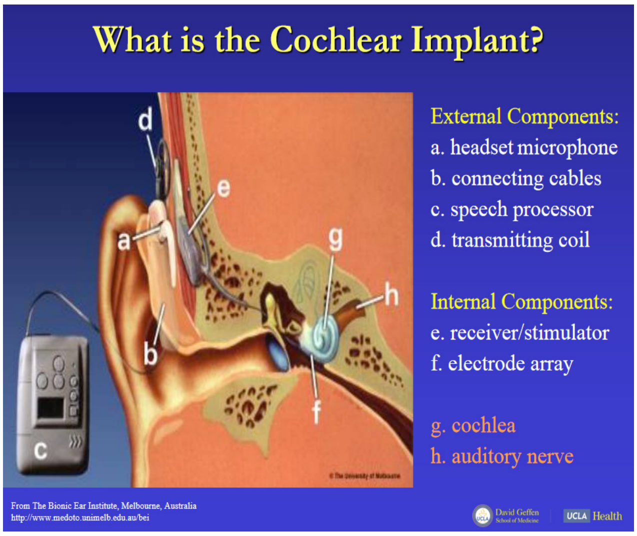
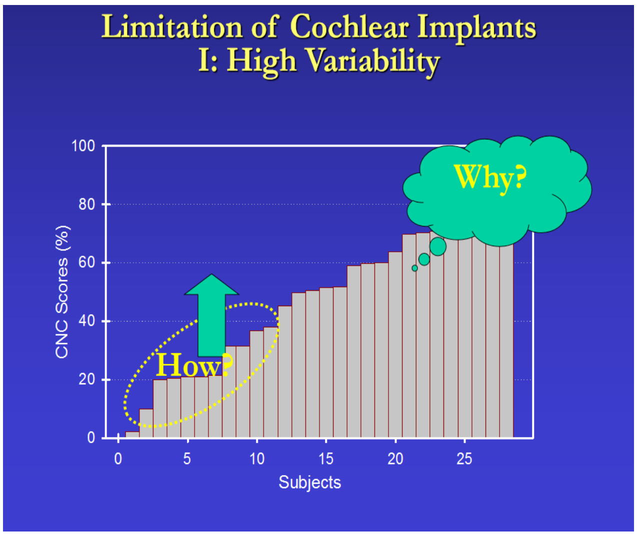
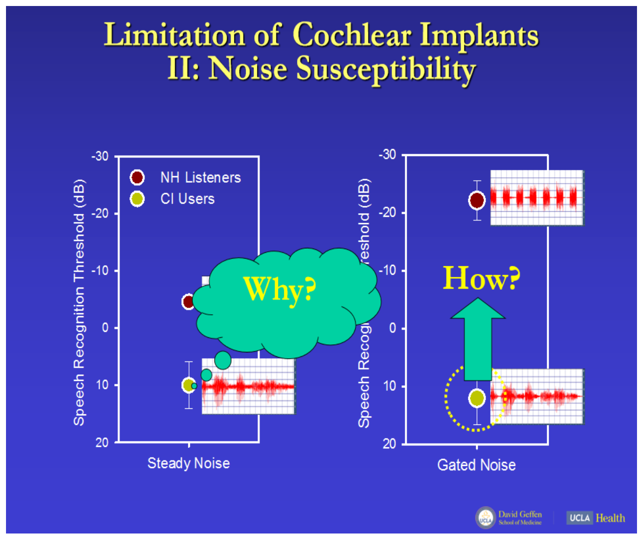
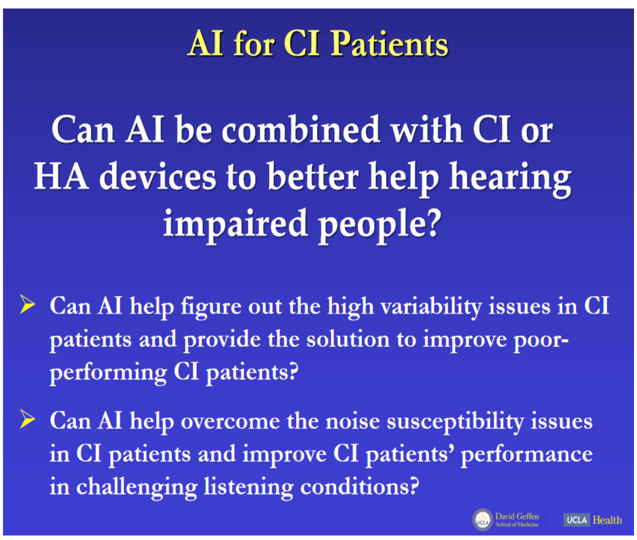

What is the Cochlear Implant?
External Components:
a. headset microphone
b. connecting cables
c. speech processor
d. transmitting coil
Internal Components:
e. receiver/stimulator
f. electrode array
g. cochlea
h. auditory nerve
a
b
c
d
e
f
g
h
From The Bionic Ear Institute, Melbourne, Australia
http://www.medoto.unimelb.edu.au/bei
UCLA Health


Amazing Technology
UCLA Health


Limitation of Cochlear Implants
I: High Variability
Why?
How?
CNC Scores (%)
100
80
60
40
20
0
0
5
10
15
20
25
Subjects


Limitation of Cochlear Implants
II: Noise Susceptibility
NH Listeners
CI Users
Why?
How?
Speech Recognition Threshold (dB)
-30
-20
-10
0
10
20
Steady Noise
Gated Noise
UCLA Health


AI for CI Patients
Can AI be combined with CI or HA devices to better help hearing impaired people?
➢ Can AI help figure out the high variability issues in CI patients and provide the solution to improve poor-performing CI patients?
➢ Can AI help overcome the noise susceptibility issues in CI patients and improve CI patients' performance in challenging listening conditions?
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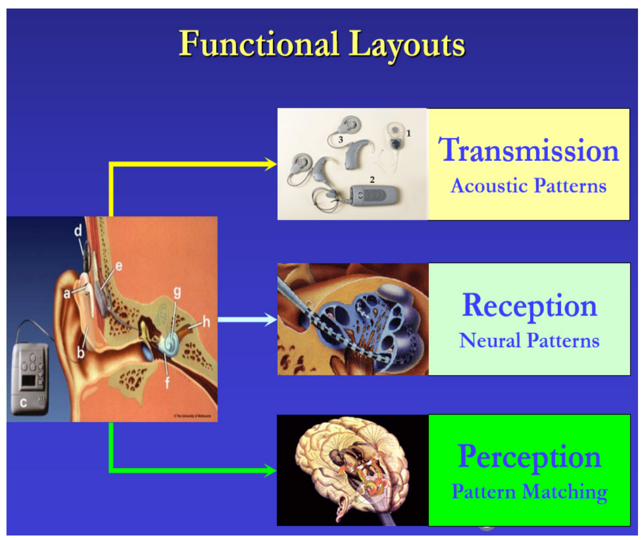
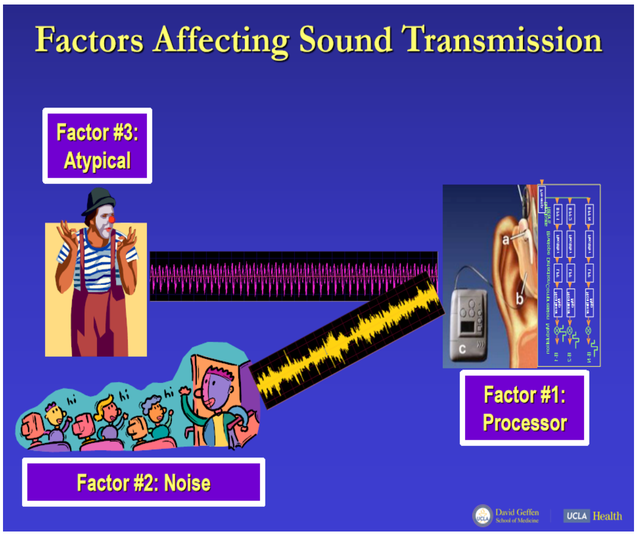
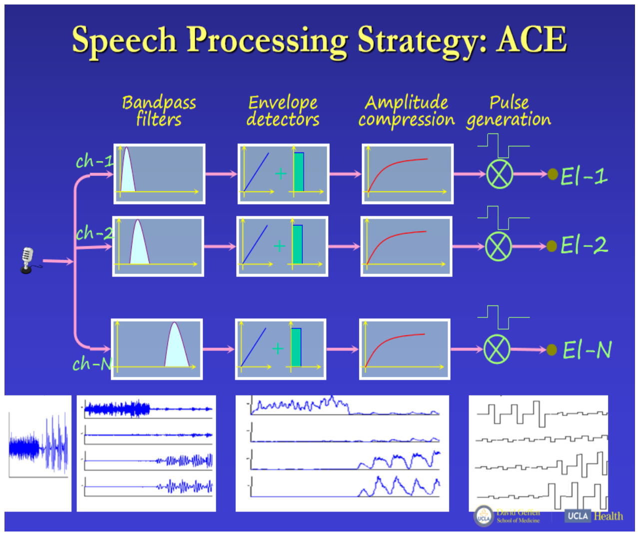
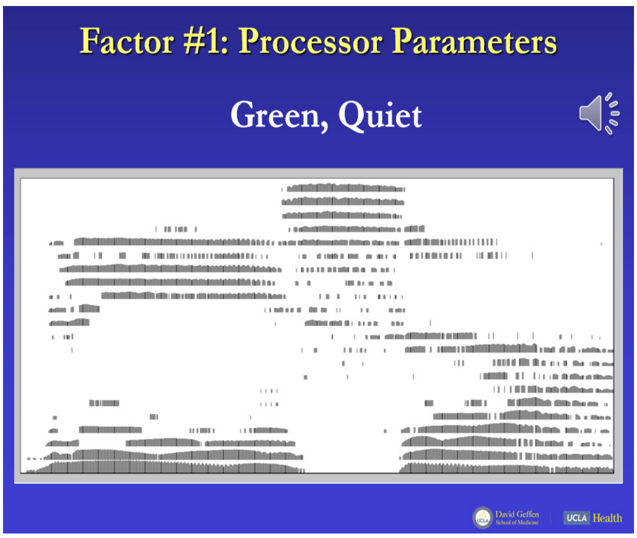
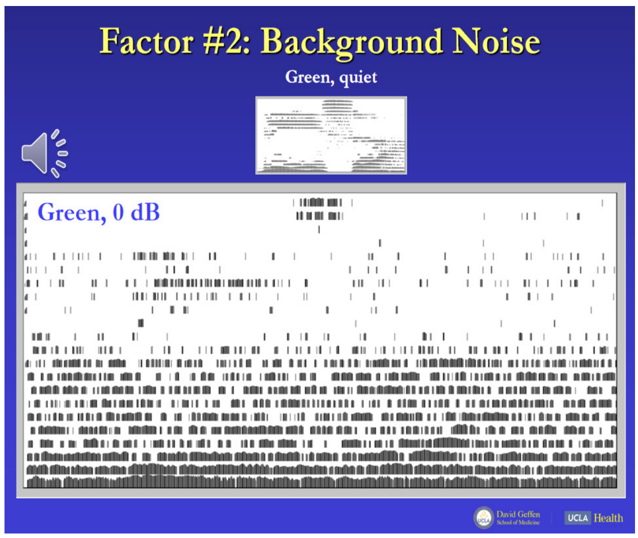
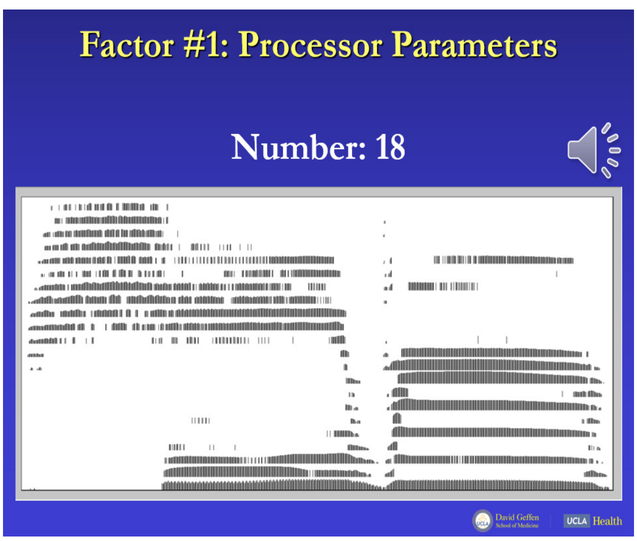

Functional Layouts
Transmission
Acoustic Patterns
Reception
Neural Patterns
Perception
Pattern Matching

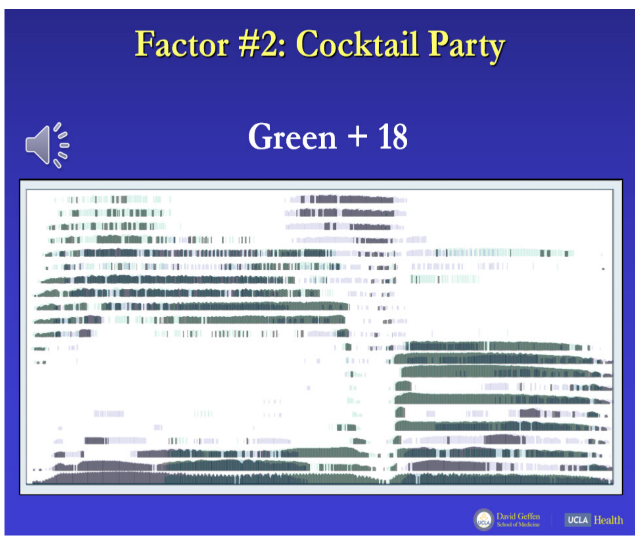

Factors Affecting Sound Transmission
Factor #3: Atypical
Factor #1: Processor
Factor #2: Noise
UCLA Health

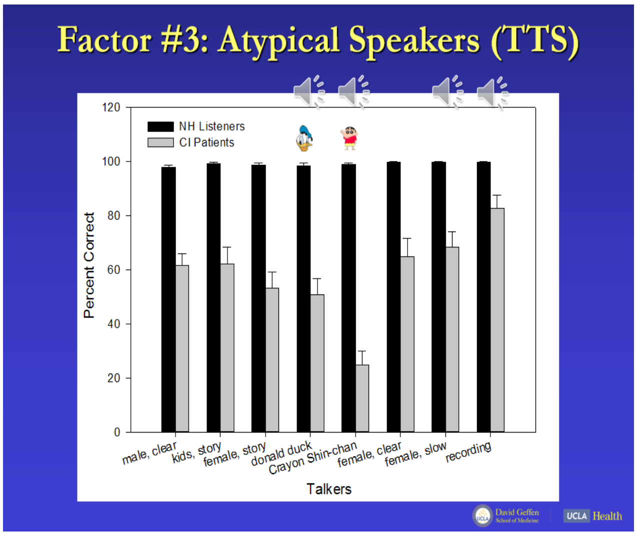

Speech Processing Strategy: ACE
Bandpass filters
Envelope detectors
Amplitude compression
Pulse generation
ch-1
ch-2
ch-N
El-1
El-2
El-N
UCLA Health

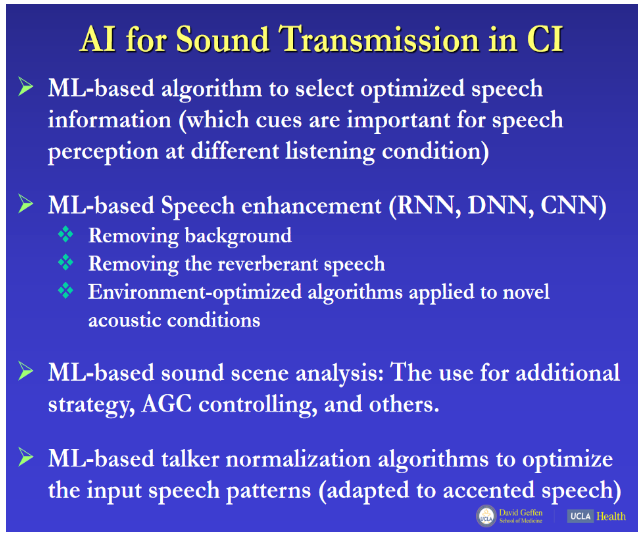

Factor #1: Processor Parameters
Green, Quiet
UCLA Health


Factor #2: Background Noise
Green, quiet
Green, 0 dB
UCLA Health


Factor #1: Processor Parameters
Number: 18
UCLA Health


Factor #2: Cocktail Party
Green + 18
UCLA Health


Factor #3: Atypical Speakers (TTS)
NH Listeners
CI Patients
Percent Correct
male, clear
kids, story
female, story
donald duck
Crayon Shin-chan
female, clear
female, slow
recording
Talkers
David Geffen School of Medicine
UCLA Health


AI for Sound Transmission in CI
ML-based algorithm to select optimized speech information (which cues are important for speech perception at different listening condition)
ML-based Speech enhancement (RNN, DNN, CNN)
Removing background
Removing the reverberant speech
Environment-optimized algorithms applied to novel acoustic conditions
ML-based sound scene analysis: The use for additional strategy, AGC controlling, and others.
ML-based talker normalization algorithms to optimize the input speech patterns (adapted to accented speech)
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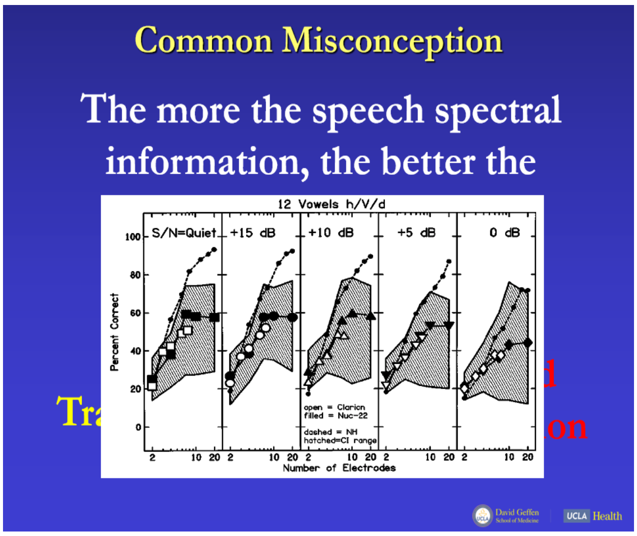
UCLA Health


