Cologne, Germany, - September 15–19th

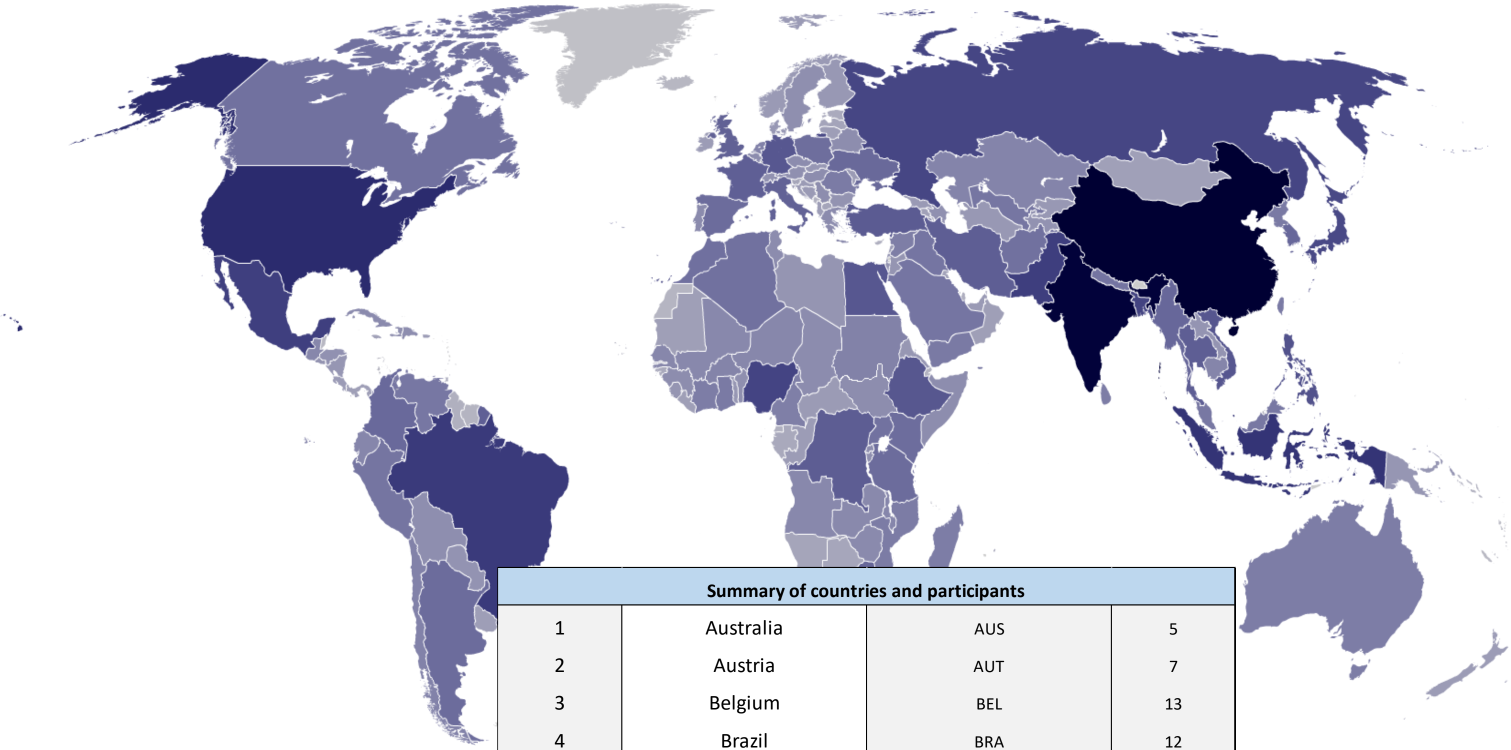
IERASG 2023

XXVIII International Evoked Response Audiometry Study Group Biennial Symposium

PROGRAM & ABSTRACTS

COLOGNE - GERMANY

Participants and countries of the 28th International Symposium of the IERASG



Summary of countries and participants			
1	Australia	AUS	5
2	Austria	AUT	7
3	Belgium	BEL	13
4	Brazil	BRA	12
5	Canada	CAN	5
6	Czech Republic	CZE	1
7	**Germany**	DEU	46
8	Denmark	DNK	16
9	Spain	ESP	5
10	France	FRA	4
11	Finland	FIN	1
12	Great Britain	GBR	11
13	India	IND	4
14	Israel	ISR	2
15	**South Korea**	KOR	21
16	Litvania	LVA	2
17	Mexico	MEX	2
18	Malaysia	MYS	1
19	The Netherlands	NDL	5
20	Norway	NOR	1
21	New Zealand	NZL	3
22	Poland	POL	3
23	Roumania	ROU	2
24	Russia	RUS	1
25	Serbia	SRB	1
26	Sweden	SWE	2
27	Switzerland	CHE	4
28	**United States**	USA	19
29	South Africa	ZAF	1

September 2023

Welcome friends of the International Evoked Response Audiometry Study Group (IERASG).

We are excited to have so many of you join us in person in Cologne for our 28th Biennial Symposium and to have a number of you online to hear our highlighted speakers.

We have waited a long time for this opportunity to come together to discuss and celebrate advances in our field of evoked response audiometry, a term we interpret broadly in IERASG! We had hoped to be in Cologne in 2021 but sadly that was not possible due to the widespread devastating effects of COVID at that time, so it is extra special for us to be coming together in 2023.

In 2021 when we held our last IERASG Symposium the World Report on Hearing had just been released. The report estimated that across the world "400 million, including 34 million children, live with disabling hearing loss, affecting their health and quality of life". Accurate and efficient screening and diagnosis of hearing, especially in children, are reliant on the methods we research. Advancing our understanding of auditory brain processes also depends on the work that we do as IERASG contributors. I hope that the excellent guest lectures, round table discussions, special student sessions, workshops, historical interviews, innovations from industry and approximately 130 free papers and posters will energise you and get you thinking about the next wave of developments and important clinical and research questions for our field.

IERASG began as an informal study group at the International Society of Audiology congress in London in 1968 established by **Prof. Hallowell Davis** and his colleagues **("Hal's Club")**. Our biennial meetings were first held in 1970 in Freiburg, Germany, so it is lovely to be back in Germany more than half a century after that important start of our study group. IERASG connections between colleagues and friends across the globe have continued to grow with each biennial meeting since those early beginnings. IERASG strives to be inclusive of all countries and of all people working at different levels in our field of evoked response audiometry. We are happy to have achieved this goal again in 2023 – we have 29 countries participating and many students and emerging researchers contributing oral papers and posters.

Previous invited **Hallowell Davis lecturers** have been influential and groundbreaking in their research, and this year's 2023 Hallowell Davis Lecture is no exception - this year we welcome **Prof. Emeritus Yvonne Sininger** who contributed so much to our field over many years, especially in the areas of paediatric audiology, newborn hearing screening, electrophysiology and otoacoustic emissions. A new highlight of the Symposium with be the Susan Small lecture. Prof. Susan Small, our former IERASG Council member and Treasurer who sadly passed away in 2022, devoted her academic career to working with infants and children. It is very fitting that **Prof. Emeritus David Stapells**, Susan's mentor, a strong contributor to IERASG over many years and host of our Vancouver meeting in 2001 will present the inaugural 2023 Susan Small lecture.

We are delighted to also welcome exciting contributions from four guest lecturers **(Dr. Michael Scherg, Prof. Dr. Tobias Moser, Assoc. Prof. Kristin Uhler, and Dr. Valderrama-Valenzuela)** and to have captured important insights from past research in two special interviews with three significant contributors to our field. It is a delight to hear from such key figures as **Prof. Deborah Hayes** and **Prof. Emeritus Jerry Northern** and to welcome back former Council Member **Prof. Emeritus Hillel Pratt**.

I am sure you will enjoy the range of excellent oral papers and posters as well as our guest speakers – the future of our field lies with all of us, but especially with our students and emerging researchers, so we are especially excited to hear from them. We hope that the conference gives you ample opportunities to discuss and ask questions and make new IERASG friends. A highlight of our Symposium has always been the Closing Remarks which for many years have been provided by Prof. Bob Burhard. We are sad not to have Bob in Cologne but we know he will be anxious to hear from our new Discussant for 2023, **Prof. Mridula Sharma** who will present the Symposium Summary.

WORDS FROM THE CHAIR

Well done Symposium organisers and very special thanks to our extraordinary host of the conference, **Prof. Dr. Martin Walger** who has been working so hard for several years now to bring us all to Cologne. Martin and the Scientific Committee have put together an outstanding programme for us!

Warm wishes for an enjoyable and productive conference from me and my fellow IERASG Council Members!

Suzanne C Purdy | CNZM, PhD | Chair, IERASG

WELCOME ALL!

It is my great pleasure to welcome you all to the 28th **Biennial Symposium of the International ERA Study Group (IERASG)** which is held after the long Covid period in presence in Cologne, Germany from the 15th to 19th September 2023!

We welcome the world leading experts, young researchers and students from all continents around the globe, working, teaching and researching clinically and scientifically in the field of Auditory Evoked Potentials (AEP) including Vestibular Evoked Myogenic Potentials (VEMP). **Around 200 participants from 29 countries** have submitted more than 120 scientific papers!

IERASG23 will go back to campus. The university's Anatomical Institute will not be a 5star hotel with sophisticated technology! It will hopefully provide a good working atmosphere, just right for a working group! This is the only way to finance a scientific conference including all social activities. Already now I apologize for technical deficiencies in this old building!

There are some new additions to the symposium program waiting for us: historical interviews, lectures and hands-on demonstrations of innovations from the industry, as well as a hybrid session to link participants from countries that cannot travel to Cologne.

As we are not allowed to set up poster boards at the conference venue for fire safety reasons, the submitted posters will be projected as e-posters in lecture hall 3 and will be presented and discussed in 11 special poster sessions in two seminar rooms with the authors present.