Common Misconception
The more the speech spectral information, the better the
12 Vowels h/V/d
S/N=Quiet
+15 dB
+10 dB
+5 dB
0 dB
Percent Correct
open = Clarion
filled = Nuc-22
dashed = NH
hatched=CI range
Number of Electrodes
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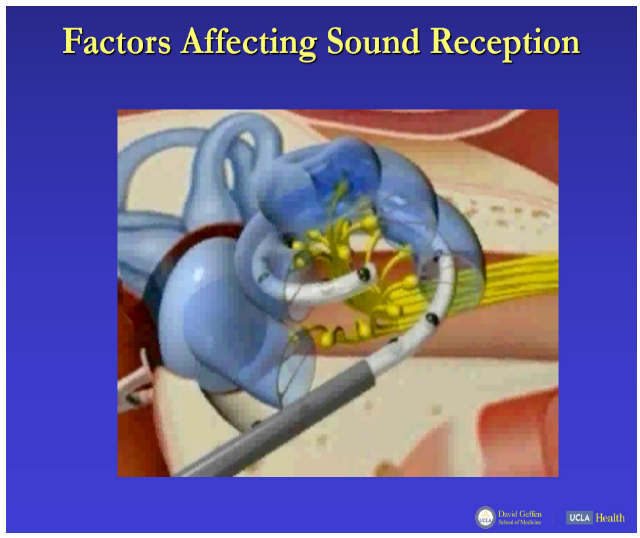
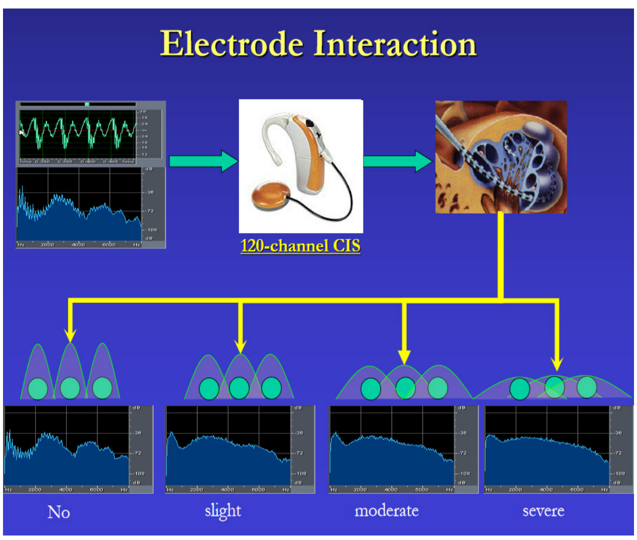
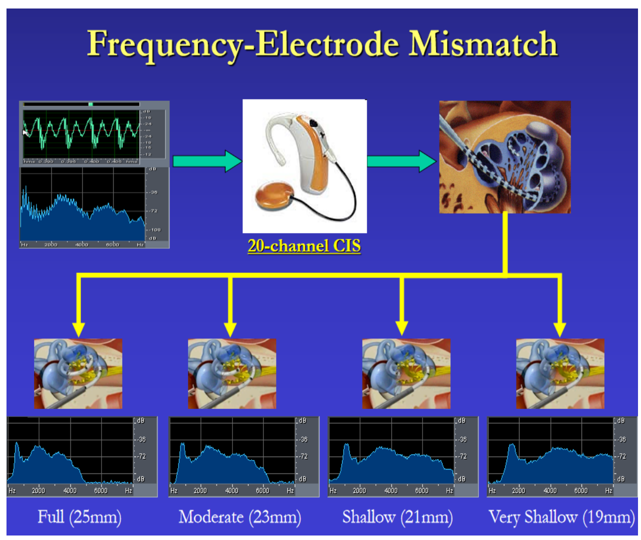
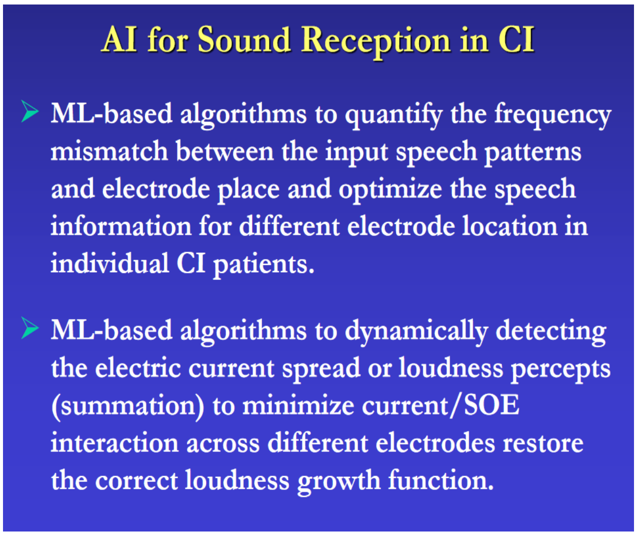
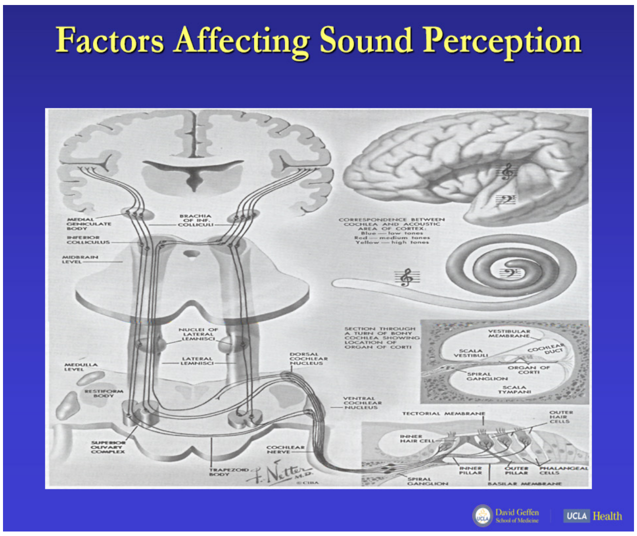

Factors Affecting Sound Reception
David Geffen School of Medicine
UCLA Health


Electrode Interaction
120-channel CIS
No
slight
moderate
severe


Frequency-Electrode Mismatch
20-channel CIS
Full (25mm)
Moderate (23mm)
Shallow (21mm)
Very Shallow (19mm)


AI for Sound Reception in CI
ML-based algorithms to quantify the frequency mismatch between the input speech patterns and electrode place and optimize the speech information for different electrode location in individual CI patients.
ML-based algorithms to dynamically detecting the electric current spread or loudness percepts (summation) to minimize current/SOE interaction across different electrodes restore the correct loudness growth function.


Commonly Forgotten Fact
It's the BRAIN to interpret and understand what is being heard.
Sound Perception
David Geffen School of Medicine
UCLA Health


Factors Affecting Sound Perception
David Geffen School of Medicine
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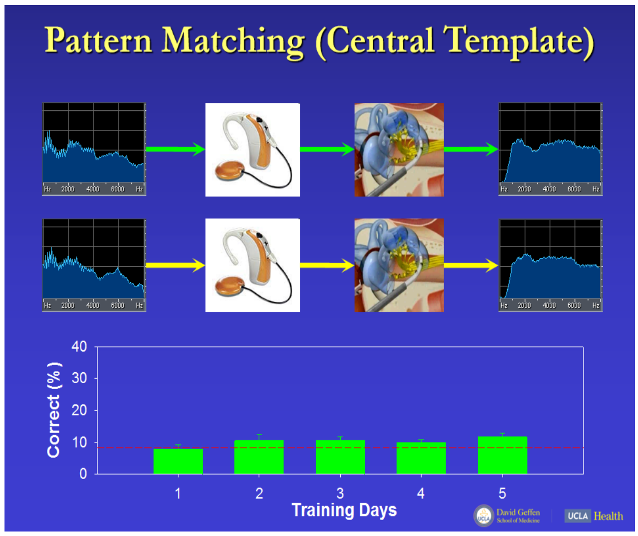
Pattern Matching (Central Template)
Correct (%)
Training Days
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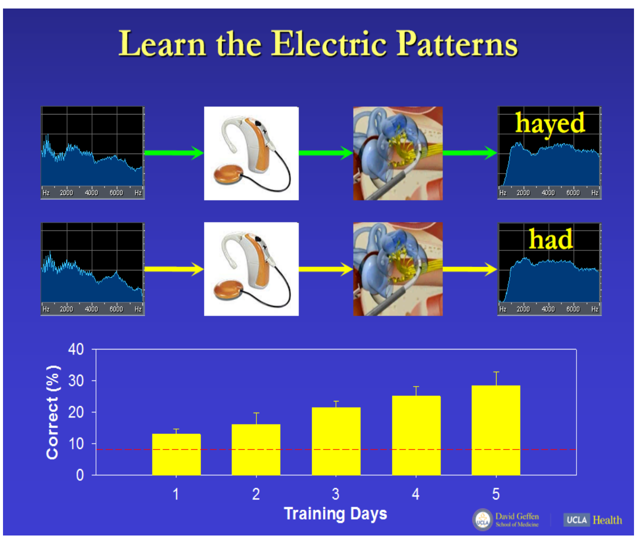
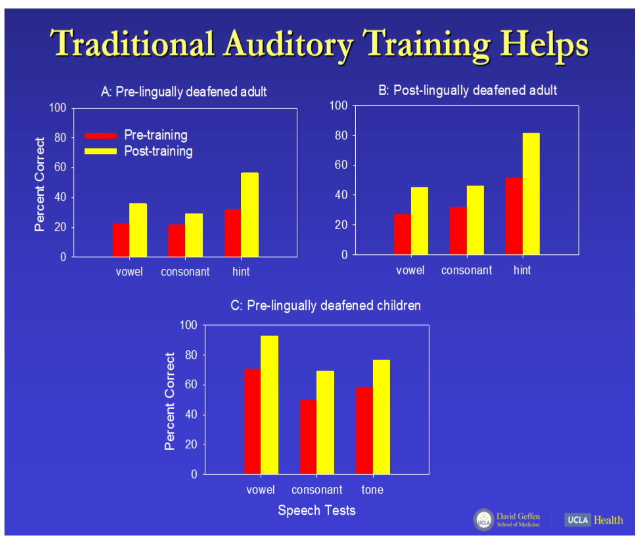
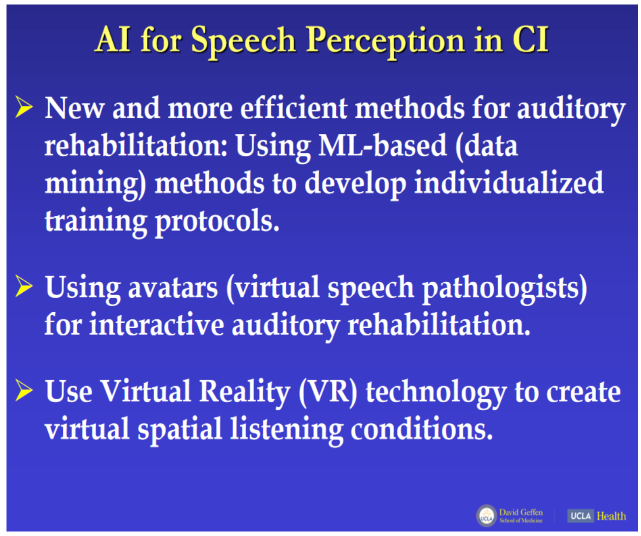
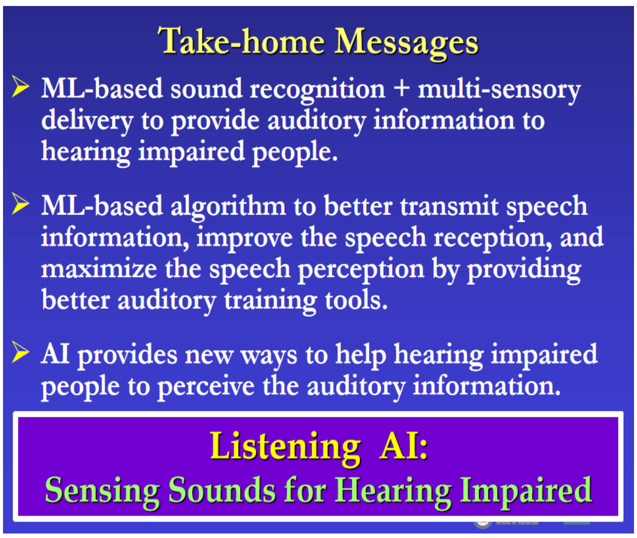
UCLA Health


Learn the Electric Patterns
hayed
had
Correct (%)
Training Days
David Geffen School of Medicine
UCLA Health

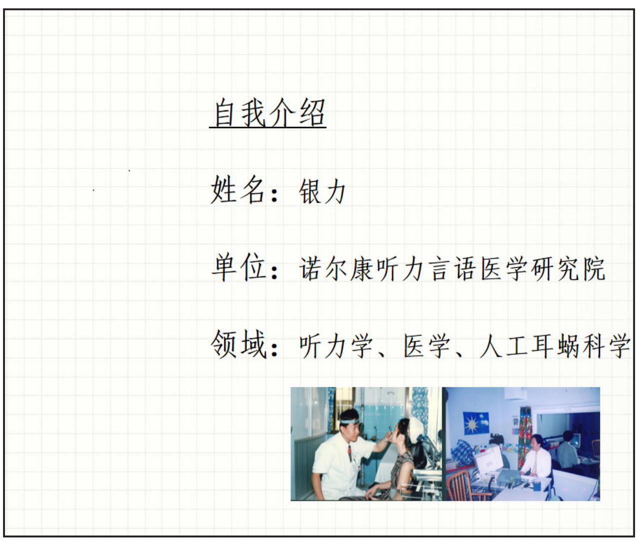

Traditional Auditory Training Helps
A: Pre-lingually deafened adult
B: Post-lingually deafened adult
Pre-training
Post-training
Percent Correct
vowel
consonant
hint
C: Pre-lingually deafened children
tone
Speech Tests
David Geffen School of Medicine
UCLA Health


CAST Technology
请选择下面所示的训练模块:
David Geffen School of Medicine
UCLA Health

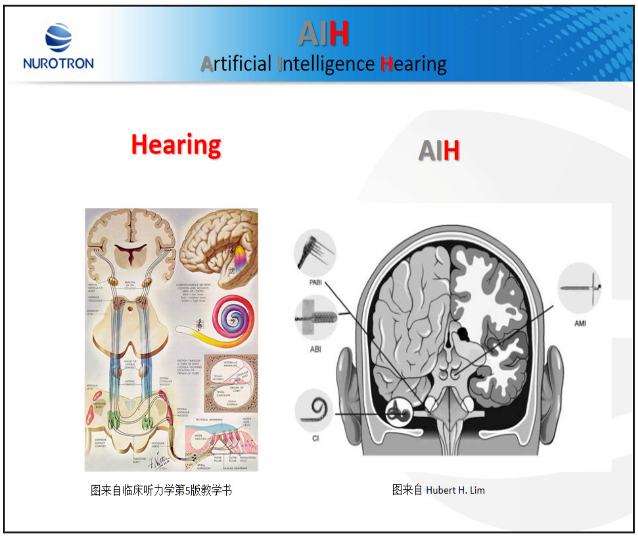

AI for Speech Perception in CI
New and more efficient methods for auditory rehabilitation: Using ML-based (data mining) methods to develop individualized training protocols.
Using avatars (virtual speech pathologists) for interactive auditory rehabilitation.
Use Virtual Reality (VR) technology to create virtual spatial listening conditions.
David Geffen School of Medicine
UCLA Health

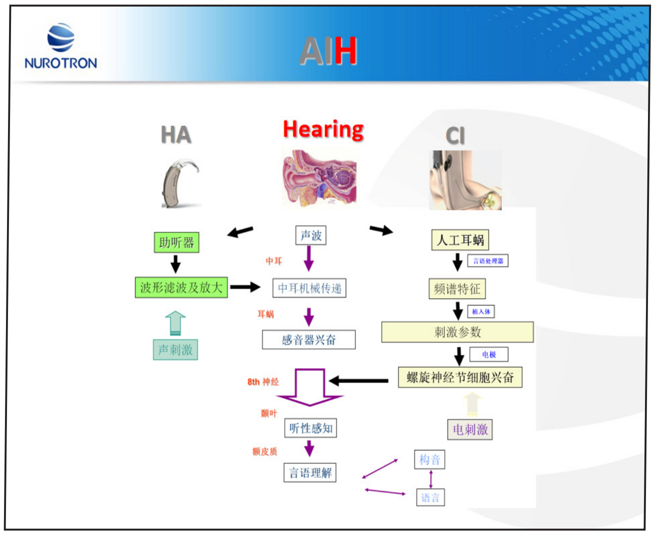

Take-home Messages
ML-based sound recognition + multi-sensory delivery to provide auditory information to hearing impaired people.
ML-based algorithm to better transmit speech information, improve the speech reception, and maximize the speech perception by providing better auditory training tools.
AI provides new ways to help hearing impaired people to perceive the auditory information.
Listening AI:
Sensing Sounds for Hearing Impaired


首届人工智能听力跨界研讨会
First Artificial Intelligent Auditory Crossover Forum
中国·杭州 2019.4.12
聆听，让生活更美好!
Hear more, Live better
NUROTRON
诺尔康


自我介绍
姓名：银力
单位：诺尔康听力言语医学研究院
领域：听力学、医学、人工耳蜗科学


AI和CI之我见
人工（听性假体）听力就是人工智能听力
Namely Artificial (Auditory Prosthesis) Hearing is Artificial Intelligence Hearing


NUROTRON
AIH
Artificial Intelligence Hearing
Hearing
AIH
图来自临床听力学第5版教学书
图来自 Hubert H. Lim


NUROTRON
AIH
HA
Hearing
CI
助听器
波形滤波及放大
声刺激
声波
中耳
中耳机械传递
耳蜗
感音器兴奋
8th 神经
颞叶
听性感知
额皮质
言语理解
人工耳蜗
言语处理器
频谱特征
植入体
刺激参数
电极
螺旋神经节细胞兴奋
电刺激
构音
语言

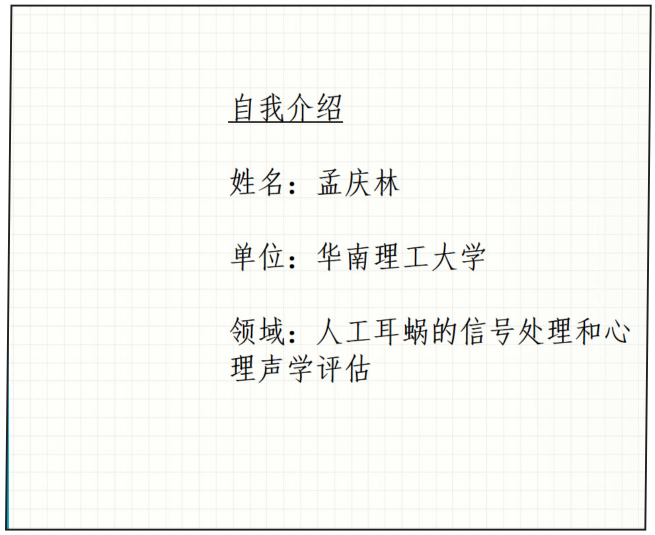

NUROTRON
AIH
Hearing
• 频谱 (频率)变化
– Tonotopic – 位置音调
– 元音识别
• 时域 (时间) 变化
– 检测到振幅瞬态和变化
– 辅音识别
• 动态范围
– 可感知的最轻声与最响的声（疼痛）之间为100 dB (声)
AIH(CI)
• 频谱变化
– 刺激位点
– 需要更多的通道
• 时域变化
– 每个通道上的振幅模式
– 每个通道要有更高的刺激率
• 动态范围
– 最轻的可感知T值与最舒适的C值间典型为 8 dB （电）
6