For the first time, we will welcome online participants in all key sessions! To give all attendees plenty of time to review the exciting papers, abstracts, posters including 3min short-presentations and all live recordings will be available on the IERASG23 homepage for another half a year after the conference for all registered guests!

The scientific symposium will be accompanied by a wonderful social program in the spirit of Hallowell Davis including an exclusive concert in the world cultural heritage, the Cologne Cathedral, a visit of the legendary Drachenfels (dragon rock), a boat trip on the beautiful Rhine river back to Cologne at night and a get together dinner with music in a beautiful whine cellar of the historical Gürzenich.

Enjoy your time in Cologne, in this lively, fun-loving and cosmopolitan city on the Rhine!

Yours, Martin Walger

Martin Walger | PhD | Symposium Chair, IERASG23

WE THANK OUR SPONSORS!

CONTENT

SCIENTIFIC COMITTEE


Steven Bell (UK)


Andy Beynon (NLD)


Robert Burkard (USA)


Barbara Cone (USA)


Robert Cowan (AUS)


Rafael Delgado (USA)


Andrew Dimitrijevic (CAN)

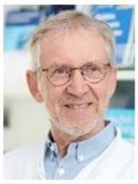

David McPherson (USA)


David Purcell (CAN)


Suzanne Purdy (NZL)


Mridula Sharma (AUS)


Joaquin T. Valderrama-V. (ESP)


Martin Walger (DEU)

IERASG COUNCIL

IERASG Council Members 2023		
Name	**officers**	**country**
Suzanne C. Purdy	Chair	New Zealand
Andy Beynon	Vice Chair	Netherlands
Andrew Dimitrijevic	Treasurer	Canada
Martin Walger	Secretary	Germany
David McPherson	Membership Secretary	USA & Canada
W. Wiktor Jedrzejczak	Website Manager	Poland
council member for…		
Jose Barajas		Spain
Steven Bell		United Kingdom
Robert Burkard		USA
Monica Chapchap		Brazil
Barbara Cone		USA
Robert Cowan		Australia
Rafael Delgado		USA
John Durrant		USA
Cynthia G. Fowler		USA
Ferdinando Grandori		Italy
Krzysztof Kochanek		Poland
Jun Ho Lee		South Korea
Guy Lightfoot		UK
Marilyn C. Perez-Abalo		USA
David Purcell		Canada
Mridula Sharma		Australia
George A. Tavartkiladze		Russia
Kristin Uhler		USA
Joaquin Valderrama		Spain

PROGRAM OVERVIEW

XXVIII IERASG Symposium - Cologne, Germany - Program at a glance

time: 08:30, 09:00, 09:30, 10:00, 10:30, 11:00, 11:30, 12:00, 12:30, 13, 13:30, 14, 14:30, 15, 15:30, 16:00, 16:30, 17:00, 17:30, 18:00, 19:00, 20:00, 21:00, 22:00, 23:00, 24:00

Friday
September 15th 2023

- 09:00–11:00 **Workshop 1** – EEG analyses – *Andrew Dimitrijevic (CAN)* – *Part A* | **Workshop 2** – eABR and eCAEP – *Andy Beynon (NDL)*, *Martin Walger (DEU)* – *Part A*
- 11:00–11:30 coffee break
- 11:30–13:00 **Workshop 1** – *Part B* | **Workshop 2** – *Part B*
- 13:00–14:00 Lunch
- 14:00–15:30 **Workshop 3** – VEMP´s – *Steven Bell (UK)*, *Andy Beynon (NDL)* – *Part A*
- 15:30–16:00 coffee break
- 16:00–17:30 **Workshop 3** – *Part B*
- 18:00–19:00 **Welcome Reception** – *Minerva´s Lounge*

Saturday
September 16th 2023

- 08:30–09:30 **XXVIII IERASG** – Opening Ceremony
- 09:30–10:30 **Hallowell Davis Lecture** – *Yvonne Sininger (USA)* – *Asymmetry in the Auditory System*
- 10:30–11:00 **Free Paper 1**
- 11:00–11:30 coffee break – Poster Session 1 *authors present* | Poster Session 2 *authors present*
- 11:30–13:00 **Free Paper 2** | Posters
- 13:00–14:00 Lunch
- 14:00–20:00 **Excursion** – *dragon castle and dragon rock* – *Rhine river cruise*

Sunday
September 17th 2023

- 08:30–09:00 **Susan Small Pediatric EP Lecture** – *David Stapells (CAN)* – *The details are important: Susan Small's research into infant hearing*
- 09:00–10:30 **Free Paper 2** | Posters
- 10:30–11:00 coffee break – Student Poster Session 1 *authors present* | Student Poster Session 2 *authors present*
- 11:00–11:45 **Historical Interview 1** – *Hillel Pratt (ISR)*
- 11:45–13:00 **Student Session 1** – *oral presentations* | Posters
- 13:00–14:00 Lunch | **Industry Presentations** – *what's new…*
- 14:00–14:45 **Guest Lecture 1** – *Michael Scherg (DEU)* – *The sources of auditory evoked responses*
- 14:45–16:00 **Round Table 1** – New frontiers of electrophysiology in clinical practice | Posters
- 16:00–16:30 coffee break – Poster Session 3 *authors present* | Poster Session 4 *authors present*
- 16:30–18:00 **Free Paper 3** | Posters
- 19:00–24:00 **get together** – *Gürzenich (whine cellar), Cologne*

Monday
September 18th 2023

- 08:30–09:00 **Guest Lecture 2** – *Kristin Uhler (USA)* – *The impact of auditory access on the speech perception during infancy and how it relates to later language outcomes*
- 09:00–10:30 **Free Paper 4** | Posters
- 10:30–11:00 coffee break – Poster Session 5 *authors present* | Poster Session 6 *authors present*
- 11:00–11:45 **Historical Interview 2** – *Deborah Hayes (USA) and Jerry Northern (USA)*
- 11:45–13:00 **Student Session 2** – *oral presentations* | Posters
- 13:00–14:00 Lunch | **Industry Presentations** – *what's new…*
- 14:00–14:45 **Guest Lecture 3** – *Tobias Moser (DEU)* – *Towards the Optical Cochlear Implant: Optogenetic Stimulation of the Auditory Pathway*
- 14:45–16:00 **Round Table 2** – Current and future developments in neural speech processing | Posters
- 16:00–16:30 coffee break – Poster Session 7 *authors present* | Poster Session 8 *authors present*
- 16:30–18:00 **Free Paper 5** | Posters
- 19:00–22:00 **Cologne Cathedral** – *visit and concert*

Tuesday
September 19th 2023

- 08:30–09:00 **Guest Lecture 4: Young Researcher** – *JoaquinT. Valderrama-Valenzuela (ESP)* – *Deconvolution for flexible recording of transient evoked potentials*
- 09:00–10:30 **Free Paper 6** | Posters
- 10:30–11:00 coffee break – Poster Session 9 *authors present*
- 11:00–12:30 **Free Paper 7**
- 12:30–13:00 coffee break
- 13:00–14:00 **Closing Ceremony** – *general assembly - awards - summary*
- 14:00–14:30 **Invitation** – XXIX IERASG Symposium 2025 – Denver/Colorado (USA)

CONFERENCE OFFICE

The 28th International Symposium of the IERASG is organized by Dr. Heike Diekmann, Congress Communication Consulting: https://www.heikediekmann.de/

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SYMPOSIUM HIGHLIGHTS

DETAILED PROGRAM

Final Program

Friday - September 15th 2023

time	ID	Lecture Hall 2	time	ID	Lecture Hall 3
09:00			09:00		
LIVE		**Workshop 1: EEG analysis** (Part 1)	Live		**Workshop 2: eABR and eACR** (Part 1)
time	ID	*Moderator: Andrew Dimitrijevic (CAN)*	time	ID	*Moderators: Andy Beynon (NLD) and Martin Walger (DEU)*
09:00	WS1	**Andrew Dimitrijevic (CAN)** Welcome and introduction	09:00	WS2	**Andy Beynon (NDL)** Welcome and Introduction to eAEP´s
09:15			09:15		**Martin Walger (DEU)** Overview eAEP´s
09:30			09:30		eABR: physiological basis and recording techniques
09:45			09:45		live Patient demo: eABR with CI mediated electrostimulation
10:00			10:00		
10:15			10:15		eABR evaluation; Q&A
10:30		*Entrance Hall* coffee break			
11:00		Lecture Hall 2	11:00		Lecture Hall 3
LIVE		**Workshop 1: EEG analysis** (Part 2)	Live		**Workshop 2: eABR and EACR** (Part 2)
time	ID	*Moderator: Andrew Dimitrijevic (CAN)*	time	ID	*Moderators: Andy Beynon (NLD) and Martin Walger (DEU)*
11:00	WS1		11:00	WS2	**Andy Beynon (NDL)** eACR: physiological basis and recording techniques
11:15			11:15		
11:30			11:30		Live patient demo
11:45			11:45		
12:00			12:00		
12:15			12:15		Plenary: Q&A, discussion
12:30			12:30		
12:45			12:45		Closure
13:00		**Lunch** *(optional)* Minerva`s Lounge or Cafeteria, University Clinic			
14:00		*Lecture Hall 2*			***We thank our sponsors!!!***
LIVE		**Workshop 3: VEMP`s** (Part 1)			
	ID	*Moderators: Steven Bell (GBR) and Andy Beynon (NLD)*			
14:00	WS3				
14:15					
14:30					
14:45					
15:00					
15:15					
15:30		coffee break			
16:00		*Lecture Hall 2*			
LIVE		**Workshop 3: VEMP`s** (Part 2)			
	ID	*Moderators: Steven Bell (GBR) and Andy Beynon (NLD)*			
16:00	WS3				
16:15					
16:30					
16:45					
17:00					
17:15					
17:30					
18:00		**Welcome Reception** Minerva`s Lounge			