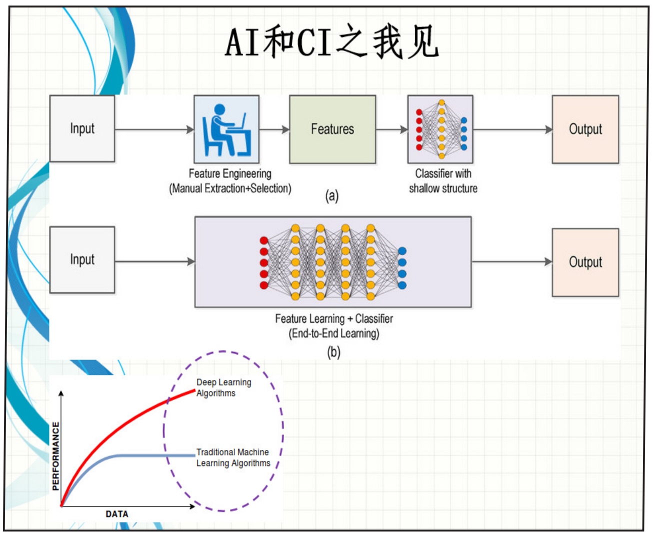

NUROTRON
人工(听性假体)听力就是人工智能听力
Namely Artificial (Auditory Prosthesis) Hearing is Artificial Intelligence Hearing

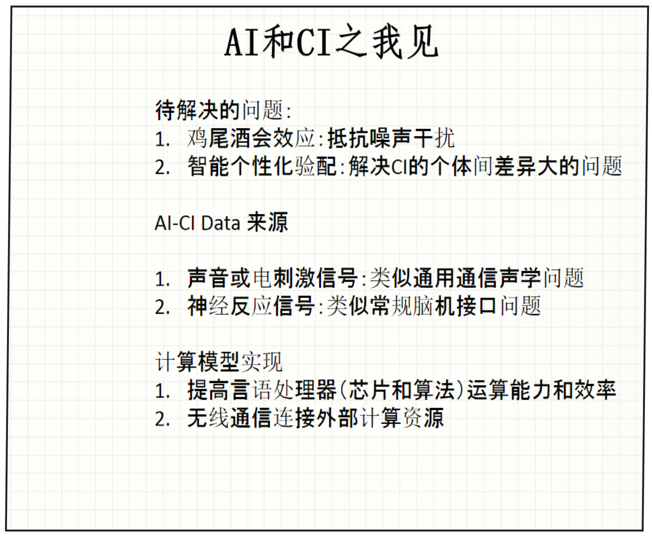

目前在做的课题展示
人工耳蜗评估系统
影响人工耳蜗植入效果的因素权重分析
• 植入者自身因素（听觉剥夺时长……）
• 手术因素
• 康复/调试因素
• 设备因素（包括信号处理等因素）
• 家庭/社会等因素
• 开展术前EABR评估中心
• 开展耳蜗死区研究


苏珍和人工耳蜗植入者们的看法
21:34
[新闻直播间]江西...
小窗
15:54

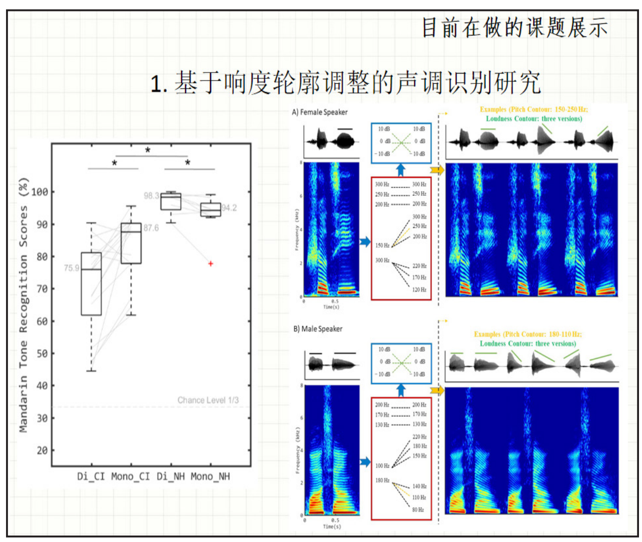

NUROTRON
诺尔康
首届人工智能
听力跨界研讨会
First Artificial Intelligent Auditory
Crossover Forum
中国·杭州 2019.4.12
聆听，让生活更美好！
Hear more, Live better


自我介绍
姓名：孟庆林
单位：华南理工大学
领域：人工耳蜗的信号处理和心理声学评估


AI和CI之我见
Input
Feature Engineering
(Manual Extraction+Selection)
Features
Classifier with
shallow structure
Output
(a)
Input
Feature Learning + Classifier
(End-to-End Learning)
Output
(b)
Deep Learning
Algorithms
Traditional Machine
Learning Algorithms
PERFORMANCE
DATA

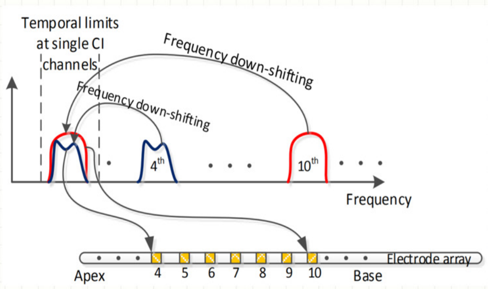

AI和CI之我见
待解决的问题：
1. 鸡尾酒会效应：抵抗噪声干扰
2. 智能个性化验配：解决CI的个体间差异大的问题
AI-CI Data 来源
1. 声音或电刺激信号：类似通用通信声学问题
2. 神经反应信号：类似常规脑机接口问题
计算模型实现
1. 提高言语处理器（芯片和算法）运算能力和效率
2. 无线通信连接外部计算资源


目前在做的课题展示
人工耳蜗中的时域信息增强
Features
Feature Engineering
1. 基于响度轮廓调整的声调识别研究
2. 新型时域精细结构增强算法：单耳和双耳
3. 新型的脉冲式仿真声模型


目前在做的课题展示
1. 基于响度轮廓调整的声调识别研究
Mandarin Tone Recognition Scores (%)
Di_CI Mono_CI Di_NH Mono_NH
Chance Level 1/3
A) Female Speaker
B) Male Speaker

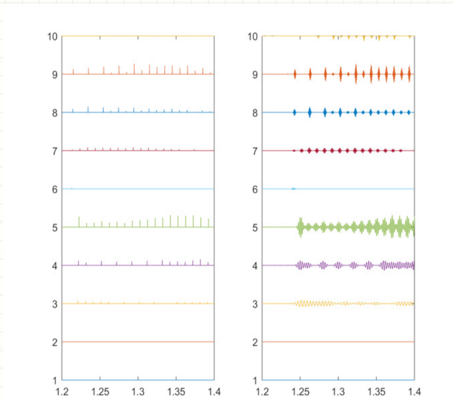
目前在做的课题展示

2.新型时域精细结构增强算法：单耳和双耳



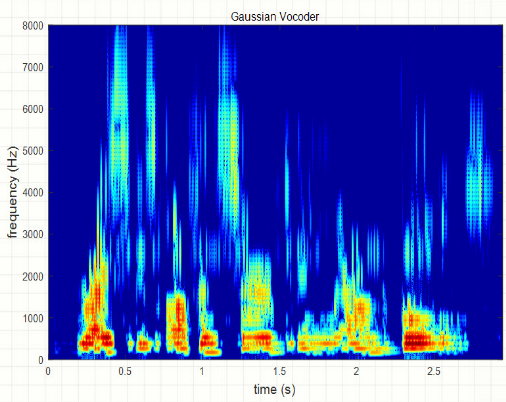
目前在做的课题展示

3.新型的脉冲式仿真声模型



目前在做的课题展示

3.新型的脉冲式仿真声模型



自我介绍

姓名：冯海泓

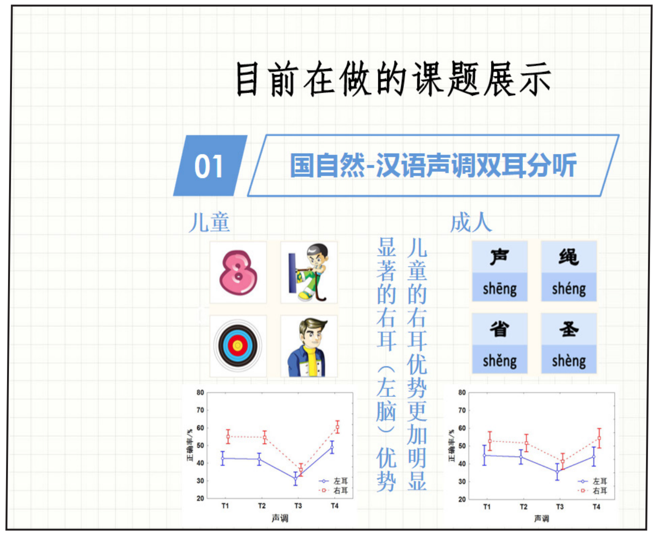
单位：中国科学院声学研究所

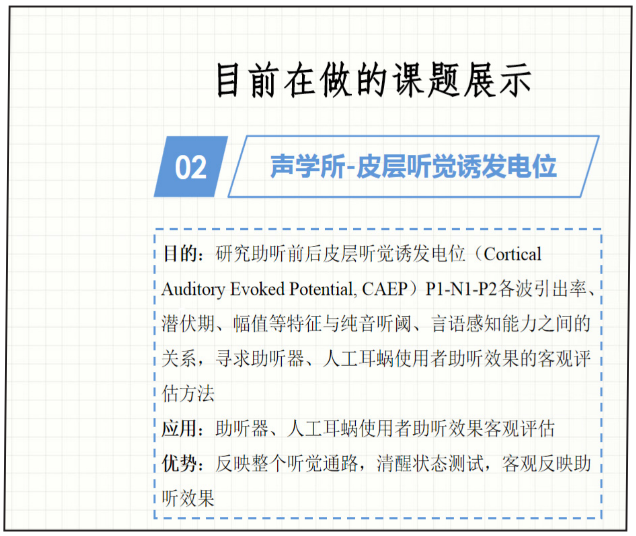
领域：助听器、人工耳蜗、水声工程

AI和CI之我见

语音增强　声源分离　双耳处理


目前在做的课题展示
01
国自然-汉语声调双耳分听
目的：研究汉语声调感知的大脑半球偏侧化及其影响因素，建立不同年龄段汉语声调双耳分听的参考数据，为利用汉语声调双耳分听进行听觉处理障碍(APD)、学习困难(LD)等疾病的临床评估建立参考基准
应用：儿童APD、LD等疾病的临床筛查
优势：双耳分听(Dichotic Listening, DL)是一种常用于大脑半球偏侧化研究的非侵入式行为测试方法


目前在做的课题展示
01
国自然-汉语声调双耳分听
儿童
成人
声 shēng
绳 shéng
省 shěng
圣 shèng
儿童的右耳优势更加明显
显著的右耳（左脑）优势
声调
左耳
右耳


目前在做的课题展示
02
声学所-皮层听觉诱发电位
目的：研究助听前后皮层听觉诱发电位（Cortical Auditory Evoked Potential, CAEP）P1-N1-P2各波引出率、潜伏期、幅值等特征与纯音听阈、言语感知能力之间的关系，寻求助听器、人工耳蜗使用者助听效果的客观评估方法
应用：助听器、人工耳蜗使用者助听效果客观评估
优势：反映整个听觉通路，清醒状态测试，客观反映助听效果


目前在做的课题展示
02
声学所-皮层听觉诱发电位
μV
P2
N1
P1
成人
ms
听力正常老年人（≥60岁）CAEP常模
潜伏期 幅值
P1 53.16±7.54 2.33±1.20
N1 101.43±9.67 -4.91±1.98
P2 197.20±13.50 6.18±2.64


目前在做的课题展示
03
上海市-互联网+听力诊断系统
目的：研发国产临床诊断与科研型听力计，推动听力诊断设备国产化与创新发展
应用：主观听力检测与临床研究
优势：在囊括传统诊断型纯音听力计测听功能的基础上，集成了快速听力筛查、言语测听、远程专家诊疗、大数据统计分析等功能


目前在做的课题展示
03
上海市-互联网+听力诊断系统

目前在做的课题展示

04 言语康复系统

目的：矫正因听力障碍、言语障碍、构音障碍等导致的吐字发音不准确问题

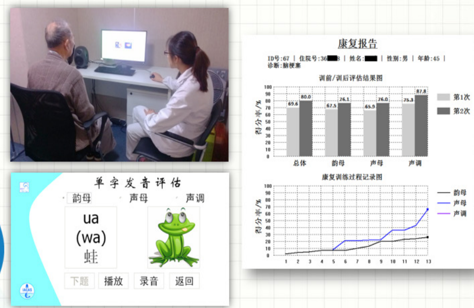
应用：协助康复师对患者进行更加系统、科学、有效的言语康复

优势：采用 “聆听交流强化训练法”，以“评估-训练-矫正-再评估”为主轴流程，以“语音-文字-图像-动画”为多重刺激，提供一套完整、科学的言语康复流程

技术：自动语音识别、语音合成、端点检测、基频提取

目前在做的课题展示

04 言语康复系统



目前在做的课题展示

05 双麦克风语音增强

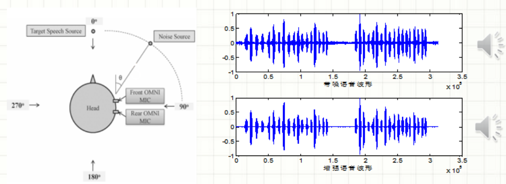
背景：人工耳蜗、助听器等听力辅助设备佩戴者对噪声容忍程度比正常人更低，所以尽可能降低无关语音的干扰对于听力患者来说显得很重要

算法：将一个带有背景噪声和方向性干扰语音的混合语音信号，经过改进算法的处理，滤除了背景噪声和侧边的干扰噪声，得到滤除后的纯净语音，效果很好

详见：方义, 冯海泓, 陈友元. 一种抑制方向性噪声的双耳语音增强算法[J]. 声学学报, 2016(6): 897-904.

目前在做的课题展示

05 双麦克风语音增强



助听器两mic下的语音增强效果
（目标语音位于0度，干扰噪声位于90度）

目前在做的课题展示

06 基于麦克风阵列的声源分离

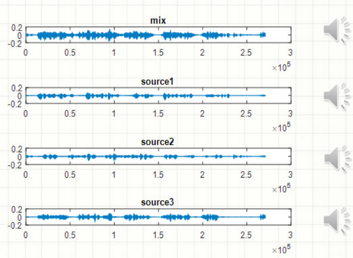
背景：在助听器、人工耳蜗、免提通讯设备等应用中，常常希望在复杂的声学环境条件下，从多种线性混合声中提取出干净的声源信号

算法：我们通过一些机器学习技术进行盲源分离，得到了很好的效果

详见：方义. 双耳语音增强算法研究[D]. 北京: 中国科学院声学研究所, 2018.

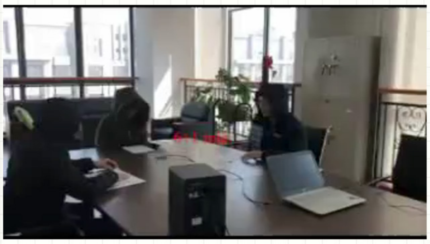
目前在做的课题展示

06 基于麦克风阵列的声源分离



目前在做的课题展示

06 基于麦克风阵列的声源分离



目前在做的课题展示

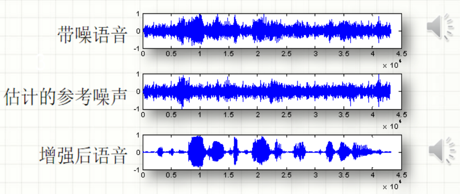
07 基于深度神经网络的语音信号处理

算法： 利用深度神经网络DNN估计Time-frequency mask，用于获取参考噪声（包括背景噪声和点源），从而提高传统自适应波束形成算法的鲁棒性，有效抑制噪声的同时使得目标语音不失真

详见： 方义, 冯海泓, 陈友元. 基于深度神经网络的双耳语音增强算法[C].中国声学学会全国声学学术会议. 2017.

目前在做的课题展示

07 基于深度神经网络的语音信号处理



<u>自我介绍</u>

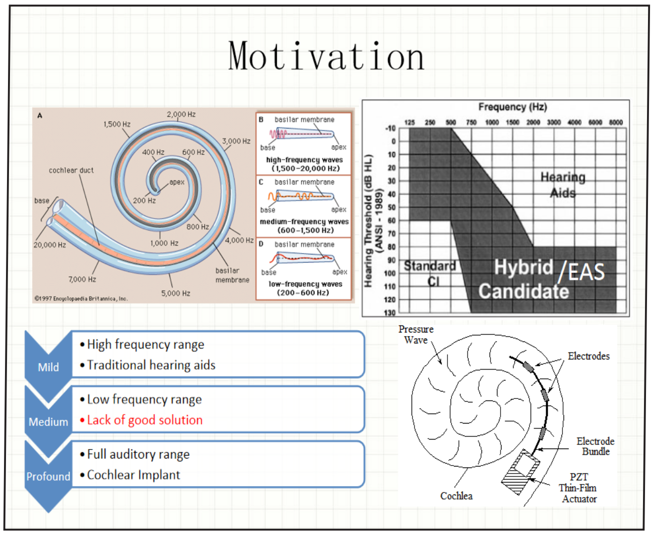
姓名：罗川

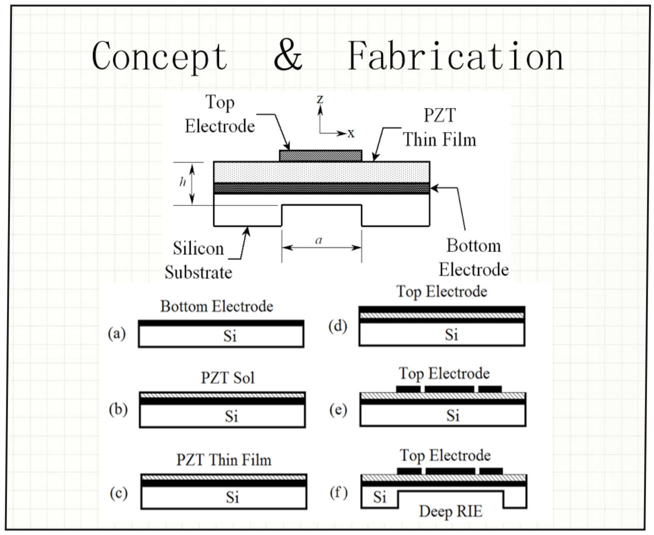
单位：清华大学精密仪器系

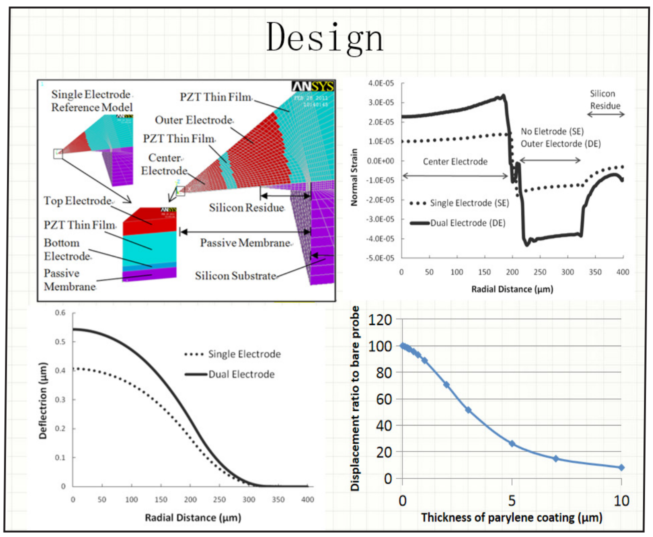
领域：MEMS声电混合刺激器

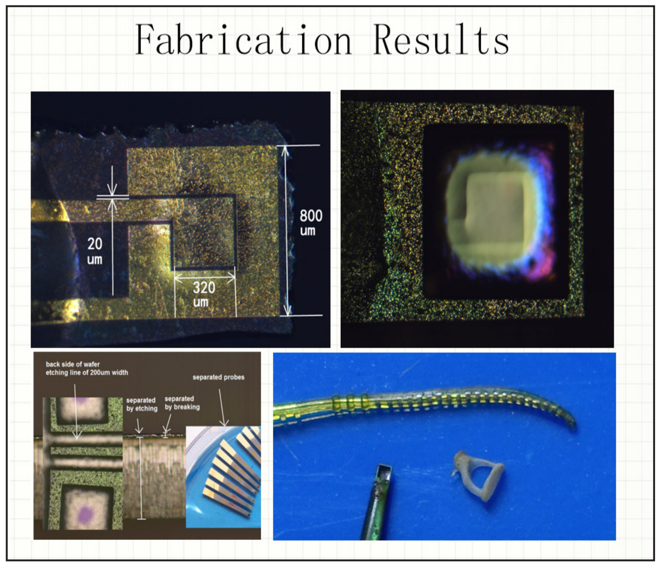
AI和CI之我见

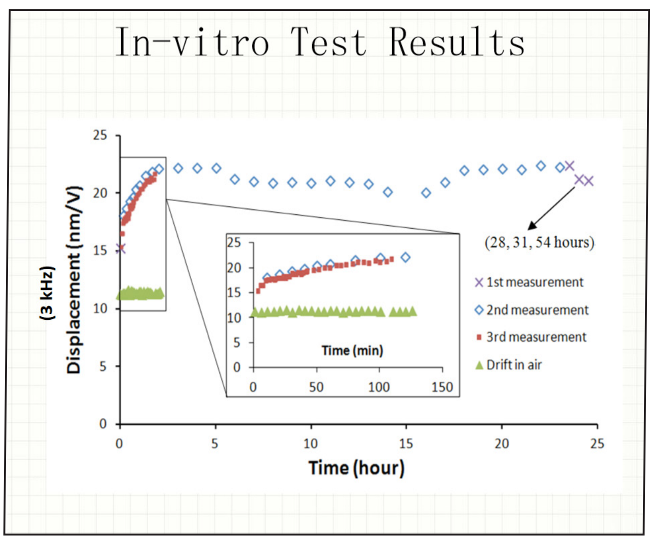
- 智能验配和参数调节
- 智能场景识别和目标增强
- 存算一体芯片、可重构芯片在信号处理和编码中的应用

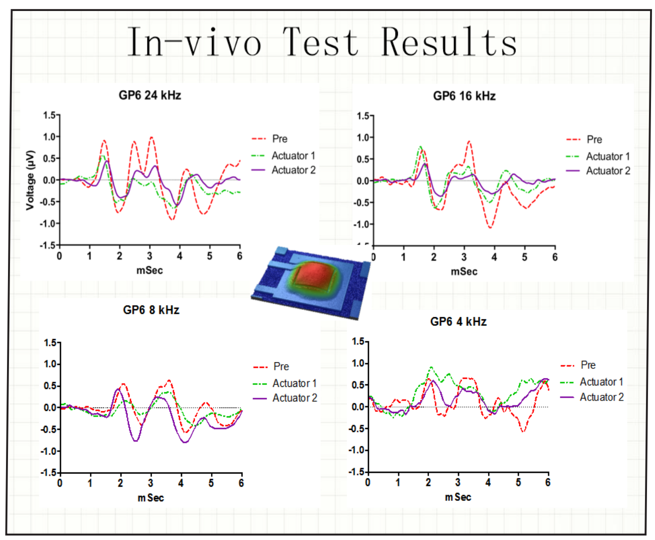

Motivation
Frequency (Hz)
Hearing Threshold (dB HL) (ANSI - 1989)
Hearing Aids
Standard CI
Hybrid /EAS Candidate
Mild
• High frequency range
• Traditional hearing aids
Medium
• Low frequency range
• Lack of good solution
Profound
• Full auditory range
• Cochlear Implant
Pressure Wave
Electrodes
Electrode Bundle
PZT Thin-Film Actuator
Cochlea


Concept & Fabrication
Top Electrode
PZT Thin Film
Silicon Substrate
Bottom Electrode
Bottom Electrode
(a) Si
(b) PZT Sol Si
(c) PZT Thin Film Si
Top Electrode
(d) Si
(e) Top Electrode Si
(f) Top Electrode Si Deep RIE

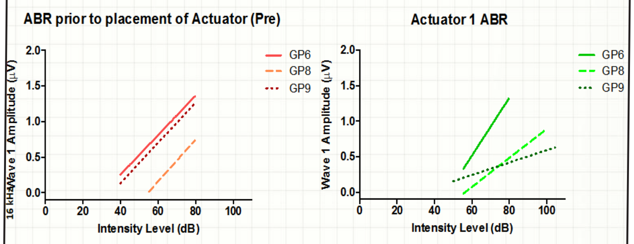

Design
Single Electrode Reference Model
PZT Thin Film
Outer Electrode
Center Electrode
Top Electrode
Silicon Residue
Bottom Electrode
Passive Membrane
Silicon Substrate
Normal Strain
No Eletrode (SE)
Outer Electrode (DE)
Center Electrode
Single Electrode (SE)
Dual Electrode (DE)
Radial Distance (μm)
Deflection (μm)
Single Electrode
Dual Electrode
Displacement ratio to bare probe
Thickness of parylene coating (μm)


Fabrication Results
800 um
20 um
320 um
back side of wafer etching line of 200um width
separated probes
separated by etching
separated by breaking


In-vitro Test Results
Displacement (nm/V) (3 kHz)
Time (hour)
Time (min)
(28, 31, 54 hours)
1st measurement
2nd measurement
3rd measurement
Drift in air


In-vivo Test Results
GP6 24 kHz
GP6 16 kHz
GP6 8 kHz
GP6 4 kHz
Voltage (μV)
mSec
Pre
Actuator 1
Actuator 2

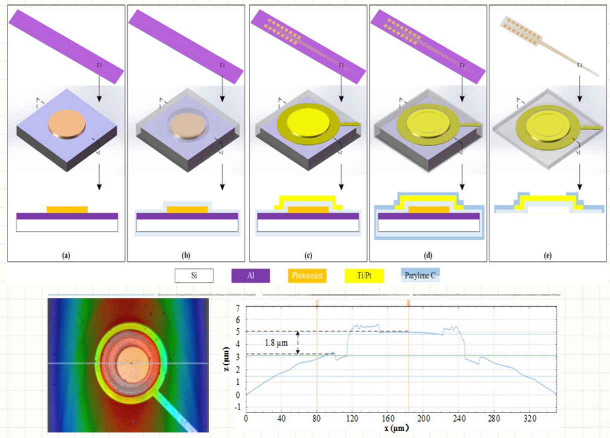
In-vivo Test Results



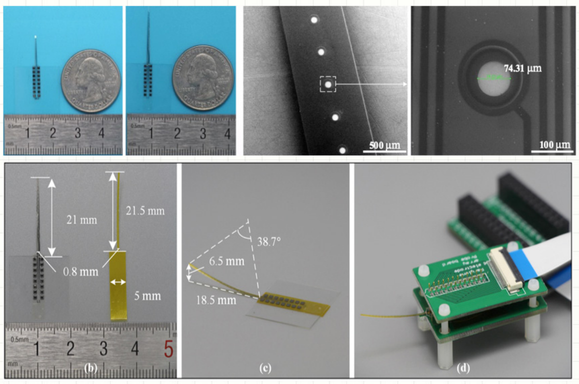
Does Actuator gain predict growth function?
Individual Animal
Actuator placement- depth, compression

	Gain (nm/V) air
GP6	82.5
GP8	30.3
GP9	35.2

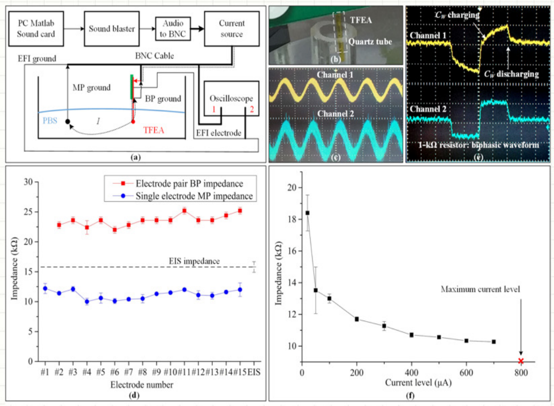
Thin-film Electrode Array



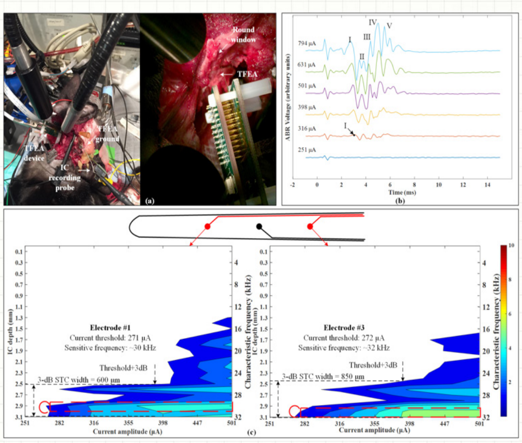
Thin-film Electrode Array



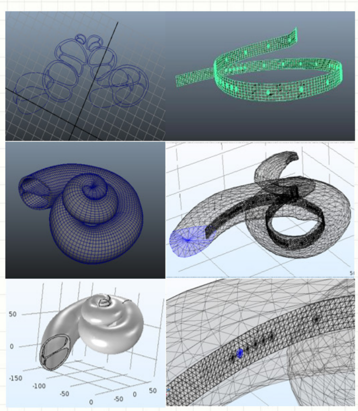
TFEA In-vitro Test



TFEA In-vivo Test



FEM of Cochlear



Future Work

- Integrated hybrid stimulator
- Micro-robotic stimulator
- Hybrid EAS experiment system
- TFEA reliability study

自我介绍

姓名：田岚 （教授 博导）

单位：山东大学 微电子学院

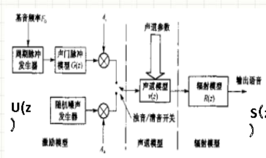
领域：智能助听技术
信号与信息处理
生物传感与智能检测

AI和CI之我见

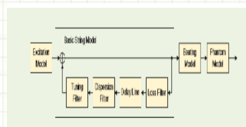
- AI在**信号降噪、特征提取、编码策略**的处理算法对CI装置使用效果起重要作用
- AI**算法硬件实现和加速芯片**在CI装置满足**系统微型化、低功耗、低延时方面起重要作用。**
- AI技术可用于**CI植入者的言语培训**

目前在做的课题展示

声音产生模型&听觉感知理论研究

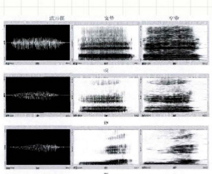


语音信号产生数学模型图

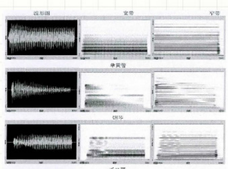


音乐信号产生模型图

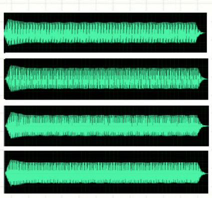
"源-系统"声音产生模型：$S(z)=H(z)\,U(z)$



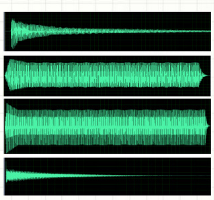
不同字对应的波形图和频谱图



三种不同乐器发同一音符对应的波形图和频谱图

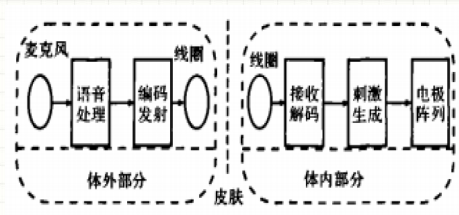


小提琴C4、D4、E4及F4音符的时域波形图



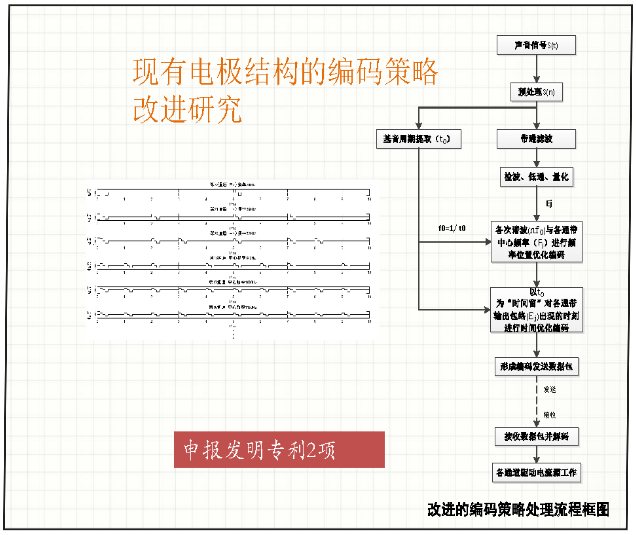
钢琴、小提琴、单簧管及钟琴C4音符的时域波形图

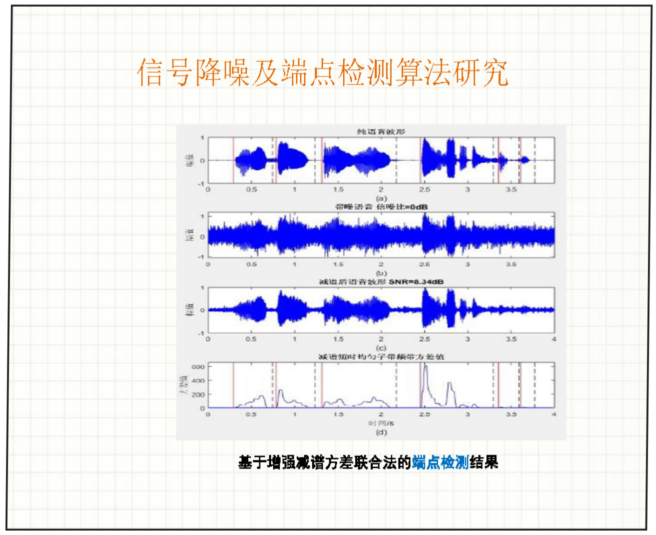
人工耳蜗（CI）---重建听觉的OTC装置

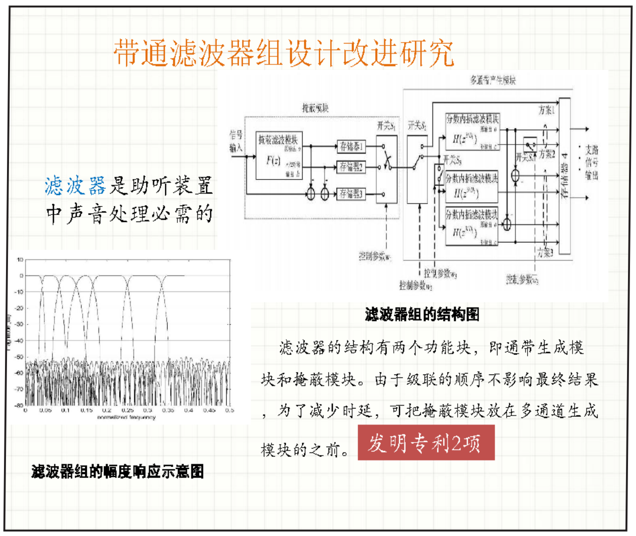


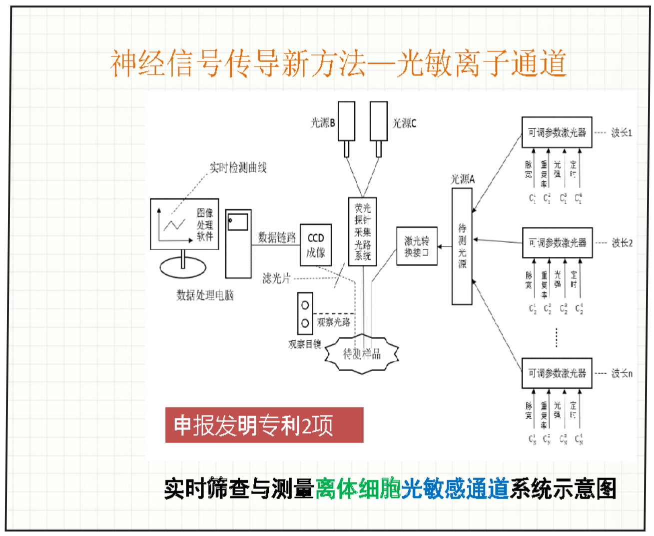
人工耳蜗系统框图

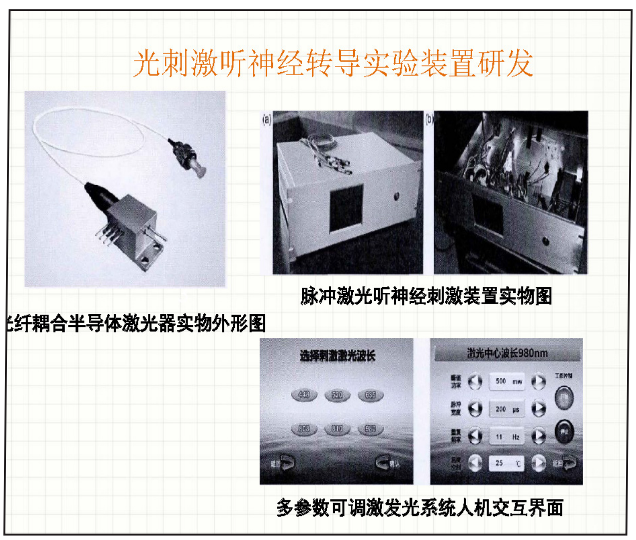
- ***人工耳蜗的核心部件：声音处理器（体外）和电极阵列（体内），两部分需协同工作才能带来良好的听觉效果。***
- 体内部分：接收/解码、刺激信号生成、传感电极阵列
- 体外部分：麦克风、语音处理器、编码发射