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Saturday - September 16th 2023

08:30 — *Lecture Hall 2*

LIVE

XXVIII IERASG Opening Ceremony

Moderator: Suzanne Purdy (NZL) and Martin Walger (DEU)

08:30	Welcome to Cologne 2023!
	Awards
	Memory of Susan Small
	Announcements

09:00

Hallowell Davis Lecture

LIVE — *Moderator: Suzanne Purdy (NZL)*

09:00	HD	**Yvonne Sininger (USA)** *Asymmetry in the Auditory System*

10:00 — *Lecture Hall 2*

Free Paper 1: ABR and signal processing

Moderators: Andy Beynon (NLD) and Sinnet Kristensen (DNK)

Time	ID		abs
10:00	FP-1	**Rafael Delgado (USA)** Comparison of auditory brainstem recordings acquired at various stimulation rates from typically developing and autism spectrum disorder children	89
10:15	FP-2	**Angel de la Torre (ESP)** Simultaneous deconvolution of multiple auditory evoked potentials in a reduced representation space	103
10:30	FP-3	**Guy Lightfoot (GBR)** The Clinical Evaluation of a Modified Fmp in Infant Auditory Brainstem Response Tests	4
10:45	FP-4	**Penelope Bundy (NZL) and Michael Maslin (NZL)** Revisiting the interleaved ABR: a relatively simple means of reducing test time?	110

10:00 — *Lecture Hall 3*

e-Poster exhibition

11:00 — *Entrance Hall*

coffee break with poster sessions

11:00 — *Seminar room 2*

ID	Poster Session 1 (authors present)	abs
P1	**David Simpson (GBR)** A Bayesian sequential test for Auditory Brainstem Response detection	97
P2	**Milaine Sanfins (BRA)** An ABR study of central gain in individuals with chronic tinnitus	17
P3	**Kyoug Ho Park (KOR)** ABR & OAE change in transplantation with mesenchymal stromal cells from human placenta in sensorineural hearing loss animal model	8
P4	**Siobhan Brennan GBR)** Measurement of Reference Equivalent Thresholds Sound Pressure Level (RETSPL) & Difference between Auditory Brainstem Response (ABR) & Puretone Audiometric Thresholds -(PTA) at 3, 6, and 8 kHz	71
P5	**Min-Hyun Park (KOR)** Correlation of hearing thresholds measured by puretone audiometry and by tone-burst auditory brainstem response.	51
P6	**Milaine Sanfins (BRA)** Auditory Brainstem Response in Normal Hearing in new equipment available in Brazil	14

11:00 — *Seminar room 3*

ID	Poster Session 2 (authors present)
P7	**Ahmad Aidil Arafat Dzulkarnian (MYS)** Evaluation of sound-working memory therapy in autism spectrum disorder children using auditory brainstem response (ABR) with psychological task
P8	**Ana Luiza Luiz (BRA) and Ana Claudia Frizzo (BRA)** Brainstem auditory evoked potential in neonates with hearing risk factors
P9	**Anna Sergeeva (DNK)** Towards ASSR-based hearing assessment using natural sounds
P10	**Jeong-Hoon Oh (KOR)** Reliability of interaural difference of SP/AP ratio in Meniere's disease
P11	**Raphael Koning (DEU)** Multi-Frequency ECochG Monitoring through the AIM System
P12	**Jae Ho Chung (KOR)** Potential Presence of Cochlear Synaptopathy in Patients fully Recovered from Sudden Sensorineural Hearing Loss

11:30 — *Lecture Hall 2*

Free Paper 2: ABR and ASSR

Moderators: Guy Lightfoot (GBR) and Mario Cebulla (DEU)

time	ID		abs
11:30	FP5	**Sinnet Kristensen (DNK)** Exploring across-frequency interaction in simultaneously recorded auditory brainstem responses	116
11:45	FP6	**Ute Geiger (DEU)** Optimal ASSR stimulus repetition rates in normal and hearing-impaired infants	38
12:00	FP7	**Mario Cebulla (DEU)** Reliability of the ASSR-based NHS for identifying children with suspected ANSD	30
12:15	FP8	**Jaime Andres Undurraga Lucero (DNK)** A novel method to detect auditory evoked potentials – the Fmpi	100
12:30	FP9	**Pauline Burkhart (DEU) and Martin Walger (DEU)** Evaluation of the fitting success of a hearing aids using ABR and a novel free-field headphone	127
12:45	FP10	**Erik Schebsdat (DEU)** Free-field evoked auditory brainstem responses in Cochlear-Implant patients - an objective method for the analysis of aggregate system latencies	16

10:30 — *Lecture Hall 3*

e-Poster exhibition

13:00 — *Entrance Hall*

Lunch

lunch boxes at entrance hall

13:30

Excursion: Dragon Rock, Dragon Castle, Rhine River Cruise

Bus departure: Anatomical Institute, Joseph Stelzmann Str. 60 - outside entrance hall

Destination: Königswinter - Dragon Castle - Dragon Rock - Rhine river cruise - Cologne

14:30	**Group I:** cable car to dragon castle and rock	
	Group II: hiking tour through nightingale valley to dragon castle and rock (45-60 min; slight ascent)	optional: visit of Dragon Castle
16:00	coffe break at dragon rock	
17:00	hiking back to Königswinter (45min)	
17:30	cable car return to Königswinter (every 30min)	
18:30	Rhine river cruise to Cologne with the "Rheinprinzessin" (Rhine princess)	Bonner Personen Schifffahrt - Google Maps
19:00	**departure**	
20:00	Dinner on board	
22:30	**arrival in Cologne**	

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Interacoustics

Sunday - September 17th 2023

		lecture hall 2	
08:30		lecture hall 2	
LIVE		**Susan Small Pediatric EP Lecture**	
		Moderator: Barbara Cone (USA)	
08:30	SSEP-1	**David Stapells (CAN)**	
		The details are important: Susan Small´s Research into Infant Hearing	

	ID	*Lecture Hall 2* — **Student Session 1**	abs
09:15	ID	**Student Session 1**	
		Moderator: Joaquin Valderrama (ESP)	
09:15	S1	**Rien Sonck (BEL)** Auditory steady-state responses: multiplexed amplitude modulation frequencies to reduce recording time	40
09:30	S2	**Marieke Snijder-van As (NDL)** New objective measurement for assessing high-frequency ototoxic damage	41
09:45	S3	**Laura Jacxsens (BEL)** Frequency-Following Responses in Sensorineural Hearing Loss: A Systematic Review	39
10:00	S4	**Esma Akis (GBR)** Exploring objective measures of auditory temporal resolution	26

	Lecture Hall 3
09:15	*e-Poster exhibition*

	Entrance Hall
10:15	*coffee break with poster sessions*

ID	*Seminar room 2* (10:15) — ***Student Poster Session 1** (authors present)*	abs
SP1	**Sebastian Roth (DEU)** Evaluation of binaural interaction in SSD CI users based on the calculated binaural interaction component of auditory brainstem responses	25
SP2	**Irem Adalilar (BEL)** Investigating Latency Differences between ASSRs of Adults and Children with Normal Hearing	105
SP3	**Miguel Tamboury-Gutierez (ESP)** Reduced Auditory Nerve Phase-locking in Healthy Older Listeners Measured with Electrocochleography	118
SP4	**Marlies Geys (CHE)** Electrocochleographic Patterns and Hearing Preservation During the Initial Year of Cochlear Implant Use	76
SP5	**Swantje Hansen (DEU)** Cortical Auditory Potentials Evoked by Changes in Interaural Phase Difference	117
SP6	**Lisbeth Birkelund Simonsen (DNK)** An electrophysiological version of the Audible Contrast Threshold (ACT™) test: Correlation to HINT and behavioural ACT as well as test-retest differences	104
P8	**Ana Luiza Luiz (BRA) and Ana Claudia Frizzo (BRA)** Brainstem auditory evoked potential in neonates with hearing risk factors	SP13

ID	*Seminar room 3* (10:15) — ***Student Poster Session 2** (authors present)*
SP7	**Ji-Won Choi (KOR)** Longitudinal EEG potentials (VEP) evoked by visual pattern reversal as an outcome prediction marker for cochlear implant users
SP8	**Hyungi Chun (USA)** The impact of speech rate and target word intensity on speech processing and listening effort in background noise in older listeners
SP9	**Sankalpa Madashetty (IND)** The impact of hearing loss on attention network tests among older individuals: An event related potential study
SP10	**Brilliant Brilliant (DEU)** Auditory cognitive and sensory load modulate neuronal oscillatory activity before and after the behavioral response
SP11	**Busra Erdem (GBR)** Comparing Vestibular Evoked Myogenic Potential (VEMP) frequency tuning curves between B71 and minishaker transducers
SP12	**Carolina Köstler (DEU)** Use of an electromagnetic actuator as an implantable microphone - first results
SP13	**Hye Ah Joo (KOR)** Patterns of Device Failure among Different Types of Hearing Aids

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Sunday - September 17th 2023

10:45 — *Lecture Hall 2*

LIVE

Historical Interview 1: *Lessons from the past - implications for the future*

Moderator: Barbara Cone (USA)

10:45	**Hillel Pratt (ISR)**
	Interviewers: Barbara Cone (USA) and Joaquin Valderrama (ESP)

11:30 — *Lecture Hall 2*

Student Session 2

Moderator: Kristin Uhler (USA)

	ID		abs
11:30	S5	**Lana Biot (BEL)** Optimization of the acoustic change complex recording procedure to accurately predict speech perception	37
11:45	S6	**Nina Aldag (DEU)** Psychoacoustic and electroencephalographic measures of amplitude modulation depth and frequency and their relation to speech recognition in cochlear implant users	70
12:00	S7	**Louise van Goylen (BEL)** Measuring listening effort using the P300 auditory evoked potential within young and older adults	5
12:15	S8	**John Cooper (BEL)** Effects of Mouth Movements on Speech Intelligibility in Naturalistic Audiovisual Environment	43

11:30 — *Lecture Hall 3*

e-Poster exhibition

12:30 — *Entrance Hall*

Lunch with Industry presentations

13:00 — *Lecture Hall 2*

Industry presentations 1: what´s new?