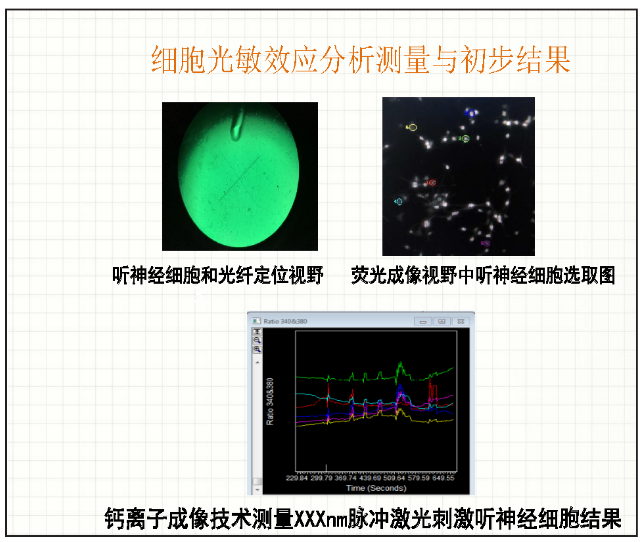

现有电极结构的编码策略
改进研究
申报发明专利2项
改进的编码策略处理流程框图

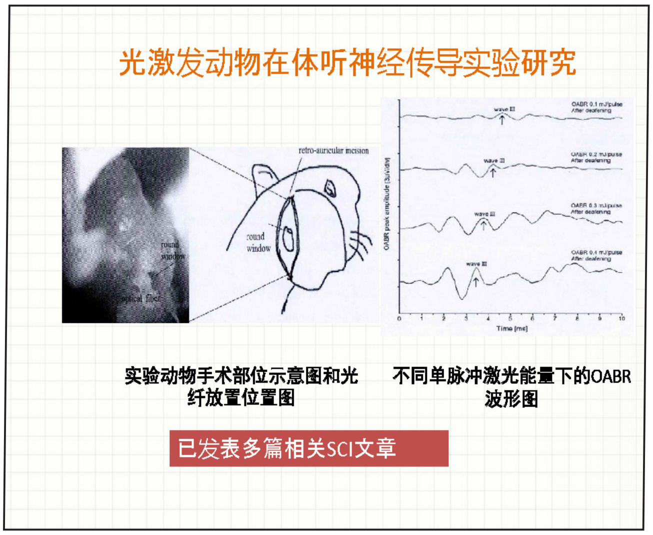

信号降噪及端点检测算法研究
基于增强减谱方差联合法的端点检测结果

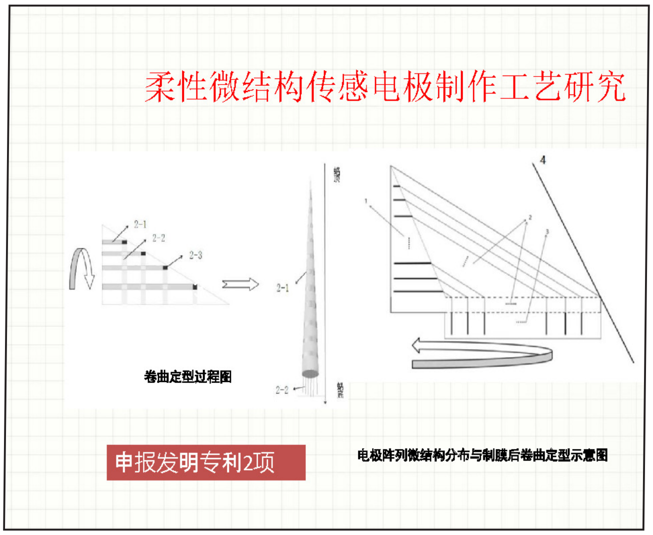

带通滤波器组设计改进研究
滤波器是助听装置
中声音处理必需的
滤波器组的结构图
滤波器的结构有两个功能块，即通带生成模
块和掩蔽模块。由于级联的顺序不影响最终结果
，为了减少时延，可把掩蔽模块放在多通道生成
模块的之前。
发明专利2项
滤波器组的幅度响应示意图

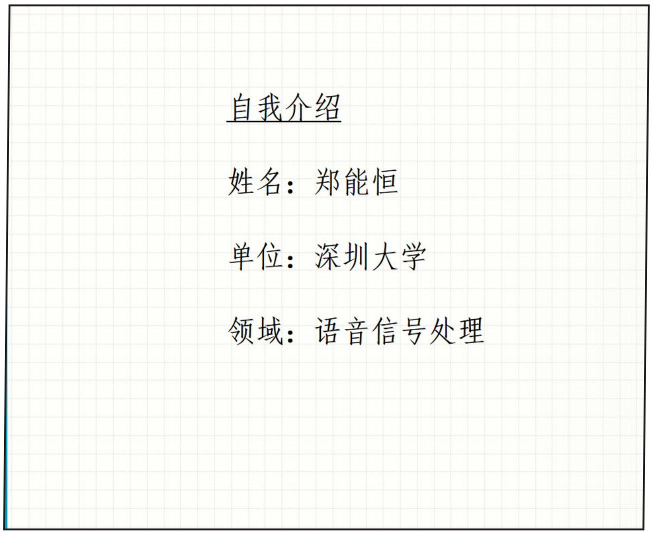

神经信号传导新方法—光敏离子通道
申报发明专利2项
实时筛查与测量离体细胞光敏感通道系统示意图

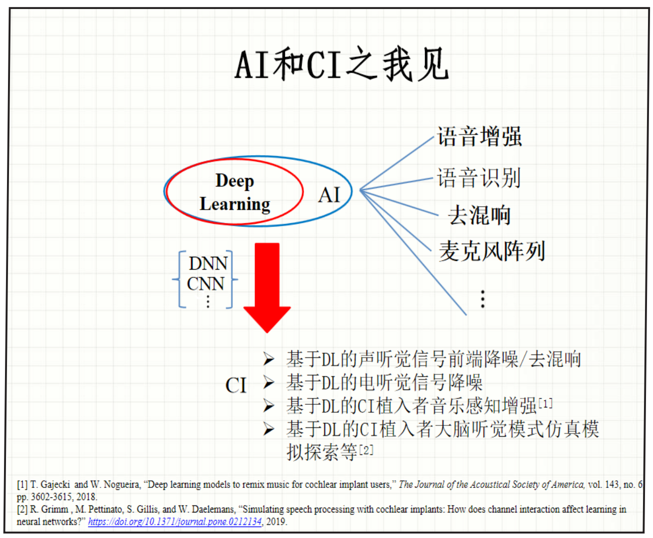

光刺激听神经转导实验装置研发
脉冲激光听神经刺激装置实物图
纤耦合半导体激光器实物外形图
多参数可调激发光系统人机交互界面


细胞光敏效应分析测量与初步结果
听神经细胞和光纤定位视野
荧光成像视野中听神经细胞选取图
钙离子成像技术测量XXXnm脉冲激光刺激听神经细胞结果









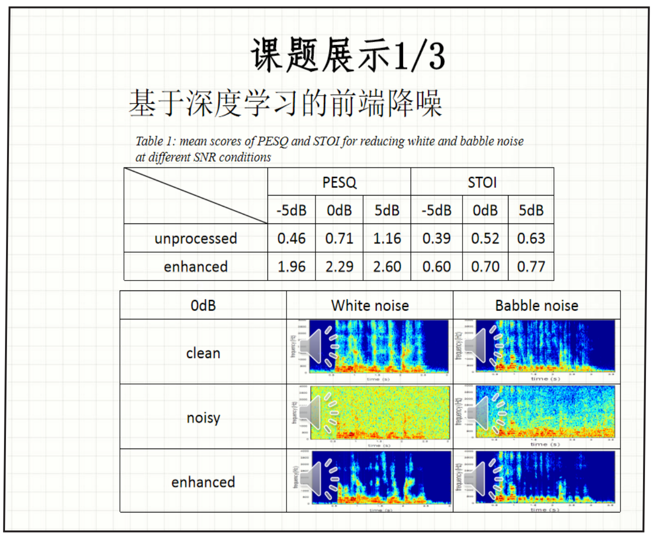


Table 1: mean scores of PESQ and STOI for reducing white and babble noise at different SNR conditions

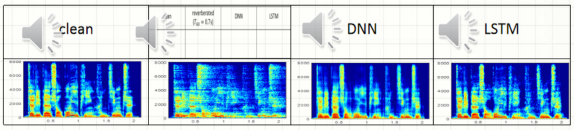
	PESQ			STOI		
	-5dB	0dB	5dB	-5dB	0dB	5dB
unprocessed	0.46	0.71	1.16	0.39	0.52	0.63
enhanced	1.96	2.29	2.60	0.60	0.70	0.77

课题展示2/3

基于深度学习的前端去混响

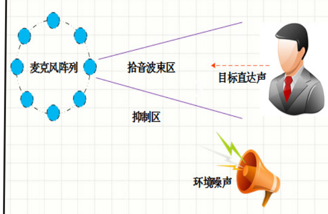
Table 2: mean scores of PESQ, STOI and segSNR for dereverberation at different five reverberation time ($T_{60}(s)$ = 0.3,0.5,0.6,0.7,0.9)

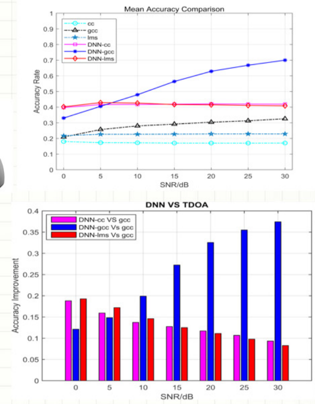
	reverberated	DNN	LSTM
PESQ	2.01	2.58	2.79
STOI	0.81	0.89	0.92
segSNR	-0.61	2.67	6.84



课题展示3/3

基于深度学习的声源定位





自我介绍

姓名：侯丽敏

单位：上海大学通信与信息工程学院

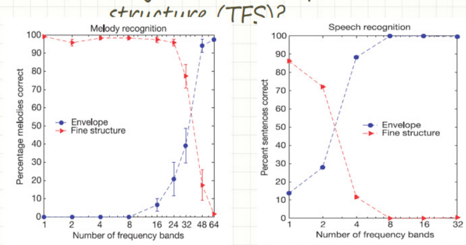
领域：语音、鼾声等音频信号处理与识别

近年来与美国高校与国内医院联合研究

【1】Hou Limin, Xu Li,.Role of short-time acoustic temporal fine structure cues in sentence recognition for normal-hearing listeners.The Journal of the Acoustical Society of America. 2018, 143(2), EL127.
【2】Li, Bei;Wang, Hui;Yang, Guang,Hou LImin.The Importance of Acoustic Temporal Fine Structure Cues in Different Spectral Regions for Mandarin Sentence Recognition.EAR AND HEARING.2016,37(1).e52-e56.
【3】Li, Bei;Hou, Limin;Xu, Li,.Effects of steep high-frequency hearing loss on speech recognition using temporal fine structure in low-frequency region.HEARING RESEARCH.2015,326,66-74.

人工耳蜗的语音信号处理

Why did we choice this Subject about temporal fine structure (TFS)?



Zachary M. Smith, et al, Chimaeric sounds reveal dichotomies in auditory perception, Nature, 416(7), 2002

Method

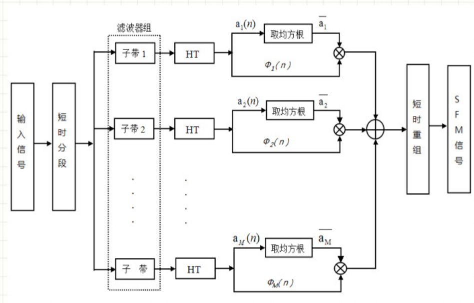
Speech signal through Hilbert Transform, then

$$S(n) = \sum_{i=1}^{M} a_i(n)\cos(\theta_i(n))$$

TFS is extracted by

$$\mathrm{TFS} = \sum_{i=1}^{M} \sqrt{\overline{a_i(n)^2}}\cos(\theta_i(n))$$

Our Methods

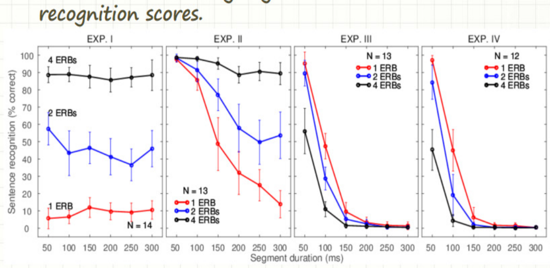


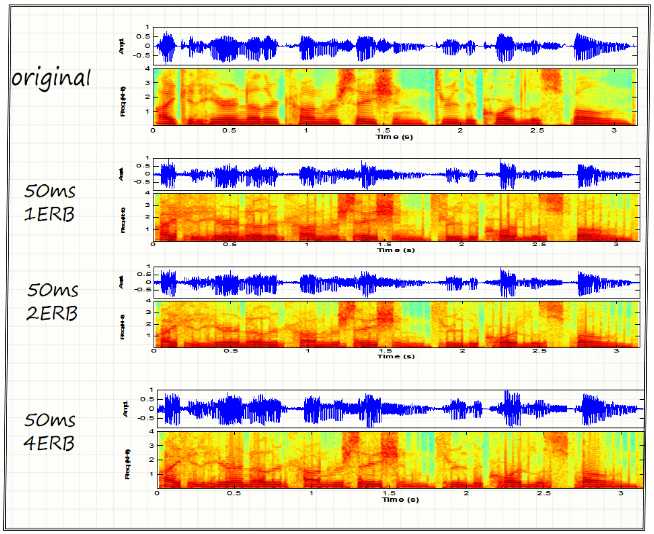
Materials and Subjects

- The speech materials were taken from the AzBio speech that consisted of 33 lists with 20 English sentences in each list. All speech sentences were sampled at 22050 Hz.
- There were 15 native English-speaking, normal-hearing adults aged from 18 to 28 years old participated in the experiments.

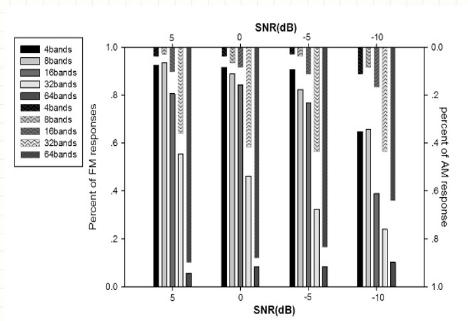
Results

A total of 72 processed sentences were used for training and a total of 360 processed sentences were used for the test. The sentences used in test were different from those used in training. Figures below show the sentence recognition scores.





Tone Recognition Results



Outlook and Prospect

- STFS includes the fine structure of speech and may ben
  for understanding tone languages, tone recognition, spe
  in noise,
  and music perception.
- These results might have important implications for spe
  processing strategies in cochlear implants.

自我介绍

姓名：张艳平　副主任

单位：华中科技大学医院

领域：临床实验室、听觉研究

姓名：龙长才 教授 博导

单位：华中科技大学 物理学院

领域：听觉机制、听力康复

AI和CI之我见

人工耳蜗中能够应用哪些人工智能技术

1、CI信号处理中的声环境辨识与适应

2、CI与智能手机信息链接与传递

目前在做的课题展示

1、国家自然科学基金项目

基于听神经发放时序特征
的电子耳蜗编码策略研究

目前在做的课题展示

2、国家自然科学基金项目

基于听觉的抗噪声语音信号处理

3、国家自然科学基金项目

运用噪声的高灵敏传感理论与技术

目前在做的课题展示

4、国家自然科学基金 《视听信息认知计算》重大研究计划项目

耳蜗信号处理新特征与机理

5、国家自然科学基金项目

耳蜗音调信息表达的激光干涉研究

目前在做的课题展示

20多篇SCI论文（包括顶级国际期刊）

5项目发明专利（包括顶级国际期刊）

全国青年学术会议优秀论文特等奖

清华大学优秀博士论文一等奖

自我介绍

姓名：赵航

单位：华东师范大学

领域：听力学临床研究

1. 听障儿童术后康复（双模式助听）
2. 中枢听处理障碍
3. 孤独症儿童听觉超敏问题
4. 隐性听力损失

NUROTRON

问题提出

实际配戴情况：

- 2009年“启聪行动”人工耳蜗项目统计结果显示：
  - 术后双模式配戴率仅29.63%

> 八、开机和调试
>
> 通常术后 1–4 周开机，一般开机后的第 1 个月内调机 1–2 次，之后根据患者情况安排时间，待听力稳定后适当延长调试间隔，最终 1 年调机 1 次。开机和调试方法及步骤可按照各产品的技术要求执行。**如果对侧耳可从助听器获益，建议尽早验配助听器。（2013年版人工耳蜗植入工作指南新加入内容）**

- 2017年，上海市聋康听障儿童双模式配戴率：56%
  - 排除掉双侧人工耳蜗和双侧助听器的孩子
  - 上海市残联免费配发助听器

NUROTRON

问题提出

家长顾虑：

1. 耳蜗听得很好，为什么还要戴助听器？

实证回应一：双模式优势有哪些？

2. 助听器和人工耳蜗是否会相互影响？

实证回应二：电声刺激是否相互拮抗？

3. 残余听力不多，戴上也没用。

实证回应三：多少残余听力能获益于双模式？

4. 孩子不喜欢戴助听器（比如老是扯下来）

实证回应四：患者不接受双模式的原因分析及建议

NUROTRON

一、双模式优势有哪些？

理论上讲，双耳双模式相对于单侧人工耳蜗的优势如下：

- **预防听觉剥夺 ①**
- 双耳聆听优势
  - **双耳声源定位 ②**
  - 双耳静噪效应 } 噪声下言语识别 ③
  - 双耳总和效应
- 声电联合优势
  - 频域：中高频（CI）+低频（HA） } 调的识别（声调、语调、乐调）④
  - 时域：包络（CI）+精细结构（HA）

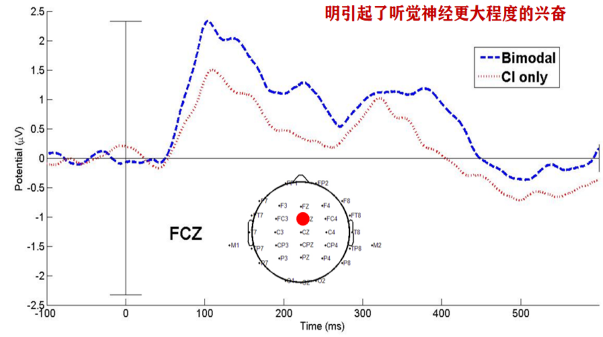
NUROTRON

一、双模式优势有哪些？

1.预防听觉剥夺

- 双模式助听CAEP的P1幅度更大，说明引起了听觉神经更大程度的兴奋

P1*



赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.