13:00	IN1	**Andre Lodwig (DEU), PATH Medical** Adaptive Noise Cancelling applied to OAE
13:15	IN2	**Rafael Delgado (USA), Intelligent Hearing Systems Corp.** Advanced SmartEP features on the IHS Duet platform for averaging, SNR estimation and audiovisual integration
13:30	IN3	**Rainer Thie (DEU), Pilot Blankenfelde** Electrical ABR und new mathematical methods for ABR-analysis
13:45	IN4	**Raphael Koning, Advanced Bionics** New avenues in cochlear implant objective measures – Advanced Bionics' AIM system

14:00 — *Lecture Hall 2*

LIVE

Guest Lecture 1

Moderator: Martin Walger (DEU)

GL1 — **Michael Scherg (DEU)**

The sources of auditory evoked responses

14:45 — *Lecture Hall 2*

LIVE

Round Table 1

New frontiers of electrophysiology in clinical practice

Moderation: Suzanne Purdy (NZL) and Martin Walger (DEU)

	ID	
14:45		**Introduction:** Suzanne Purdy (NZL) and Martin Walger (DEU)
15:00	FP11	**Steven Bell (GBR)** Gaussian Processes for efficient audiogram estimation with Auditory Brainstem Responses
15:15	FP12	**David Stapells (CAN)** Cochlear contributions to the ABR to narrowband chirps versus 2-1-2 linear-gated tones: A high-pass noise/derived response study
15:30	FP13	**Andy Beynon (NDL)** Intraoperative ECochG in cochlear implantation: the ANN/CM-ratio as predictive measure of hearing preservation
15:45	FP14	**Pascale Sandmann (DEU)** The time course of auditory and audio-visual speech processing in cochlear-implant users revealed by cortical evoked potentials

16:00 — *Entrance Hall*

coffee break with poster sessions

16:00 — *Seminar room 2* — *Poster Session 3 (authors present)*

ID	
P13	**Daniel Polterauer (DEU)** Transtympanic electrically evoked auditory brainstem response in local anesthesia (= LA-TT-EABR) using the MED-EL stimulation and Nihon Kohden recording system vs. an Inomed stimulation and recording setup
P14	**Daniel Polterauer (DEU)** Transtympanic electrically evoked auditory midbrain response in local anesthesia (= LA-TT-EAMLR) as a pre-operative tool for checking cochlear implant (= CI) candidacy in an intrasubject comparison to established equivalent measurements of the auditory brainstem (= LA-TT-EABR) and auditory cortex (= LA-TT-EALR)
P15	**David P. Herrmann (DEU)** Correlating the intraoperative electrically evoked auditory brainstem response with postoperative high-resolution computed tomography scans
P16	**Rahel Bertschinger (CHE)** Feasibility of Extracochlear Stimulation to Induce Hearing and Reduce Tinnitus
P17	**Karin Frånlund (SWE)** Cortical auditory evoked potentials (P1 latency) in children with cochlear implants correlated with clinical language tests
P18	**Hye Ah Joo (KOR)** Cochlear Implant Outcomes in the Elderly Patients: Experience over 10 years in Asan Medical Center

16:00 — *Seminar room 3* — *Poster Session 4 (authors present)*

ID	
P19	**Milaine Sanfins (BRA)** Electrophysiological Testing for an Auditory Processing Disorder and Reading Performance in students.
P20	**Ho Yun Lee (KOR)** Auditory Evoked Responses as Predictors of Decreased Sound Tolerance in Tinnitus Patients
P21	**Allison Mackey (SWE)** Revisiting the transient-evoked otoacoustic emissions passing criteria used for newborn hearing screening
P22	**Fatin Nabilah Jamal (MYS)** Evaluation of sound and working memory therapy using suppression transient otoacoustic emission among autism spectrum disorder children
P23	**Lan Lan (CHN)** The Feature of Extended High-frequecy and Distortion Product Input-Output of Auditory Neuropathy Patients
P24	**Luciana- Macedo de Resende (BRA)** Study of acquired cochlear synaptopathy in young adults

16:45 — *Lecture Hall 2*

Free Paper 3: Otoacoustic Emissions (OAE)

Moderators: Wiktor Jedrzejczak (POL) and Beth Prieve (USA)

	ID	
16:45	FP15	**Jazek Smurzynski (USA)** Recording distortion product otoacoustic emissions (DPOAEs) using the adaptive noise cancelling algorithm
17:00	FP16	**Ernst Dalhoff (DEU)** Pulsed DPOAE latency as reference for ABR measurements?
17:15	FP17	**Srikanta Mishra (USA)** Speech-in-noise recognition: Don"t forget cochlear tuning!
17:30	FP18	**Wiktor Jedrzejczak (POL)** Insights into the modulation of peripheral hearing by attentional level based on several experiments involving otoacoustic emissions and auditory evoked potentials

16:30 — *Lecture Hall 3*

e-Poster exhibition

19:30

get together

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Gürzenich Köln - Google Maps

24:00

Monday - September 18th 2023

		Lecture Hall 2
08:30		**Guest Lecture 2**
LIVE		*Moderator: Mridula Sharma (AUS)*
08:30	GL2	**Kristin Uhler** (USA) The impact of auditory access on the speech perception during infancy and how it relates to later language outcomes

		Lecture Hall 2	09:15	Lecture Hall 3
09:15		*Lecture Hall 2*	09:15	*Lecture Hall 3*
		Free Paper 4: Auditory Long Latency Responses (ALR and ERP)		e-Poster exhibition
	ID	*Moderators: Monica Chapchap (BRA) and Michael Maslin (NZL)*		
09:15	FP19	**Huib Versnel (NDL)** The acoustic change complex as objective measure of speech perception in noise		
09:30	FP20	**Ana Claudia Frizzo (BRA)** Acoustic Change Complexes to fundamental frequency shifts in elderly people with hearing loss		
09:45	FP21	**Pedro Menezes (BRA)** Forward masking in speech-evoked cortical auditory evoked potential: Effect of masker-probe interval		
10:00	FP22	**Raphael Koning (DEU)** Objective Measurement of Cortical Potentials with the Cochlear Implant Electrode		
10:15	FP23	**Michael Maslin (NZL) and Suzanne Purdy (NZL)** Mismatch responses and the ability to objectively index sound discrimination in infants with normal hearing		
10:30	FP24	**Emilie Cardon (BEL)** Cortical auditory evoked potentials as biomarkers to detect the presence of chronic tinnitus		

10:45		*entrance hall*
		coffee break with poster sessions

10:45	Seminar room 2	10:45	Seminar room 3
ID	*Poster Session 5 (authors present)*	ID	*Poster Session 6 (authors present)*
P25	**Rafael Delgado (USA)** Simultaneous Acquisition of Speech Frequency Following Responses and Cortical Auditory Evoked Potentials	P31	**Kathy Vander Werff (USA)** Cortical auditory evoked responses in post-concussion adolescents: implications of injury, maturation, and background noise
P26	**Milaine Sanfins (BRA)** Frequency Following Responses to speech stimuli from birth to age 11 years: preliminary data	P32	**Pedro Menezes (BRA)** The effect of forward masking on cortical auditory evoked potentials in adults: assessing central auditory processing disorder
P27	**Laura Jacxsens (BEL)** Differences in auditory processing of vowels preceded by another vowel versus a consonant, a study using frequency-following responses	P33	**Amani Shalaby (EGY)** Noise reduction algorithms measured by ACC in pediatric hearing aid users
P28	**Ghadah Aljarboa (GBR)** Comparing Cortical Responses to Continuous Speech and Speech Modulated Noise During Passive Listening	P34	**Pedro Menezes (BRA)** Effects of forward masking and signal-to-noise ratio on speech-evoked cortical auditory evoked potentials
P29	**Bei Li (CHN)** Evaluating the effectiveness of audiovisual interaction mechanisms in improving speech resolution in noisy environments of hearing impaired patients using auditory evoked potentials: a preliminary study	P35	**Ana Claudia Frizzo (BRA)** Effect of AÇAI on heart rate and auditory cortical response
P30	**So Yun Lim (KOR)** Analysis of the correlation between hearing loss and cognitive impairment	P36	**Luciana Macedo de Resende (BRA)** Amusia and its electrophysiological correlates in neurofibromatosis type 1: an in-depth analysis

Monday - September 18th 2023

Lecture Hall 2

11:15 — Historical Interview 2: *Lessons from the past - implications for the future*

LIVE

Moderator: Barbara Cone (USA)

Deborah Hayes (USA) and Jerry Northern (USA)

Interviewers: Barbara Cone (USA) and Suzanne Purdy (NZL)

12:00 — Free Paper 5: Speech processing, FFR, EFR

Moderators: Jose Barajas (ESP) and Pascale Sandmann (DEU)

	ID	
12:00	FP25	**Frank Boehnke (DEU)** Frequeny following responses for phase-time analysis of the auditory pathway
12:15	FP26	**Sarah Verhulst (BEL)** Supra-threshold Envelope-following Responses in the Ageing Population: Relationships with Hearing Sensitivity and Speech Intelligibility
12:30	FP27	**Madison Brown (AUS) and <u>Mridua Sharma</u> (AUS)** The role of attention and memory in understanding conversation in noise in adults: neural tracking study
12:45	FP28	**Anna Weglage (DEU)** Audiovisual speech processing in the first months of CI use

12:00 — *Lecture Hall 3*

e-Poster exhibition

13:00 — *Entrance hall*

Lunch with Industry presentations

Lecture Hall 2

Industry presentations 2: what´s new?

13:15	IN5	**Philipp Spitzer, MedEl** Innovative Evoked Response Audiometry with MED-EL
13:30	IN6	**Jörg Pesch, Cochlear** Diagnostics for smart and connected hearing implant care
13:45	IN7	**Mario Cebulla (DEU) and Eckhart Stürzebecher (DEU), Interacoustics Research Unit** CM detector for automatic ASSR-based Hearing Threshold Assessment

14:00 — *Lecture Hall 2*

LIVE

Guest Lecture 3

Moderator: Andrew Dimitrijevic (CAN)

14:00 — GL3

Tobias Moser (DEU)

Towards the Optical Cochlear Implant: Optogenetic Stimulation of the Auditory Pathway

14:45 — *Lecture Hall 2*

LIVE

Round Table 2

Current and future developments in neural speech processing

Moderator: Andy Beynon (NDL) and Mridula Sharma (AUS)

	ID	
14:45		**Introduction:** Andy Beynon (NDL) and Mridula Sharma (AUS)
15:00	FP29	**Jonas Vanthornhout (BEL)** The effect of binaural unmasking on speech envelope tracking
15:15	FP30	**Bonnie Lau (USA)** Decoding of Speech Envelope in Co-located and Segregated Noise in Infant and Child EEG Data
15:30	FP31	**Waldo Nogueira (DEU)** Decoding Selective Attention From Single-Trial EEG Data in Cochlear Implant Users with Ipsilateral Residual Hearing
15:45		**General Discussion**

16:00 — *Entrance Hall*

coffee break with poster sessions

16:00 — *Seminar room 2* — *Poster Session 7 (authors present)*

	ID	
P37	P37	**Mugdha Arkadi (IND)** Impact of Aging on Masseter Vestibular Evoked Myogenic Potentials
P38	P38	**Bei Li (CHN)** A preliminary study on the mechanism of cross-modal plasticity between vestibular myogenic evoked potentials and auditory cortical evoked potentials induced by noise stimulation
P39	P39	**Ji-Song Hong (KOR)** Study on protective effect of novel samll chemical compound against cisplatin-induced ototoxicity
P40	P40	**Hyun Jin Lee (KOR)** Association between HbA1c and Hearing Loss
P41	P41	**Seog-Kyun Mun (KOR)** Role of microRNA-375-3p-mediated regulation in tinnitus development.

16:00 — *Seminar room 3* — *Poster Session 8 (authors present)*

ID	
P42	**Mats Rekswinkel (DNK)** Cortical and behavioural discrimination in response to vowel-like spectral cues
P43	**Rafael Delgado (USA)** Using the McGurk effect to elicit audiovisual multisensory Event Related Potentials
P44	**Pedro Menezes (BRA)** Mismatch Negativity in children with phonological disorder
P45	**Luciana Macedo de Resende (BRA)** Musical training in teenagers with Type 1 Neurofibromatosis: effects on auditory perception and its electrophysiological correlates
P46	**Ulrike Pohle (DEU)** Influences of perceptual and cognitive deficiencies on complex speech processing: an electroencephalography (EEG) pilot study
P47	**Qingchun Pan (CHN)** Event related potentials and brain network functional connectivity mechanisms in patients with noise induced hearing loss: a preliminary study

16:30 — *Lecture Hall 2*

Free Paper 6: Electrocochleography (ECochG) and eAEP

Moderators: Rafael Delgado (USA) and Jun-Ho Lee (KOR)

	ID	
16:30	FP32	**Jeong-Seo Kim (KOR)** Acoustically evoked compound action potentials recorded from cochlear implant users with preserved acoustic hearing
16:45	FP33	**Adam Walkowiak (POL)** Validation of a newly developed SPL Chirp for intracochlear ECochG measurement
17:00	FP34	**Sabine Haumann (DEU)** Continuous intracochlear ECochG measurement to preserve residual hearing in CI surgeries
17:15	FP36	**Martin Walger (DEU)** Preoperative assessment of auditory nerve function in challenging cases using round-window eABR (rw-eABR)
17:30	FP37	**Amparo Callejon Leblic (ESP)** Electrically-evoked cortical potentials in cochlear implant users: Towards an objective fitting measure of central auditory detection

16:30 — *Lecture Hall 3*

e-Poster exhibition

20:00 — Cologne Cathedral: exclusive concert


girls chorus of the Cologne Cathedral

21:00

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Tuesday - September 19th 2023

Time	ID	Programme	abs
08:30		*Lecture Hall 2*	
LIVE		**Guest Lecture 4: Young Researcher**	
		Moderator: Steven Bell (GBR)	
08:30	GL4	**Joaquin T. Valderrama-Valenzuela** (ESP) Deconvolution for flexible recording of transient evoked potentials	
09:15		*Lecture Hall 2*	
		Free Paper 7: ECAP and EP special	
	ID	*Moderators: Andy Beynon (NLD)*	abs
09:15	FP38	**Jeong-Seo Kim (KOR)** The effect of intracochlear electrode design on electrically evoked compound action potential growth and spread of excitation functions	50
09:30	FP39	**Jan Dambon (DEU)** Covariates of facilitation in electrically evoked compound action potentials.	60
09:45	FP40	**Huib Versnel (NDL)** The electrically evoked compound action potential with varying pulse phase duration and assessment of auditory nerve health	85
10:00	FP37	**Amparo Callejon Leblic (ESP)** Electrically-evoked cortical potentials in cochlear implant users: Towards an objective fitting measure of central auditory detection	
10:15	FP41	**Angel de la Torre (ESP)** Live demonstration of a portable, affordable, and versatile auditory evoked potentials recording system mostly based on off-the-shelf electronics	102

Time	Programme
09:15	*Lecture Hall 3*
	e-Poster exhibition

Time	ID	Programme
10:30		*Entrance hall*
		coffee break with poster sessions
10:30		*Seminar room 2*
	ID	*e-Poster Session 9 (authors present)*
	P48	**Milaine Sanfins (BRA)** Long latency auditory evoked potentials and cortical gain in patients with tinnitus disorder
	P49	**Luciana Macedo de Resende (BRA)** Comparative study of cognitive and hearing skills in functionally independent elderly
	P50	**Beth Prieve (USA)** Preliminary Analysis of Auditory Brainstem and Cortical Responses Evoked by Running Speech in Preterm and Term Infants
	P51	**Juan Manuel Cornejo (MEX)** Loudness topography in the early deafness implanted patient
	P52	**Ignacio Calderon De Palma (NLD)** Illuminating regularity violations: optical imaging in an auditory oddball paradigm
	P53	**Melissa Macaskill (FRA)** What is known about functional connectivity assessed with electroencephalography in children with mild traumatic brain injury
11:00		*Lecture Hall 2*
		Student Session 3
	ID	*Moderator: Maria Perez-Abalo (USA)*
11:00	S9	**Heleen Van Der Biest (BEL)** Platinum- induced ototoxicity: potential bio-markers of cochlear synaptopathy
11:15	S10	**Nele De Porteere (BEL)** Music festivals: The effect of recreational noise exposure on young adults hearing
11:30	S11	**Taegyeong Kim (KOR)** Comparison of newborn hearing screening program results in different periods
11:45		**Hybrid Poster Session**
	ID	*Moderator: Maria Perez-Abalo (USA)*
11:45	P54	**Srividya Asuri (IND)** Auditory Event-related potentials for word stimuli in the Kannada language among native Kannada speakers with Dementia
11:50	P55	**Leigh Biagio de Jager (ZAF)** ANSD case study: More for good measure?
11:55	P56	**Che Muhammad Amir Che Awang (MYS)** A preliminary study of the effect of various contralateral auditory attention tasks on efferent pathway among patient with schizophrenia.

Time	Programme
11:00	*Lecture Hall 3*

Time	Programme
12:00	*Entrance hall*
	coffee break
12:30	*Lecture hall 2*
LIVE	**Closing Ceremony**
	Moderator: Suzanne Purdy (NZL) and Martin Walger DEU)
12:30	**Suzanne Purdy (NZL)** Poster awards, Susan Small Travel Award winners
12:40	**Mridula Sharma (AUS)** 28. IERASG Symposium: congress summary
13:10	**Suzanne Purdy (NZL)** IERASG general assembly: retirements and new council members, future Symposium venues
13:20	**Kristin Uhler (USA)** Invitation to the XXIX IERASG Symposium, June 2025, Boulder, Colorado (USA)
13:30	**Martin Walger (DEU) and Suzanne Purdy (NZL)** closing remarks, farewell
13:45	**End of the XXVIII IERASG Symposium**

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ABSTRACTS

Hallowell Davis Lecture

Asymmetry in the Auditory System

Sininger, Yvonne

Professor Emerita

Department of Head & Neck Surgery, David Geffen School of Medicine at University of California, Los Angeles. C&Y Consultants, Santa Fe, New Mexico, USA

Keywords: Lateral Asymmetry, Auditory Corticofugal Connections, Otoacoustic Emissions, Auditory Brainstem Response, Cortical Auditory Evoked Potentials

Processing of auditory signals in human speech is primarily a function of the auditory areas of the left hemisphere of the brain and processing of tonal or melodic stimuli is more readily accomplished by auditory areas of the right hemisphere. There is substantial evidence that temporal/spectral acoustic properties of the stimulus, rather than the linguistic properties, dictate the lateralization of processing [1, 2]. The distinguished cytoarchitecture of auditory areas in left and right temporal lobes can explain their specialized function with the left optimized for processing speed and the right for spectral analysis [3-5]. Given the need for real-time processing of the variety of complex features of acoustic stimuli, it is reasonable to have simultaneous parallel processing strategies for spectral qualities and temporal features in the two hemispheres [6].