NUROTRON

一、双模式优势有哪些？

2. 声源定位能力

- 双模式助听ILD和ITD的缺失，使得声源定位非常困难
- 部分双模式助听患者声源定位能力有所提高（主要对象为成人受试者）
- 调试时越接近双耳响度平衡（loudness balance），声源定位能力越好
- 尝试采用双耳强度差增强（ILD enhancement）、头影效应增强（head shadow enhancement）等算法提高双模式定位能力

- Dieudonné B, Francart T. Head shadow enhancement with low-frequency beamforming improves sound localization and speech perception for simulated bimodal listeners.[J]. Hearing Research, 2018.
- Francart T, Lenssen A, Wouters J. Enhancement of interaural level differences improves sound localization in bimodal hearing[J]. Journal of the Acoustical Society of America, 2011.
- Litovsky R Y, Johnstone P M, Godar S P. Benefits of bilateral cochlear implants and/or hearing aids in children[J]. International Journal of Audiology, 2006.
- Ching T Y C, Wanrooy E V, Hill M, et al. Binaural redundancy and inter-aural time difference cues for patients wearing a cochlear implant and a hearing aid in opposite ears[J]. International Journal of Audiology, 2005.
- Seeber B U, Baumann U, Fastl H. Localization ability with bimodal hearing aids and bilateral cochlear implants.[J]. Journal of the Acoustical Society of America, 2004.
- Tyler R S, Parkinson A J, Wilson B S, et al. Patients utilizing a hearing aid and a cochlear implant: speech perception and localization[J]. Ear & Hearing, 2002.

NUROTRON

一、双模式优势有哪些？

2. 声源定位能力

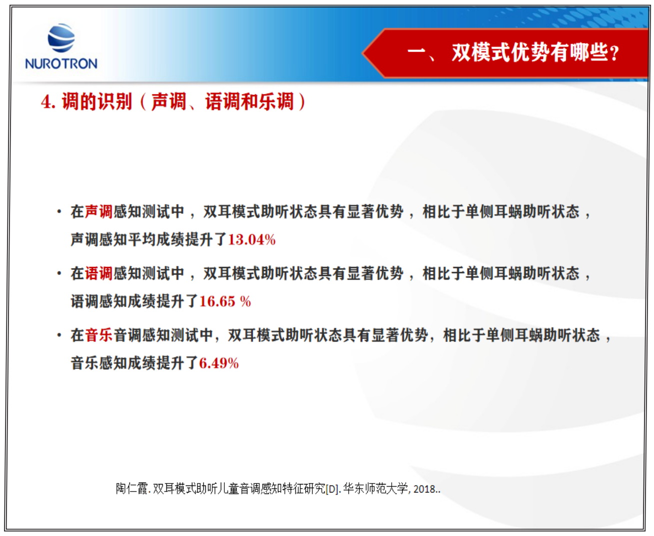
组别	无分辨能力	有分辨能力	合计
单侧人工耳蜗	15（100%）	0（0.00%）	15
双耳双模式	26（74.29%）	9（25.71%）	35

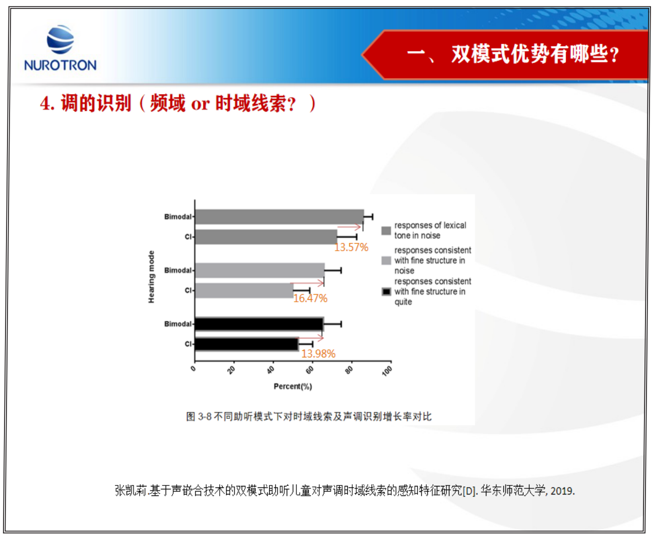
* p=0.025

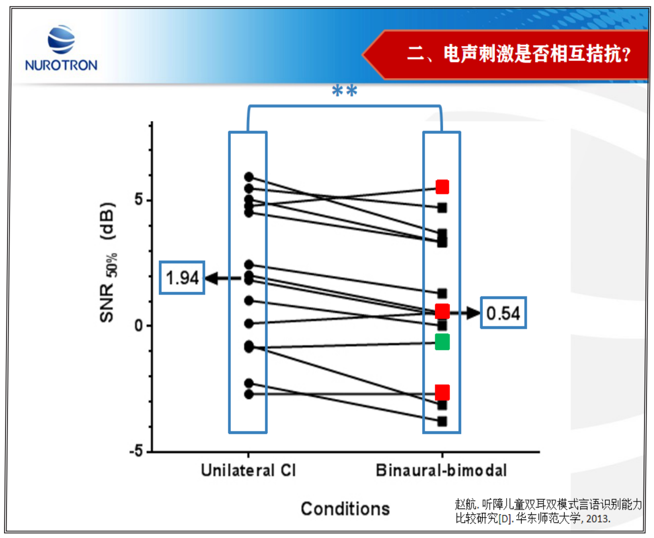
- 有25%的4–7岁儿童受试者通过双模式助听获得分辨左右声源的能力
- 其声源定位能力与助听器补偿水平及术前双耳配戴助听器时间有关
- 人工耳蜗麦克风的位置对于双侧耳蜗植入儿童定位能力影响巨大
  - 最佳位置：耳廓后（存在耳钩设计、重量及导线等问题）
  - AB公司最新处理器在头件上增加了麦克风，也是一个解决方案

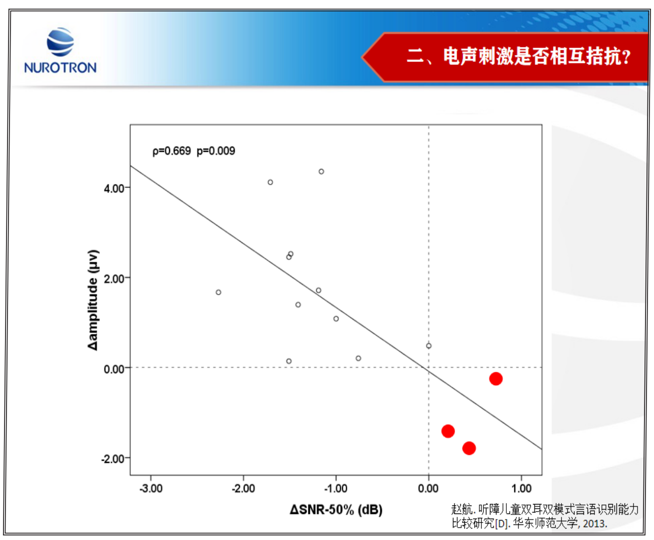
陶仁霞,李进,刘巧云,赵航.4~7岁双耳双模式助听儿童声源定位能力研究[J].听力学及言语疾病杂志,2018:1-3


NUROTRON
一、双模式优势有哪些？
3. 噪声下言语识别
封闭项测试结果
助听模式 样本量 中位数
Bimodal 39 0.43
CI 39 2.03
ΔSNR50% 39 1.60
** p=0.000
开放项测试结果
助听模式 样本量 中位数
Bimodal 18 8.38
CI 18 10.87
ΔSNR50% 18 2.49
** p=0.000
• 在封闭项测试中，共计有72%的受试者体现出了双模式优势，其中受益最大的受试者提高了5.8dB的信噪比，中位数提高了1.6dB的信噪比
• 在开放项测试中，共计有78%的受试者体现出了双模式优势，其中受益最大的受试者提高了6dB的信噪比，中位数提高了2.49dB的信噪比
• 本实验为信号声与噪声同源（正前方0°），即仅有双耳总和效应发挥作用的结果
• 如果信号源与噪声源分离，双耳静噪效应将发挥作用，双模式助听优势将进一步提高
赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.


NUROTRON
一、双模式优势有哪些？
4. 调的识别（声调、语调和乐调）
• 在声调感知测试中，双耳模式助听状态具有显著优势，相比于单侧耳蜗助听状态，声调感知平均成绩提升了13.04%
• 在语调感知测试中，双耳模式助听状态具有显著优势，相比于单侧耳蜗助听状态，语调感知成绩提升了16.65 %
• 在音乐音调感知测试中，双耳模式助听状态具有显著优势，相比于单侧耳蜗助听状态，音乐感知成绩提升了6.49%
陶仁霞. 双耳模式助听儿童音调感知特征研究[D]. 华东师范大学, 2018..


NUROTRON
一、双模式优势有哪些？
4. 调的识别（频域 or 时域线索？）
Bimodal
CI
13.57%
Bimodal
CI
16.47%
Bimodal
CI
13.98%
Hearing mode
0
20
40
60
80
100
Percent(%)
responses of lexical tone in noise
responses consistent with fine structure in noise
responses consistent with fine structure in quite
图 3-8 不同助听模式下对时域线索及声调识别增长率对比
张凯莉.基于声嵌合技术的双模式助听儿童对声调时域线索的感知特征研究[D]. 华东师范大学, 2019.

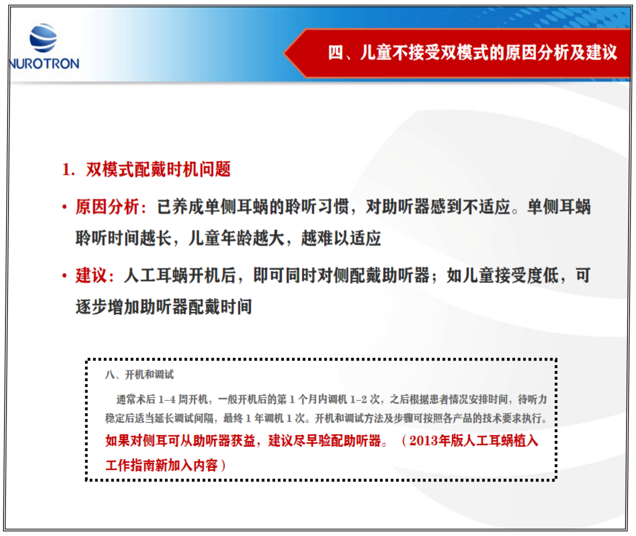

NUROTRON
二、电声刺激是否相互拮抗？
**
SNR 50% (dB)
5
0
-5
1.94
0.54
Unilateral CI
Binaural-bimodal
Conditions
赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.


NUROTRON
二、电声刺激是否相互拮抗？
ρ=0.669 p=0.009
4.00
2.00
0.00
-2.00
Δamplitude (μv)
-3.00
-2.00
-1.00
0.00
1.00
ΔSNR-50% (dB)
赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.


NUROTRON
二、电声刺激是否相互拮抗？
双模式配戴时间＜6个月
赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.


NUROTRON
二、电声刺激是否相互拮抗?
双模式配戴时间对其优势发挥的影响ΔSNR50%（dB）
因素水平	样本量	中位数
0-6个月	7	-1.08
6-12个月	9	1.51
12-18个月	9	2.38
18个月以上	14	1.30
** p=0.01
• 其中配戴6个月以上的受试者，未发现双模式助听产生了负面效果
• 约有25%的双模式助听使用者，在刚戴上助听器时会受一些影响，需要一段适应期（小于6个月）
• 推测和双耳助听的间隔时间有关
赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.


NUROTRON
三、多少残余听力能获益于双模式?
助听器补偿效果对双模式优势发挥的影响ΔSNR50%（dB）
有效补偿范围（Hz）	样本量	中位数
250-3000	19	1.71
250-2000	8	1.30
250-1000	7	1.41
P＞0.05
• 噪声下言语识别：只要非植入耳在250-1000Hz有可用残余听力，就能获益于双模式助听
• 声调感知：非植入耳250Hz和500Hz的助听效果与声调感知能力相关度最高，中高频不相关（除4000Hz外）
• 声源定位：非植入耳补偿效果越好，双模式助听获益越大
赵航. 听障儿童双耳双模式言语识别能力比较研究[D]. 华东师范大学, 2013.
陶仁霞. 双耳模式助听儿童音调感知特征研究[D]. 华东师范大学, 2018.


NUROTRON
四、儿童不接受双模式的原因分析及建议
1. 双模式配戴时机问题
• 原因分析：已养成单侧耳蜗的聆听习惯，对助听器感到不适应。单侧耳蜗聆听时间越长，儿童年龄越大，越难以适应
• 建议：人工耳蜗开机后，即可同时对侧配戴助听器；如儿童接受度低，可逐步增加助听器配戴时间
八、开机和调试
通常术后 1-4 周开机，一般开机后的第 1 个月内调机 1-2 次，之后根据患者情况安排时间，待听力稳定后适当延长调试间隔，最终 1 年调机 1 次。开机和调试方法及步骤可按照各产品的技术要求执行。
如果对侧耳可从助听器获益，建议尽早验配助听器。（2013年版人工耳蜗植入工作指南新加入内容）


NUROTRON
四、儿童不接受双模式的原因分析及建议
2. 助听器调试时应注意的问题
• 响度平衡：我国听障儿童普遍存在非植入耳听力极差，且耳蜗和助听器在不同机构调试的问题，实现响度平衡有困难。建议：将助听器增益调到最舒适级（most comfortable levels, MCLs)也有利于发挥双模式优势
• 全频or互补：全频放大、限制高频与非线性频率压缩（移频）需纳入考虑，大部分受试者（成人）更偏好通过移频功能限制高频增益的双模式助听音质
• Dorman MF, Loizou P, Wang Shuai, Zhang T, Spahr A, Loiselle L, Cook S. Bimodal Cochlear Implants: The Role of Acoustic Signal Level in Determining Speech Perception Benefit. Audiol Neurotol. 2014;19:234–238.
• Davidson LS, Firszt JB, Brenner Ch, Cadieux JH. Evaluation of hearing aid frequency response fittings in pediatric and young adult bimodal recipients. J Am Acad Audiol. 2015;26(4).
• Kokx-Ryan M, Cohen J, Cord MT, Walden T, Makashay MJ, Sheffield BM, Brungart DS. Benefits of nonlinear frequency compression in adult hearing aid users. J Amer Acad Audiol. 2015;26:838-55.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First Artificial Intelligent Auditory Crossover Forum
中国·杭州 2019.4.12
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Hear more, Live better
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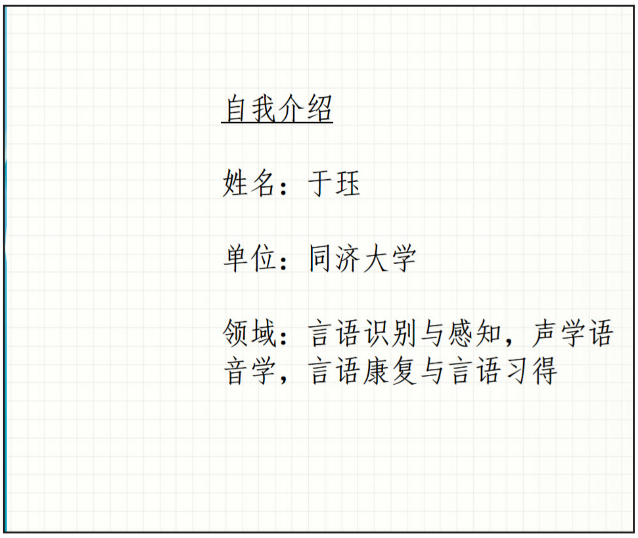
诺尔康


自我介绍
姓名：于珏
单位：同济大学
领域：言语识别与感知，声学语音学，言语康复与言语习得

AI和CI之我见

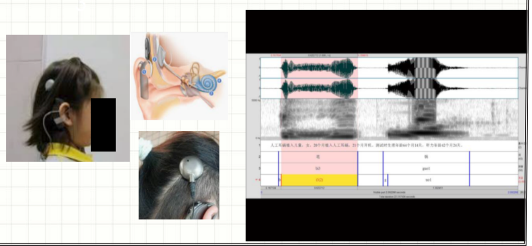
个人认为AI与CI的结合是必然的，CI本身就是人工听觉，这个听觉假体可以远不止于是一个被动的接听装置，可以成为“类脑”智能。

- **从言语链的角度来看：**言语交际包括语音的产生、传递和感知的过程。发音人在整个过程中还会自我监控言语的产出，实时调整。对于CI用户而言，这个自我监控的过程除了语言编码，语音的产出是否符合用户想要传递的言语信息，达到语用的功效尤为重要。所以我认为增加CI的实时（**on-line**）言语人工智能监控功能是未来的方向。
- **从CI术后调机及言语康复角度来看：**能否让CI这一假体装置参与或者反馈大脑听觉加工，同时将自动语音识别技术应用进来，参与线下（**off-line**）言语产出的自动评估也是人工智能介入的一个切入点。