Laterality of processing of auditory stimuli has been demonstrated by comparing performance across left and right ear presentations taking into account that the primary route from the periphery to the brain is crossed. Kimura and colleagues have demonstrated a right ear advantage for speech perception and a left ear advantage for distinguishing tonal stimuli [7, 8] reflecting differences in cortical processing capacity.

Subtle but consistent differences in performance by ear have been demonstrated in peripheral and brainstem physiologic measures of auditory function as well. However, unlike the asymmetric cortical cytoarchitecture, no such lateral distinctions in anatomical layout can be found at lower centers.

For example, a small but consistent right ear advantage has been shown for the auditory brainstem response (ABR) from human infants when it is elicited by click stimuli [9, 10]. Otoacoustic Emissions (OAEs) elicited by transient stimuli have consistently been shown to be larger when elicited from the right ear [11-15]. Sininger and Cone-Wesson [16] have also demonstrated that human newborns show larger click-evoked OAEs in the right ear but also larger tone-evoked DPOAEs in the left ear. These results mimic the type of asymmetrical processing in the contralateral hemispheres. Inhibition of the OAE induced by contralateral noise, known as the Medial Olivocochlear (MOC) Reflex which is mediated in the brainstem has also been shown to be asymmetric [17-19] by ear.

Sininger and colleagues have incorporated asymmetry analysis in a variety of experiments over time, including newborn sensitivity measures with ABR, newborn screening measures utilizing ABR and OAE and analysis of prenatal drug exposures on auditory system function. The last phase of Sininger's research involved documenting asymmetry in typical and unilaterally deaf subjects using both psychophysical measures and cortical evoked potentials [20]. The results of these studies will be highlighted in the presentation.

Finally, the consistent nature of asymmetrical processing by stimulus type at subcortical levels of the auditory system, without structural or physiological basis, can be explained by the intricacies of the corticofugal efferent

system [21-25]. Functional and physiological experiments have demonstrated connections between the auditory cortex and the cochlear hair cells and all levels between [22]. The importance of accounting for asymmetry in descriptions and clinical analysis of auditory system data has not yet been established but certainly will take a bigger part in future directions of auditory research.

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Susan Small Pediatric EP Lecture

SSEP

The details are important: Susan Small's research into infant hearing

Stapells, DR [1]

[1] School of Audiology and Speech Sciences, The University of British Columbia, Vancouver, British Columbia, CANADA

We lost Susan Small to an aggressive brain tumour in January 2022. Up until her diagnosis late in 2020, Susan was an astute and productive researcher, a well-respected teacher and research mentor, a generous faculty colleague, and a sought-after clinician-researcher. Over her research career, she supervised the research of 20 graduate students and at least 20 undergraduate students.

I had the good fortune of being Susan's Ph.D. supervisor and, later, her faculty colleague and research collaborator. Years later, after I had retired and then subsequently "returned", Susan welcomed me into her lab as a research collaborator. Additionally, we often worked together on BCEHP matters.

After 10 years practicing as a clinical audiologist, Susan Small began her research career in Audiology and Hearing Science in the Fall of 2001, when she began her Ph.D. studies at the University of British Columbia. Susan's first Audiology-related publication, in 2003, provided RETFLs (i.e., 0 dB nHL thresholds) for BC brief-tone stimuli for ABR. From 2003 through to the present, her research has resulted in at least 36 publications (26 refereed papers, 10 chapters), including 5 in 2022-2023 (Susan also published 5 papers in fish Biology before deciding to become an Audiologist!)

In her CV, Susan described her research interests as: "to understand how hearing matures through investigations that focus on both peripheral (external ear to 8th nerve) and central (brainstem to cortex) processing…. [the] goal is to advance our knowledge of the changes that occur early in life and to apply these findings clinically to improve hearing health for young children." Susan's highly relevant research program usually involved difficult studies that sought the detailed answers required both to understand hearing in infants *and* to apply these results clinically.

In this talk, we celebrate Susan's research. I will highlight some of Susan's studies into infant hearing, which included (but were not limited to): (i) understanding "artifactual" ASSRs to AC and BC stimuli; (ii) recording ASSRs to BC stimuli in adults and infants; (iii) delineation of the maturation of bone-conduction hearing (including: thresholds at different ages, occlusion effects, effective masking levels, ipsi/contra ASSR asymmetries, and ABR vs ASSR thresholds in infants); and (iii) Cortical responses in infants (including: studies of the ACC to speech stimuli in infants, effects of S/N ratio on CAEPs to speech, and infant responses to lateralized noise shifts).

We can honour Susan by continuing her research program, including replicating and/or extending her studies, so that we better understand infant hearing and can apply this research clinically.

Abbreviations:

BCEHP: British Columbia Early Hearing Program
ABR: Auditory Brainstem Response
AC: Air Conduction
ACC: Acoustic Change Complex
ASSR: Auditory Steady-State Response
BC: Bone Conduction
CAEP: Cortical Auditory Evoked Potential
CV: Curriculum Vitae
RETFL: Reference Equivalent Threshold Force Level

e-mail corresponding author: stapells@mail.ubc.ca

Workshop 1: Advanced EEG analyses

Andrew Dimitrijevic (Toronto, Canada)

Welcome to the IERASG workshop! The workshop will be spread across two parts. Videos will be posted online. These are meant to give you a "head start" and make sure that things are working.

Part 1 will cover simulating EEG/ERP data and analyses. This includes looking at "ERP" peaks and performing time-frequency analyses. A real data set will be provided. Participants will learn how to perform analysis in EEGLAB, FieldTrip, and Brainstorm.

Part 2 will cover source analysis and an introduction to temporal response functions (a method to look at brain responses to continuous speech).

Unlisted videos can be found here:

https://www.youtube.com/playlist?list=PLxnkLO0KmNyr7RRRaBMtudgWF3z5f1SQe

Participants are encouraged to run these analysis routines on their own dataset. There will be time for Q&A.

All analysis will be in freely available Matlab programs (EGLAB, FieldTrip, and Brainstorm)

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Workshop 2, Part A: Electrically evoked auditory brainstem responses (eABR)

Andy Beynon (NDL) and Martin Walger (DEU)

The workshop will focus on the physiological basics and practical clinical hands-on training to perform electrically-evoked responses on the brainstem level (eABR). The prerequisites to setup your CI is the electrical stimulator (typically, the manufacturer's CI interface hard/software) on the one hand and your clinical EP system to record the EABRs on the other hand.

Aspects of preoperative eABR will also be presented, where electrical stimulation can be applied at the promontory, round window, or intracochlearly via a probe electrode and electrical stimulator.

Besides the technical specifications regarding the stimulation and recording parameters settings to evoke short latency brainstem potentials (hardware requirements), also non-technical factors and quality assessments are presented and discussed.

The practical performance of a CI-mediated eABR measurement will be demonstrated on a volunteer subject. Thus, the registration and evaluation can be demonstrated live.

The hands-on training will mainly focus on avoiding external noise factors, the role of different stimulus lengths, stimulation rates, filter settings, and the fact how to deal with electrical artefacts caused by the CI, i.e. all important factors to take into account when obtaining adequate responses for further analysis. Practical 'tips and tricks' will be given to facilitate successful clinical assessment of electrically-evoked brainstem potentials in CI patients. There will be plenty of room for questions and discussion.

After this workshop, the participant:

- *is able to setup, perform and interprete two-channel auditory brainstem responses (eABR)*
- *knows advantages, limitations and pitfalls of brainstem EPs*
- *is able to recognize external interferences that might happen during intraop EP recordings in the OR and is able to solve these practical problems*

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Workshop 2, Part B: Electrically evoked cortical responses (eCAEP)

Andy Beynon (NDL) and Martin Walger (DEU)

Different practical setups to obtain electrically-evoked auditory cortical potentials

The aim of this instructional workshop is to give the clinician/clinical researcher basic knowledge how to obtain auditory cortical responses in patients with a cochlear implant. The workshop consists of hands-on demos how to setup your EP device, accompanied by practical background information, tips & tricks, and how to deal with pitfalls that may ruin your data, most of the time caused by (usually trivial) hard/software mistakes.

The workshop will also demonstrate different configurations to record exogenous and endogenous components of auditory detection, discrimination and cognitive processing using straight-forward single/dual-channel setups, thus relatively easy executable in everyday clinical settings.

After this workshop, the participant:

- *knows the differences between acoustically- and electrically-evoked potential recordings*
- *is familiar with the main electrical stimulation parameters and its influence on EP response morphology*
- *is aware of prerequisite hardware to successfully obtain eAEP recordings*
- *is able to setup hard/software configurations for electrophysiological cochlear implant assessment*

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Workshop 3: Vestibular Evoked Myogenic Responses (VEMP)

Steven Bell (GBR) and Andy Beynon (NDL)

In this workshop, we will elucidate on Vestibular Evoked Myogenic Potentials (VEMP) and their clinical application in specific patient populations. The workshop consists of two parts: the first part of the workshop will cover the basics and principles of VEMP recordings. The second part of the workshop consists of a practical hands-on demo where participants have the opportunity to practice the acquisition of VEMPs.

In the first part of the workshop, the basic principles and differences of cervical- and the ocular- VEMPs will be addressed. The influence of using various stimulation parameters and options to acquire cervical- and ocular VEMPs are discussed. Optimal acquisition conditions to obtain these electromyogenic responses are addressed. Practical tips and tricks for a successful recording of cervical- and ocular-VEMPs are given for clinical vestibular pathologies, e.g. how to optimizing VEMP recording for patients with Meniere's Disease or in patients with superior semicircular canal dehiscence syndrome (SCDS). Some discussion will be had of recent research findings related to VEMP with example findings of clinical applications of VEMP.