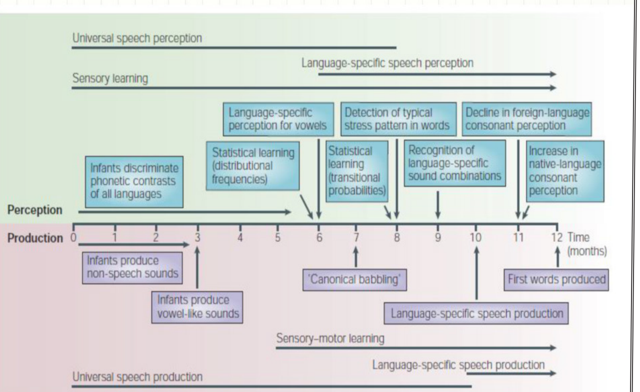
研究方向：临床应用、AI+评估、言语康复

目前与上海交通大学附属第九人民医院耳鼻咽喉头颈外科听力中心以及上海同济大学附属养志康复中心言语康复科都有合作项目，主要包括：

- 建立不同年龄段耳蜗儿童的动态言语评估标准
- 对听障儿童言语现状及发展作全面的科学分析
- 为开发临床言语自动评估系统、儿童言语康复治疗的可视化程序提供量化指标。



•一岁内婴儿语言感知与产出的发展过程（Kuhl, 2004）



NUROTRON 1. 健听儿童与听障儿童言语发展语音库建设

CI　NH

- 语音声学参数是语音声学特征的集合，是有声语言资源的量化方式。在语言理论研究、言语工程、病理语言诊断及康复训练等诸方面都具有不可替代的作用。
- 该语料库旨在大规模收录不同年龄段听障儿童（考虑植入时长、家庭背景、方言背景等等）多种言语样本，提取不同言语单位（包括单字、词、句子、语篇）的语音特征参数（包括音段层，韵律层），同时以健听儿童言语发展平行库为参考，整理耳蜗儿童言语发展中的共征与特性，为其言语能力评估提供量化指标并开发相应的人工智能平台，辅助医生临床诊断。

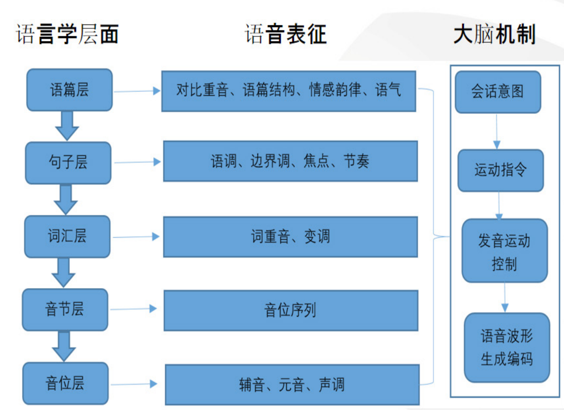
目前已完成近100名健听儿童与50名耳蜗儿童言语样本的语音记录　（每位发音人时长近60分钟的录音语料）

NUROTRON 2. 普通话耳蜗儿童语音范畴习得研究

- 言语发声起步晚，语音错误较多（由于其听力受损，语言发展晚于同龄儿童）
  - 语音错误的模式？发音困难？
- 言语**可懂度、清晰度、流畅度、自然度**都不够（元辅音的饱和度，语流音变，轻重音，语调等）
  - 缺乏具体的量化指标
- 个体表现差异性大，受多个因素的影响（家庭背景，手术年龄，佩戴*CI*时长/产品型号，康复训练等）
  - 各因素受特定语言的制约

语音科学研究中心

NUROTRON 言语习得的语言学—语音表征—大脑交互机制



NUROTRON

- Yu, J. & Zhang, M.Q., 2019, LEXICAL-TONE PRODUCTION IN PRELINGUALLY DEAFENED MANDARIN-SPEAKING CHILDREN WITH COCHLEAR IMPLANTS.
- Yu, J. & Xia, X. Y., 2019, PRODUCTION OF MANDARIN STOP CONSONANTS IN PRELINGUALLY DEAF CHILDREN WITH COCHLEAR IMPLANTS .
- 于珏，廖怡源，2018, 人工耳蜗儿童元音习得发展研究
- 于珏，2017-2018, 交叉课题： 人工耳蜗儿童汉语声调习得的认知与神经机制研究

NUROTRON

3. 临床听力筛查—方言版及方言普通话版林氏六音频率范围确定

- ■ 不同语言发音方式不同，语音各异，因此“林氏六音”实际在不同的语言中有不一样的频率范围，需要具体情况具体分析。
- ■ 建议对不同方言区普通话做进一步测试，同时补充声调基频数据，丰富普通话“林氏六音”数据

王非凡, 于珏, 马良, 张美琪, 夏欣雨, 2019, 上海普通话版“林氏六音”频率范围分析

NUROTRON

4. 普通话耳蜗儿童的音位感知与脑机制研究

- ■ 所有语言中的音位都是范畴，音位的感知一定是范畴感知。
- ■ 音位感知的范畴化程度（定量）

- ■ 内部因素：当音位内部起决定性作用的频率信息在走向上处于相对稳态时，其不同音位之间感知的范畴化程度低，反之则高
- ■ 外部因素：音位外部的语境、实验方法跟听者的语言经验都会对音位的范畴化感知产生重要影响

NUROTRON

- ■人工耳蜗儿童各音位范畴的确立
- ■人工耳蜗儿童感知不同音位的声学线索
- ■人工耳蜗儿童音位、韵律感知的脑机制与声学线索特征的关系

语音科学研究中心

<u>自我介绍</u>

姓名：张畅芯

单位：华东师范大学

领域：言语听觉加工的神经机制
特殊儿童认知功能干预
大脑可塑性

AI和CI之我见

当生活环境中有两个（或多个）人同时讲话时，听者的语音识别难度会大幅增加。

可以将AI的噪音识别技术用于CI，并扩大不同噪音的语音之间的差异，降低语音分流的难度。

目前在做的课题展示

Speech Perception
in a Noisy and Reverberant Environment

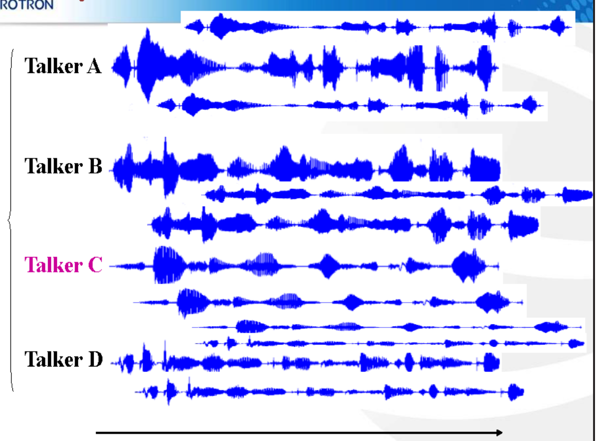
嘈杂、混响环境下的语音识别

Reverberant environments

Any a hard surface can generate reflecting sound waves, or echoes.

5

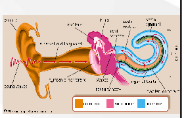
A noisy and reverberant environment



6

Energetic masking and informational masking

- **Energetic masking**
  - Mainly occurs in the cochlea
  - Leading to a degraded or noisy representation of the signal at the peripheral processing level



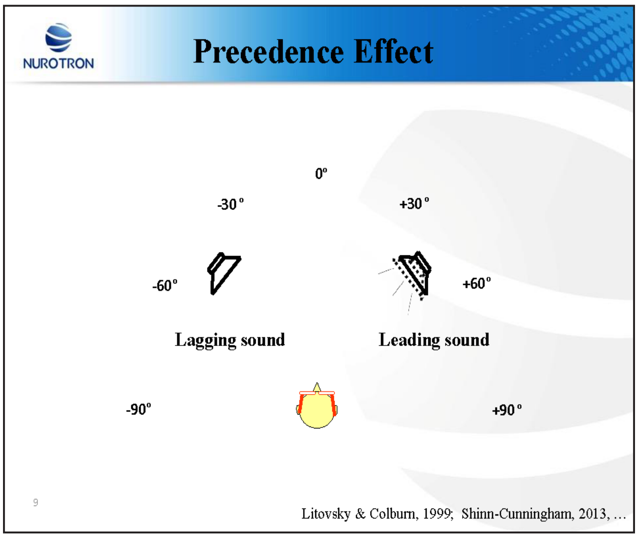
- **Informational masking**
  - Mainly occurs in the central auditory nervous system
  - Interferes with higher level of processing at both perceptual (e.g., phonemic identification) and cognitive (e.g., semantic processing) levels

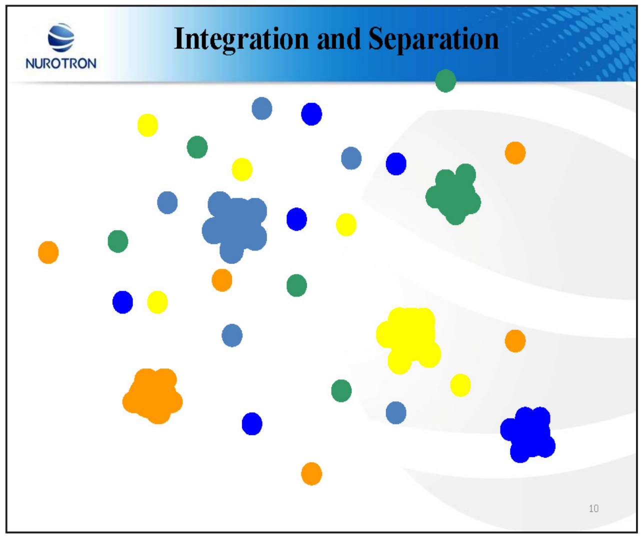
7

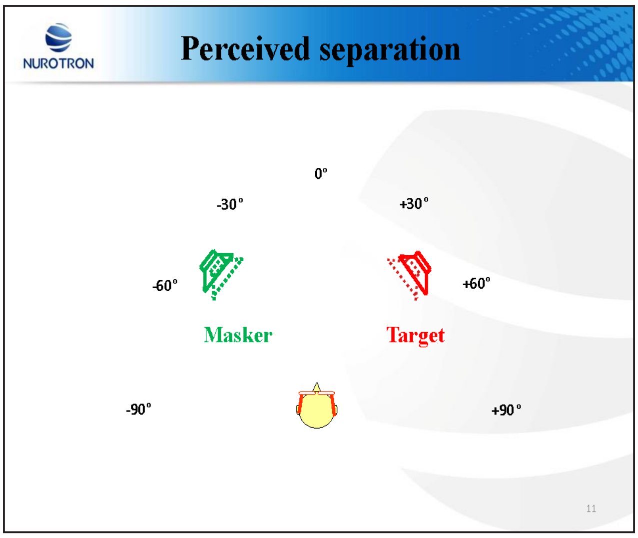
How people understand speech in a noisy and reverberant environment?

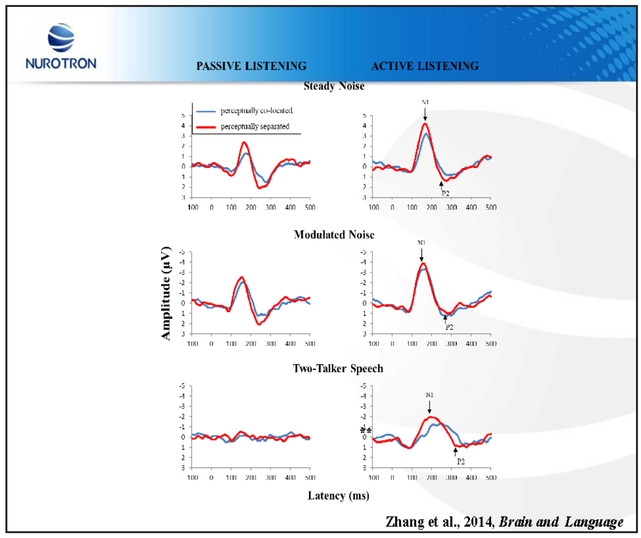
- Familiarity with the voice of the target talker (Brungart et al., 2001; Newman & Evers, 2007; Yang et al., 2007; Huang et al., 2010)
- Familiarity with the identity of the target talker (Yonan & Sommers, 2000; Newman & Evers, 2007)
- Knowledge of the location of the target talker (Kidd et al., 2005; Singh et al., 2008)
- Expectation of the content of the target speech (Freyman et al., 2004)
- Visual cues (Helfer and Freyman, 2005, Wu et al., 2013)
- Perceived separation between the target and masker (Freyman et al., 1999; Li et al., 2004; Wu et al., 2005; Zhang et al., 2014; 2016; 2019)

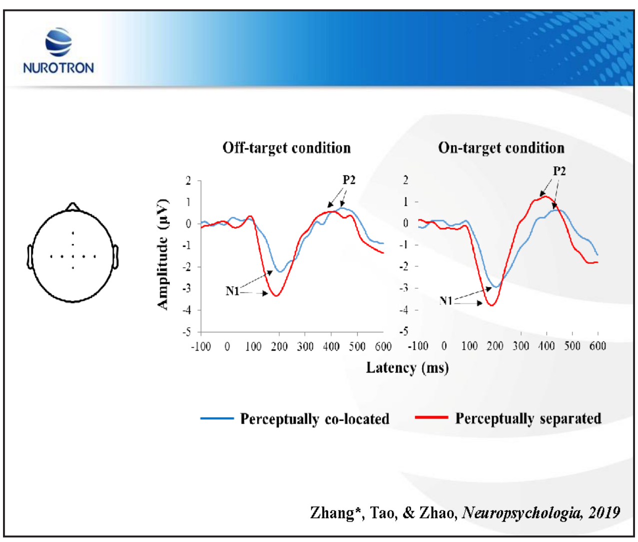
8


NUROTRON
Precedence Effect
0°
-30°
+30°
-60°
+60°
Lagging sound
Leading sound
-90°
+90°
9
Litovsky & Colburn, 1999; Shinn-Cunningham, 2013, …


NUROTRON
Integration and Separation
10


NUROTRON
Perceived separation
0°
-30°
+30°
-60°
+60°
Masker
Target
-90°
+90°
11


NUROTRON
PASSIVE LISTENING
ACTIVE LISTENING
Steady Noise
perceptually co-located
perceptually separated
Modulated Noise
Amplitude (μV)
Two-Talker Speech
Latency (ms)
Zhang et al., 2014, Brain and Language


NUROTRON
Off-target condition
On-target condition
Amplitude (μV)
P2
N1
Latency (ms)
Perceptually co-located
Perceptually separated
Zhang*, Tao, & Zhao, Neuropsychologia, 2019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NUROTRON
诺尔康

自我介绍

姓名：陈忠敏

单位：复旦大学

领域：实验语音学

AI和CI之我见

- 婴儿1-4个月就有语音的知觉和音类的范畴感知，
- 6-8月语音感知一般不受母语影响，不同语种的婴儿语音感知模式和程度高度一致。
- 8-9月以后母语与非母语的语音感知呈现差异。
- 以后母语是声调语言的儿童声调感知能力不断增强。非声调母语儿童声调感知能力逐渐减弱。

NUROTRON

- 所以人类语音感知特点：
  - 有样例积累(exemplar accumulation)的过程
  - 根据样例做出范畴化(categorization)规则
  - 范畴感知增强(categorical perception enhancement)
  - 主观感知匹配

目前在做的课题展示

- 人类语音感知的特点及其相关的神经机制
- 语音感知与语音演变

Development and Clinical Introduction of the Nurotron Cochlear Implant Electrode Array

Stephen Rebscher, David Daomin Zhou, Fan-Gang Zeng

1.Department of Otolaryngology, University of California San Francisco, San Francisco, USA (SR).
2.Nurotron Biotechnology Inc., Irvine, USA (DDZ).
3.Department of Otolaryngology, University of California Irvine, Irvine, USA (FGZ).

Abstract

As the only medical device used in the treatment for deafness, the cochlear implant has benefited to more than half a million individuals worldwide. However, the device has limited penetration due to its high cost, especially in low- and middle-income countries. China alone has 27.8 million deaf people, but less than 100,000 of them have received a cochlear implant. The Nurotron Venus device was developed to address the need for an affordable yet safe and effectivecochlear implant. The present study describes the design, development, and evaluation of the Nurotron intracochlear electrode array. The standard array is 22 mm in length from the round window marker to the apical tip of the carrier and has 24 electrodes, with a surface area of 0.32 mm^2 and center-to-center spacing of 0.85 mm. The Nurotron arrayhas been tested to meet the mechanical, chemical, and electrical requirements specified by the ISO Standard 14708-07. Human temporal bone and clinical trial results showed that the Nurotron array is easy to insert (7.8/10 rating with 10 indicating the highest ease of use) and has a low complication rate (12.5%) of severe insertion trauma while achieving high device stability and reliability (6 array failures in 43,000 patient years of experience). As a critical component, the Nurotron array has contributed to the high level of Nurotron implant speech performance, equivalent to that produced by other existing devices. The Nurotron device has benefited 10,000 deaf people and helped reduce the unit cost from US$25,000 in 2011 to US$4,620 in 2017 through the Chinese Government Tender Program. New, slim, and micromachined electrodes are being developed to further improve performance and accessibility.

Key Words: Auditory prosthesis, cochlear implants, deafness, electric stimulation, electrodes

Article source:

Rebscher S, Zhou DD, Zeng FG. Development and Clinical Introduction of the Nurotron Cochlear Implant Electrode Array. J Int Adv Otol 2018; 14(3): 392-400.

Implementation and preliminary evaluation of ‘C-tone’: A novel algorithm to improve lexical tone recognition in Mandarin-speaking cochlear implant users

Lichuan Ping[1], Ningyuan Wang[2], Guofang Tang[2], Thomas Lu1, Li Yin[2],Wenhe Tu[2], Qian-Jie Fu[3]

1.Nurotron Biotechnology, Inc., Irvine, CA, USA.
2.Zhejiang Nurotron Biotechnology Co., Ltd, Zhejiang, PR China.
3.Department of Head and Neck Surgery, David Geffen School of Medicine, UCLA, Los Angeles, 2100 West Third Street, Suite 100, Los Angeles, CA 90057, USA.

Abstract

Objectives: Because of limited spectral resolution, Mandarin-speaking cochlear implant (CI) users have difficulty perceiving fundamental frequency (F0) cues that are important to lexical tone recognition. To improve Mandarin tone recognition in CI users, we implemented and evaluated a novel real-time algorithm (C-tone) to enhance the amplitude contour, which is strongly correlated with the F0 contour.