In the second part of this workshop, participants have the opportunity to perform VEMP measurements in a hands-on training session using 2 different clinical EP devices that support clinical recording of VEMPs. Influence of changing stimulation and recording parameters on response quality and its effect for interpretation are demonstrated, practiced and discussed in order to facilitate adequate interpretation of the different VEMP morphologies by the clinician.

Learning goal:

- *After this workshop, the participant is able to set up, perform, analyse and interpret cervical- and ocular VEMP recordings for clinical application.*

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Guest Lectures

GL1

The sources of auditory evoked responses

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Keywords: Evoked potentials, auditory evoked responses, electroencephalography, source analysis, dipole localization, auditory cortex

BAEP: Depending on their latency, auditory evoked responses (AER) are subdivided into early, middle and late components. The early components (< 10 ms) are elicited by brief sounds and require a few thousand averages to be recorded from the scalp using an electrode at the vertex referenced to the ipsi- and contralateral earlobes. Due to their origin in the brainstem, they are called brainstem auditory evoked potentials (BAEP) or auditory brainstem responses (ABR). Using source analysis and considering the timing of the action potentials along the ascending auditory pathway, Scherg and von Cramon (1985) could identify the origins of the different waves of the ABR: Waves I and I- originate along the auditory nerve. Waves III and III- reflect the output of the ipsilateral cochlear nucleus and the action potential volley crossing the brainstem. Waves IV and V represent predominantly the ipsi- and contralateral output from the superior olivary complexes into the lateral lemnisci. These findings were supported by lesion studies in patients.

MAEP: The middle latency auditory evoked potentials peak at 19 and 30 ms. They originate in primary auditory cortex and can be recorded both electrically (MAEP: N19, P30) and magnetically (MAEF: N19m, P30m). Scherg and von Cramon (1986) have also shown radial components of the lateral auditory cortex (N27-P39) following brief stimuli and demonstrated that unilateral lesions of the auditory radiation or cortex abolish all middle latency components on the lesioned side. The P50m component localizes more laterally along Heschl's gyrus and is particularly enhanced in musicians.

LAEP: The late auditory evoked potentials arise from various structures bilaterally in the temporal lobe. The largest component, N100 (or N100m) is a superposition of activities from at least two regions, summing the energy onset response (EOR) of the planum temporal and the contributions from the primary and secondary auditory cortices along the Heschl's gyrus. The sustained potential (or field) following a periodic, regular tonal stimulus, adds to the surface N100 and has a pitch-related part that originates in the anterior part of Heschl's gyrus similar to the (true) mis-match negativity and melody-related components. The studies of the group of André Rupp of the University of Heidelberg in the past two decades have shown the representations of a multitude of features of an auditory stimulus in various regions of the temporal lobe by using auditory evoked fields. When stimulus presentation is combined with a motor or cognitive task, also other brain regions become involved and contribute to the LAEP after the primary processing in the auditory cortex has taken place.

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GL2

Impact of auditory access on speech perception during infancy

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Keywords: hearing loss, electroencephalography (EEG), infancy, hearing aids, EHDI, language

Background: The early stages of perceptual skill development depend on the interaction between language experiences and the maturation of auditory sensory pathways. In infants with normal hearing (INH), the first year of life is a crucial period for refining speech perception abilities, which are shaped by exposure to language. Studies suggest that exposure to speech sounds is vital for the refinement of speech discrimination abilities. Therefore, infants who are hard-of-hearing (IHH) are vulnerable to atypical development during this period. However, the impact of inconsistent auditory cue access on the development of speech perception is not yet known. IHH provide a unique population for studying the role of experience in the development and refinement of speech perception abilities, as well as identifying those at risk for poor speech perception abilities.

Methods: Our lab has employed both electroencephalography (EEG) and a conditioned head turn (CHT) behavioral paradigm to examine auditory cue access and speech perception abilities, respectively, over the first year of life. Using these measures of speech discrimination in a within-subject design, we can predict both receptive and expressive language abilities.

Results: Oscillatory EEG measured at 3 months of age can be used to predict behavioral speech discrimination at 9 months of age with up to 92% accuracy among IHH and INH who met the Early Hearing Detection and Intervention benchmarks (Uhler et al 2021). Both EEG and CHT, measures of acoustic cue encoding and discrimination, predict spoken expressive and receptive language outcomes (Uhler et al 2022). Finally, our preliminary work suggests that the oscillatory alpha-band EEG can be used to validate hearing aid fittings (Uhler et al 2023).

Conclusion: Our results suggest that infant speech discrimination can be measured over the first year of life among IHH and INH. These findings highlight the importance of considering both hearing status and hearing age when interpreting the results. Additionally, our work supports the importance of assessing infant speech discrimination as it is related to spoken language abilities at 30 months of age regardless of hearing status. Overall, however, our results confirm that use of traditional signal averaging is a poor metric of speech discrimination at an individual level. Future work will explore the replicability and maturation of the oscillatory EEG measures among IHH and INH using benchmarks of auditory development, which have been well-established among IHH.

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GL3

Towards the Optical Cochlear Implant: Optogenetic Stimulation of the Auditory Pathway

Tobias Moser [1] for the Göttingen Optogenetic Hearing Restoration Program

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Keywords: Cochlear Implant, Optogenetic, Restoration of Hearting

Background: When hearing fails, cochlear implants (CIs) provide open speech perception to most of the currently 1 Mio CI users. CIs bypass the defective sensory organ and stimulate the auditory nerve electrically. The major bottleneck of current CIs is the poor coding of spectral information, which results from wide current spread from each electrode contact. As light can be more conveniently confined, optical stimulation of the auditory nerve presents a promising perspective for a fundamental advance of CIs. Moreover, given the improved frequency resolution of optical excitation and its versatility for arbitrary stimulation patterns the approach also bears potential for auditory research.

Methods: Developing optogenetic stimulation for auditory research and future CIs requires efforts toward design and characterization of appropriate optogenetic actuators, viral gene transfer to the neurons, as well as engineering of multichannel optical CIs.

Results: The presentation will summarize the current state of optogenetic hearing restoration and report on recent breakthroughs on achieving high temporal fidelity and frequency resolution as well as on establishing multichannel optical CIs.

Conclusion: Preclinical proof of concept for optogenetic hearing restoration has been achieved and this work is being translated to late preclinical trials in non-human primates. We are currently preparing gene therapy and optical CIs for the first in human trial that we aim for in 2027.

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GL4

Deconvolution for flexible recording of transient evoked potentials

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Keywords: deconvolution, latency-dependent filtering, full-range auditory evoked potentials, compact representation.

Background: Traditionally, to enhance the signal-to-noise ratio of auditory evoked potentials (AEPs), electroencephalogram segments are averaged. However, this requires an inter-stimulus interval longer than the duration of the AEP to prevent contamination from neighbouring responses. On the other hand, *deconvolution* algorithms allow for the recording of transient overlapping AEPs. Here we present the fundamentals and the research potential of a deconvolution method based on matrix processing.

Methods: *Iterative Randomised Stimulation and Averaging* (IRSA) consists of an iterative process in which the AEP is estimated after suppressing the interference from adjacent responses [1]. A matrix-based formulation of this method [2] significantly reduced the high computational cost of its predecessor and demonstrated that the algorithm converges onto a least-squares (LS) deconvolution [3]. In addition, the matrix implementation of this method allowed for the representation of AEPs in a lower-dimension vector space compared to the *time* or *frequency* domains typically used for AEPs [4], and we showed that deconvolution in this reduced space is feasible and appropriate [5].

Results: Overcoming the maximum-rate limitation of the averaging method enabled the design of an experiment which was appropriate to characterise both short-term and long-term adaptation mechanisms for the first time in humans [6]. Further, our research showed that projecting the AEP onto a reduced vector space and projecting back onto the original time domain provided a latency-dependent filtering that facilitated a compact representation of AEPs from cochlea to cortex [4]. Performing deconvolution in the reduced space leads to an optimal least squares estimation of the AEP [5].

Conclusion: Deconvolution algorithms overcome the maximum stimulus presentation rate limitation imposed by averaging methods, thus providing greater flexibility in designing AEP experiments. Representing AEPs in domains different than time or frequency represents a new avenue for AEP research, with numerous potential applications. For instance, the latency-dependent filtering method enables a compact representation of AEPs from the entire auditory pathway—a natural representation that removes the traditional discontinuities between peripherical, middle and central AEPs. The methods have demonstrated their robustness through simulations, and supplementary materials such as toolboxes are available to facilitate their implementation.

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Industry Presentations: What`s new?

IN-1

Adaptive Noise Cancelling applied to OAE

Andre Lodwig, Thomas Rosner

PATH medical GmbH, Germering

Adaptive noise cancelling (ANC) aims at removing noise from a recorded signal by using a second channel for recording the noise alone. The idea of doing so is not new, the main reference dates back 1976. The principle is different from “active noise control”, as used in noise reducing headphones,

where “anti-sound” is created.

Applied to OAE, ANC means recording an extra sound channel outside the ear canal, in which OAE are to be recorded. This signal is processed with an adaptive filter and subtracted from the ear-canal recording, before detecting OAE from it.

Since the coupling from the outside to the inside of the ear canal during the OAE measurement is not previously known, a real time adaptation needs to be implemented to adapt the filter.

A general limitation is the nature of the diffuse sound field, which limits the correlation of both signals. Another complication is the fact that the OAE stimulus will also leak into the noise-recording- microphone.

Nevertheless, it turns out that a quite effective noise reduction can be achieved with the ANC principle with up to 12 dB reduction up to about 4 kHz. The method is commercially available in the PATH medical QSCREEN newborn screener for both TEOAE and DPOAE.

IN-2

Advanced SmartEP features on the IHS Duet platform for averaging, SNR estimation and audiovisual integration

Rafael E. Delgado, Ph.D.