Methods: The C-tone algorithm was implemented in clinical processors and evaluated in eight users of the Nurotron NSP-60 CI system. Subjects were given 2 weeks of experience with C-tone. Recognition of Chinese tones, monosyllables, and disyllables in quiet was measured with and without the C-tone algorithm. Subjective quality ratings were also obtained for C-tone.

Results: After 2 weeks of experience with C-tone, there were small but significant improvements in recognition of lexical tones, monosyllables, and disyllables ($P < 0.05$ in all cases). Among lexical tones, the largest improvements were observed for Tone 3 (falling–rising) and the smallest for Tone 4 (falling). Improvements with C-tone were greater for disyllables than for monosyllables. Subjective quality ratings showed no strong preference for or against C-tone, except for perception of own voice, where C-tone was preferred.

Discussion: The real-time C-tone algorithm provided small but significant improvements for speech performance in quiet with no change in sound quality. Pre-processing algorithms to reduce noise and better real-time F0 extraction would improve the benefits of C-tone in complex listening environments.

Conclusions: Chinese CI users’ speech recognition in quiet can be significantly improved by modifying the amplitude contour to better resemble the F0 contour.

Key Words: Cochlear implant, Lexical tone, Mandarin speech, C-tone, Nurotron

Article source:
Lichuan Ping,Ningyuan Wang,Guofang Tang,Thomas Lu,Li Yin,Wenhe Tu&Qian-Jie Fu(2017)Implementation and preliminary evaluation of ‘C-tone’: A novel algorithm to improve lexical tone recognition in Mandarin-speaking cochlear implant users ,Cochlear Implants Intemation-al,18:5,240-249.

陕西省45名大龄听障儿童植入诺尔康人工耳蜗后1年康复效果分析

王晓平　蔡砾洋　宋蕾　任利敏

【摘要】

随着人工耳蜗技术的发展与成熟,人工耳蜗成为重度/极重度感音神经性耳聋患者重建听觉系统的唯一途径.近年来,国家政策对残疾人的帮扶力度越来越大,人工耳蜗的植入年龄逐步拓宽,大龄听障儿童在错过最佳植入年龄的情况下也能顺利植入人工耳蜗.本文通过对陕西省45名植入诺尔康人工耳蜗的大龄听障儿童康复1年后听觉语言能力、听觉行为分级标准(categories of auditory performance,CAP)和言语可懂度分级标准(speech intelligibility rating,SIR)的评估结果进行分析对比,为其康复训练提供参考.

【关键词】双侧植入;双模调试;儿童;语言;掩蔽空间释放.

Objective and subjective evaluations of the Nurotron Venus cochlear implant system via animal experiments and clinical trials

Na Gao[1,2,3*], Xin-Da Xu[1,2,3*], Fang-Lu Chi[1,2,3], Fan-Gang Zeng[4], Qian-Jie Fu[5], Xian-Hao Jia[1,2,3,] Yan-Bo Yin[1,2,3],Li-Chuan Ping[6], Hou-Yong Kang[7], Hai-Hong Feng[8], Yong-Zhen Wu[1,2,3] & Ye Jiang[1,2,3]

1.Department of Otology and Skull Base Surgery, Eye Ear Nose & Throat Hospital, Fudan University, Shanghai, PR China.
2.Shanghai Auditory Medical Center, Shanghai, PR China.
3.Key Laboratory of Hearing Science, Ministry of Health, Shanghai, PR China.
4.Departments of Anatomy and Neurobiology, Biomedical Engineering, Cognitive Sciences and Otolaryngology – Head and Neck Surgery,University of California, Irvine, CA, USA.
5.Department of Biomedical Engineering, University of Southern California, Los Angeles, CA, USA.
6.Nurotron Biotechnology Inc., Hangzhou, Zhejiang, PR China.
7.Department of Otolaryngology – Head and Neck Surgery, The First Affiliated Hospital of Chongqing Medical University, Chongqing, PR China.
8.Shanghai Acoustics Laboratory, Chinese Academy of Sciences, Shanghai, PR China.

Abstract

Conclusion: This study described objective and subjective evaluations of the Nurotron Venus™ Cochlear Implant System and indicated that this system produced a satisfactory performance.

Objective: To observe the performance of the Nurotron Venus™ cochlear implant (CI) system via electrophysiological and psychophysical evaluations.

Methods: A 26-electrode CI system was specially designed. The performance of MRI in animal and cadaveric head experiments, EABR in cats experiment, the correlation between ESRT and C level, and psychophysics evaluations in clinical trials were observed.

Results: In the animal and cadaveric head experiments, magnet dislocation could not be prevented in the 1.5 T MRI without removal of the internal magnet. The EABR was clearly elicited in cat experiment. In the clinical trial, the ESRT was strongly correlated with C level (p50.001). The human clinical trial involving 57 post-lingually deafened native Mandarin-speaking patients was performed. Residual hearing protection in the implanted ear at each audiometric frequency was observed in 27.5–46.3% patients post-operatively. A pitch ranking test revealed that place pitches were generally ordered from apical to basal electrodes. The recognitions of the perceptions of 301 disyllabic words, environment sounds, disyllabic words, and numerals were significantly better than the pre-operative performance and reached plateaus.

Key Words: Bilateral Cochlear implant, electrically evoked auditory brainstem responses (EABR),electrically evoked-stapedius reflex threshold(ESRT), MRI, Nurotron, pitch ranking, speech perception

Article source:
Gao N, Xu X D, Chi F L, et al. Objective and subjective evaluations of the Nurotron Venus cochlear implant system via animal experiments and clinical trials.[J]. Acta otolaryngologica, 2015, 136(1):1-10.

儿童诺尔康人工耳蜗植入者术后长期康复效果分析

于丽玫　李佳楠　王丽燕　王倩　苗艳　张阳　申敏　薛静　魏佩芳　韩睿　杨仕明

1 中国聋儿康复研究中心;
2 解放军总医院耳鼻喉科头颈外科听觉植入中心，解放军耳鼻咽喉研究所.

【摘要】

目的：观察儿童诺尔康人工耳蜗植入患者术后3年的康复效果，评价该国产人工耳蜗的安全性和有效性。

方法：201 1年4月至6月植入诺尔康晨星人工耳蜗系统的双侧重度或极重度感音神经性聋患儿60例，植入年龄12～71个月，平均(39。6±18．9)个月。所有植入患儿术后3～4周开机，并在开机后3个月、1年、2年和3年定期随访，对人工耳蜗装置的使用情况和工作状态进行跟踪，同时对其听觉康复效果进行评估，并应用SAS 9．13统计软件进行数据分析。

结果：60例患儿均手术成功，开机后能坚持每日佩戴使用人工耳蜗，随访期间无与人工耳蜗植入相关的并发症发生，人工耳蜗装置整体工作状态良好。患儿声场言语频率的助听听阈测试，韵母、声母、单音节词和双音节词测试，Ling氏六音测试，婴幼儿有意义听觉整合量表(Infant—Toddler Meaningful Auditory Integration Scale，IT．MAIS)得分均较术前明显提高，并随着人工耳蜗使用时间延长而逐渐改善。植人儿童的语法能力、理解能力、交往能力和表达能力测试结果也随着耳蜗使用时间的延长有明显提高。

结论：随着人工耳蜗使用时间的延长，儿童植入者的听觉和语言评估测试结果显著提高，诺尔康晨星人工耳蜗系统具有良好的安全性和有效性。

【关键词】耳蜗植入术；测听法；治疗结果；儿童

Development and evaluation of the Nurotron 26-electrode cochlear implant system

Fan-Gang Zeng [a], Stephen J. Rebscher [b], Qian-Jie Fu [c],Hongbin Chen [d],Xiaoan Sun [d], Li Yin [d],Lichuan Ping [d] ,Lichuan Ping [d],Haihong Feng [e],Shiming Yang [f],Shusheng Gong [g],Beibei Yang [h],Hou-Yong Kang [i],Na Gao [j],Fanglu Chi [j]

a Center for Hearing Research, University of California, Irvine, CA 92697, USA
b Department of Otolaryngology e Head and Neck Surgery, University of California, San Francisco, CA 94143, USA
c Department of Otolaryngology e Head and Neck Surgery, University of California, Los Angeles, CA 90095, USA
d Nurotron Biotechnology Inc., Hangzhou, Zhejiang 310011, China
e Shanghai Acoustics Laboratory, Institute of Acoustics, Chinese Academy of Sciences, Shanghai 200032, China
f Department of Otolaryngology e Head and Neck Surgery, Chinese PLA General Hospital, Beijing 100853, China
g Department of Otolaryngology e Head and Neck Surgery, Tongren Hospital of Capital Medical University, Beijing 100730, China
h Department of Otolaryngology e Head and Neck Surgery, The Second Affiliated Hospital of Zhejiang University, Hangzhou 310000, China
i Department of Otolaryngology e Head and Neck Surgery, The First Affiliated Hospital of Chongqing Medical University, Chongqing 400016, China
j Department of Otolaryngology e Head and Neck Surgery, The Eye and ENT Hospital of Fudan University, Shanghai 200031, China

Abstract

Although the cochlear implant has been widely acknowledged as the most successful neural prosthesis,only a fraction of hearing-impaired people who can potentially benefit from a cochlear implant have actually received one due to its limited awareness, accessibility, and affordability. To help overcome these limitations, a 26-electrode cochlear implant hasbeen developed to receive China's Food and Drug Administration (CFDA) approval in 2011 and Conformite Europeenne (CE) Marking in 2012. The present article describes design philosophy, system specification, and technical verification of the Nurotron device, which includes advanced digital signal processing and 4 current sources with multiple amplitude resolutions that not only are compatible with perceptual capability but also allow interleaved or simultaneous stimulation. The article also presents 3-year longitudinal evaluation data from 60 human subjects who have received the Nurotron device. The objective measures show that electrode impedance decreased within the first month of device use, but was stable until a slight increase at the end of two years. The subjective loudness measures show that electric stimulation threshold was stable while the maximal comfort level increased over the 3 years. Mandarin sentence recognition increased from the pre-surgical 0%-correct score to a plateau of about 80% correct with 6-month use of the device. Both indirect and direct comparisons indicate indistinguishable performance differences between the Nurotron system and other commercially available devices. The present 26-electrode cochlear implant has already helped to lower the price of cochlear implantation in China and will likely contribute to increased cochlear implant access and success in the rest of the world.

Article source:

Zeng, F.-G., et al., Development and evaluation of the Nurotron 26-electrode cochlear implant system, Hearing Research (2014), http://dx.doi.org/10.1016/j.heares.2014.09.013

参考译文:
诺尔康26电极人工耳蜗植入系统的开发及评估

曾凡钢[1] Stephen J. Rebscher[2] 付前杰[3] 陈洪斌[4] 孙晓安[4] 银力[4] 平利川[4] 冯海弘[5] 杨仕明[6] 龚树生[7] 杨蓓蓓[8] 康厚墉[9] 高娜[10] 迟放鲁[10]

屠文河[4] 翻译 银力[4] 陈洪斌[4] 校译

1 加州大学听觉研究中心 美国尔湾 CA 92697
2 加州大学耳鼻咽喉头颈外科 美国旧金山 CA 94143
3 加州大学耳鼻咽喉头颈外科 美国洛杉矶 CA 90095
4 浙江诺尔康神经电子科技股份有限公司 杭州 310011
5 中国科学院声学研究所东海研究站 上海 200032
6 中国人民解放军总医院耳鼻咽喉头颈外科 北京 100853
7 首都医科大学附属北京同仁医院耳鼻咽喉头颈外科 北京 100730
8 浙江大学附属第二医院耳鼻咽喉头颈外科 杭州 310000
9 重庆医科大学附属第一医院耳鼻咽喉头颈外科 重庆 400016
10 复旦大学附属眼耳鼻喉科医院耳鼻咽喉头颈外科 上海 200031

【摘要】

本文阐述了诺尔康26电极人工耳蜗的设计理念、系统特点及技术验证。该人工耳蜗具有先进的数字信号处理技术和多精度的4个电流源，不仅与感知能力匹配，而且可进行间隔或同时刺激。此外，本文描述了60例诺尔康人工耳蜗植入者3年的评估数据。客观测试显示，电极阻抗值在使用设备1个月后降低，此后持续保持稳定，直到2年时略有上升。主观响度测试显示，电刺激阈值相对稳定，最大舒适阈在3年中逐渐提高。汉语句子识别率从术前的0%增长至开机6个月时约80%的水平。间接和直接对比研究均显示诺尔康人工耳蜗与其他同类人工耳蜗产品使用效果相当。

【关键词】人工耳蜗；诺尔康；开发；评估

Analysis of the performance of post-lingually deafened patients with Nurotron®Venus™ cochlear implants

JIANAN LI*, FEI JI*, WEI CHEN*, HUI ZHAO, DONGYI HAN & SHIMING YANG

Department of Otolaryngology-Head and Neck Surgery, and Institute of Otolaryngology, Auditory Implantation Center,Chinese People's Liberation Army General Hospital, Beijing, China

Abstract

Objective: The aim of this study was to analyze the safety and effectiveness of a new cochlear implant (CI) system developed in China, the Nurotron Venus device.

Material and methods: Fifteen post-lingually deafened patients received Nurotron Venus CIs in our hospital. The safety and effectiveness of the devices were evaluated within 2 years after implantation. Patients'hearing thresholds were assessed. In addition, the speech perception performance of Nurotron Venus CI recipients was compared with that of 15 Cochlear Nucleus CI24 recipients.

Results and conclusion: During 2 years of observation, all the Nurotron recipients used their devices regularly and effectively. The aided hearing thresholds of all the recipients were within the speech spectrum. The average scores of HOPE sentences and HOPE monosyllable words tests among Nurotron CI recipients were 82.88 ± 21.40% and 56.67 ± 9.77%, respectively. The average scores among Cochlear Nucleus CI24 recipients were 87.33 ± 14.44% and 52.8 ± 12.76%, respectively. There was no statistically significant difference in the speech test scores between these two groups when assessed using the t test. The Nurotron Venus cochlear implant system worked safely and effectively. The speech perception of Nurotron recipients was similar to that of the other CI system recipients.

Key Words: Safety, effectiveness, auditory performance, speech perception

Article source:
LJIANAN LI*, FEI JI*, WEI CHEN, et al. Analysis of the performance of post-lingually deafened patients with Nurotron®Venus™ cochlear implants. Acta Oto-Laryngologica. 2014; 134: 609–614.

参考译文：
语后聋患者诺尔康-晨星人工耳蜗植入术后康复效果分析

1 李佳楠*,1 冀飞*，2 陈伟*，1 赵辉，1 韩东一，1 杨仕明

1.解放军总医院耳鼻咽喉头颈外科听觉植入中心,北京 100853
2.空军总医院耳鼻喉科

【摘要】

目的：分析中国自主品牌诺尔康-晨星人工耳蜗系统产品的安全性和有效性。

方法：2010 年 3 月至 2010 年 4 月在我科植入诺尔康-晨星人工耳蜗系统的语后聋受试者 15 例，对受试者开机 2 年后产品的使用情况和工作状态进行随访以验证产品的安全性和有效性；将受试者术前和术后 2 年的声场测听听阈进行自身对照，并将本组受试者与 15 例植入澳大利亚 Nucleus CI24 型人工耳蜗的语后聋患者的听觉言语康复情况进行比较。

结果：在术后 2 年的随访中，诺尔康植入者均正常并有效佩戴人工耳蜗，所有植入者的助听听阈均满足正常言语交流。诺尔康-晨星人工耳蜗植入组 HOPE 短句识别率得分平均为 82.88%±21.40%，HOPE 单音节词识别率得分平均为 56.67%±9.77%；澳大利亚 Nucleus CI24 植入组的短句和单音节词识别率平均得分分别为 87.33%±14.44%和 52.8%±12.76%。

结论：中国自主品牌诺尔康-晨星人工耳蜗系统在观察期内工作正常，安全有效。言语识别率与其它人工耳蜗无明显差异。

【关键词】安全性，有效性，听觉能力表现，言语感知

先天性聋人工耳蜗植入儿童皮层听觉诱发电位的研究

卢伟　陈丽丽　鲁倩　孙淑萍　雷一波　陈雪清　米思　莫玲燕

1 郑州大学第一附属医院耳科；
2 首都医科大学附属北京同仁医院 北京市耳鼻咽喉科研究所 耳鼻咽喉头颈科学教育部重点实验室(首都医科大学)；
3 北京市通州区人工耳蜗康复中心

【摘要】

目的：对先天性聋人工耳蜗植入儿童皮层听觉诱发电位(cortical auditory evoked potential，CAEP)的研究，探讨中枢听觉发育与人工耳蜗植入年龄之间的关系。

方法：5岁前植人人工耳蜗的先天性聋患儿110例，测试时年龄12—80个月，其人工耳蜗使用时间从刚开机到48个月。声场下以65 dBSPL的／m／、／t／、／g／为测试声，进行CAEP测试，记录其P1、N1及P2波。分析各波的引m率、人工耳蜗植入年龄以及使用时间与P1波潜伏期的关系。

结果：P1波的总体引出率为66．4％，Nl波为15．5％，P2波为12．7％；P1波的引出率明显高于N1波(x2=228．542，P=0．00)和P2波(x2=257．438，P=0．00)，差异具有统计学意义。／m／、／t／、／g／等三种刺激声的P1波引出率分别为64．1％、66．9％和68．3％，差异无统计学意义(x2=0．589，P=0．75)；三种刺激声之间P1的潜伏期(P=o．22)和幅度(P=0．09)，差异均无统计学意义。植入年龄≤42月龄组P1潜伏期进人与年龄相当的正常值范围的百分比(95．3％)明显高于>42月龄组(66．7％)，差异具有统计学意义(P= 0．02)。在42月龄前植人人工耳蜗的儿童中，耳蜗使用时间分别为1年、2年、3年和4年的各组之间，在进入年龄相当的正常P1潜伏期范围的百分比上，差异无统计学意义(P=1．00)。

结论：先天性聋患儿42月龄前植入人工耳蜗，其听觉中枢更有可能实现正常发育，而且一经植入使用，即可迅速发育达到正常听力的水平。

【关键词】听觉丧失；诱发电位，听觉；耳蜗植入术；儿童

首届人工智能听力跨界研讨会合影留念

首届人工智能听力跨界研讨会参会专家名单

姓名	单位
米思	北京通州语训学校
陈忠敏	复旦大学
孙建军	海军总医院
刘娅	海军总医院
张畅芯	华东师范大学
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朱舒明	浙江中医药大学
冯海泓	中国科学院声学研究所
李军锋	中国科学院声学研究所

* 以上名单以单位首字母排序

杭州总部
地址：浙江省杭州市余杭区龙潭路17号
邮编：311121
电话：4006 222 571
传真：0571-88179905
邮箱：service@nurotron.com
网址：http://www.nurotron.com