Director of Research and Software Development

SmartEP offers advanced clinical and research tools for the acquisition of auditory and visual evoked potentials that provide enormous flexibility for stimulating, recording, and processing of data on the compact portable Duet clinical platform. The SmartEP software allows data to be acquired and stored in sweep blocks, providing options for different averaging, processing and statistical quality measures to be conducted.

Various live averaging methods such as standard, weighted, Bayesian weighted and Median averaging will be presented. Demonstrations will include how the various averaging methods affect noise and how data can be reaveraged using any of these methods during live acquisition or offline. Various signal-to-noise estimation methods including Fsp, Fmp and d-prime will also be presented. Finally, the presentation will also include methods for integrating visual and auditory stimulation using a newly developed Visual Stimulation Control hardware module that provides accurate synchronization between auditory and visual stimuli. The acquisition, averaging and analysis options provided in SmartEP enable clinicians and researchers to utilize a wide range of advanced techniques that are best suited for their particular needs and recording conditions in an easy to use and clinically friendly portable system.

IN-3

New developments of Pilot Blankenfelde

Rainer Thie

Pilot Blankenfelde, Blankenfelde, Germany

General

Pilot Blankenfelde GmbH was established in Brandenburg/Germany in 1990. The company develops, manufactures and sells electronic medical equipment. It has its own production facility in Blankenfelde, Germany.

Product line

The company's main field of activity is the development and production of diagnostic - instruments for ENT – applications.

Portfolio:	Audio – system	Corona e3
	ERA – System	Corona e3 *(evoke)*
	Automated – ABR	evoflash
	OAE with ANR	Corona e3 *(emission)*
	Electrical Promontory Test	Electrical stimulator
	PTA	Corona e3 *(enquire)*

Development / What's new

The core business of the company is product development by using of associated scientific experts. This is provided by an in-house staff with high qualifications in hardware and software technologies. The knowledge and insights into specific special ENT-requirements are generated by direct cooperation with several medical research departments.

What's NEW!

1. Cochlear implant diagnostic

One of an important scientific project was determined to develop closed applicable solutions for pre/intra/postoperative CI – diagnostic.

The resulting unique Cochlear Implant diagnostic concept is an innovative outcome after a successful cooperation between Mr. Prof. Martin Walger (Clinical department of pediatric audiology / University Cologne) and Pilot Blankenfelde GmbH. This part of our product portfolio is worldwide unique.

Main parts of the CI – concept:

1. Subjective electrical promontory test by using of an accurate adjustable electrical stimulator.
2. Objective electrical ABR by using of an external electrical stimulator
3. Intraoperative electrical ABR after first placement of the CI during the operation
4. Postoperative analyse of ABR or LLR by using of free-field speaker.

The concept provides the most needed pre/intra/postoperative CI – diagnostic modules to watch the complete processes.

2. ABR-phase analysis + denoising (ongoing)

The ongoing project is based on a tight scientific collaboration between the Neuroscience department of the university Saarland and the Pilot company. Mr. Prof. Dr. Daniel Strauss who is the full professor of the SNN unit and specialist in event related potentials is the associated cooperation partner in the development of special phase analysis methods of the recorded ABR-potentials. The aim is to provide additional useful objective features (green or red highlighted results) in the process of analysis.

IN-4

New avenues in cochlear implant objective measures – Advanced Bionics' AIM system

Dr. Raphael Koning

Advanced Bionics Germany GmbH, Hannover, Germany

The AIM system of Advanced Bionics is used for objective measures in Advanced Bionics' cochlear implant recipients. It offers a variety of applications focusing on maximizing the hearing performance of cochlear implant users.

The current use of the AIM system in clinical practice is to use real-time measurements of the cochlear microphones to provide real-time feedback to the surgeon during the insertion of the electrode array. The cochlear microphonics are used as an indicator if the delicate structures in the cochlea are touched or damaged by the insertion of the electrode. Results of recent studies suggest that residual hearing and cochlear structure of cochlear implant recipients can be preserved with the use of real-time feedback based on electrocochleography. Although the main application of the AIM system is insertion monitoring, Advanced Bionics always looks to extent the functionality of its objective measurement platform. Future applications are the support of evoked potential machines to record electrically evoked auditory brainstem responses. Due to the flexible technological capabilities of the Advanced Bionics implant systems, it was shown that cortical auditory evoked potentials could be measured using the implanted electrode in the cochlear as a sensor for the brain activity. In clinical studies, it was shown that the recording of central potentials via the intracochlear electrode is possible in adults and children without the need of additional equipment. This proof-of- concept opens new avenues to the realization of a brain computer interface application in cochlear implant users. In this presentation, an overview of clinical evidence for the different applications of the AIM system is given.

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IN-5

Innovative Evoked Response Audiometry with MED-EL

Dr. rer.nat. Philipp Spitzer

MedEl Medical Electronics Innsbruck, Austria

Hearing implants from MED-EL and the corresponding software support recording evoked responses from the auditory nerve in several ways. Clinically available methods include ECAP (AutoART or ART), ECochG (ART Advanced Setup) and EABR (EABR Task with external equipment). Exploring new ideas for characterizing, extending, or optimizing recording evoked responses requires full control of the measurement sequence and access to the recorded raw data. This talk will focus on ways to access and process the raw data of AutoART measured with MAESTRO as an example of how that can be done with MED-EL. Additionally, one possibility is shown on how to freely define the stimulations and corresponding recordings to realize and evaluate not-yet-available innovative measurement concepts in studies. Lastly, some not-so-well- known tips and tricks relevant to the audience are presented.

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IN-6

Diagnostics for smart and connected hearing implant care

Jörg Pesch, Cochlear AG

For hearing implants, the current care model is still very much a centralized, expert-based, in-clinic model. Major bottlenecks are that (1) interactions with hearing implant (HI) users and the visibility of their issues in daily-life situations to professionals are mainly limited to in-clinic visits and to retrospective reviews, (2) expert professionals are too much involved in routine care which may hamper them to serve new implant candidates or to have more bandwidth for more demanding cases. Furthermore, this model is hard to scale up to serving more HI users in the future, while this is highly needed (WHO 2021 Report on Hearing).

An attractive alternative is to distribute the care process, involving local care givers and ultimately the hearing implant users themselves. The expert clinician can still monitor remotely (human-on-the- loop). We believe strongly that such a distributed care model can improve hearing outcomes, while improving the experience of all people involved. E.g., HI users can go on and live their lives, only needing to see a clinician and being tested in the clinic when there is a good reason.

This evolution to a more distributed care model – connected care – has kicked off. The latest generation of Cochlear's hearing implants have wireless smartphone connectivity, enabling to connect through the cloud with the clinician.

Cochlear is developing new technologies and tools to go beyond the capabilities of the current solutions. Diagnostic data can be collected more frequently (continuously monitored) and with higher precision and diversity. Objectives measures on different levels can cover the integrity of the electrode-neural interface, the status of cochlear health and neural health as well as the correct device function and settings.

Clinicians will not have time to manually interpret the large data streams. Therefore, intelligent agent technologies will be required to interpret the data and alert users and clinicians or make predictions about upcoming clinical events, which enables a pro-active treatment of these issues.

For example, such a feature will address a major challenge in our field: long-term preservation of residual hearing. A timely detection of an unusual (e.g., inflammatory) event and a quick referral to the ENT clinic may help to prevent this.

IN-7

CM detector for automatic ASSR-based Hearing Threshold Assessment

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Keywords: auditory steady-state responses, automatic response detection, cochlear microphonics, auditory neuropathy spectrum disorder

Background: It has recently been discussed whether hearing screening and hearing threshold assessment can accurately be completed using automated ASSR methods for children with auditory neuropathy spectrum disorder (ANSD). Possible causes for the claimed potential failures were investigated here.

Methods: At the ENT clinic Würzburg, raw data of routinely performed ASSR examinations with the Interacoustics A/S Eclipse were collected during a limited period for quality evaluation. In total, the data pool contained ASSR recorded from 274 patients. They are a common mix of patients scheduled for ASSR examination during routine clinical practice. The data analysis is based on visual identification of cochlear microphonics, wave V in ABR and ASSR measurements and analysis of corresponding patient files.

Results: Cochlear microphonics (CM) were found in 18 of the 274 patient records. Four of these 18 were obtained from patients with ANSD. One patient with ANSD without click auditory brainstem responses up to 100 dBnHL demonstrated clear ASSR responses from 65 dBnHL upwards. Where click stimulation suggests an auditory nerve defect, narrow-band chirps were shown to evoke ASSR in certain patients. CMs are elicited by narrow-band chirps in the same way as by broadband stimuli. CM residuals as well as a presumed enlarged wave I with absent neural responses, always accompanied by CM, were found as possible causes of misinterpretation at high stimulus levels. A CM detector was created.

Conclusion: The CM detector, indicating the presence of CM, will prevent misinterpretation of clinical ASSR results. In addition, the CM Detector extends the diagnostic possibilities: Detected CM in the absence of ASSR suggest a retrocochlear disorder.

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Free Paper

FP-1

Comparison of auditory brainstem recordings acquired at various stimulation rates from typically developing and autism spectrum disorder children

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Keywords: Autism Spectrum Disorders (ASD), Auditory Brainstem Response (ABR), Continuous Loop Averaging Deconvolution (CLAD)

Background: Autism Spectrum Disorders (ASD) are characterized by persistent deficits in social communication and social interaction across multiple contexts and restricted, repetitive patterns of behavior, interests, or activities. Symptoms cause clinically significant impairment in social, occupational, or other important areas of functioning. Although ASD symptoms are present in the early developmental period and can be recognized in the first two years of life, many children are not diagnosed until much later. Early identification and intervention are critical for the improvement of outcomes in many disabilities including ASD. Auditory brainstem response (ABR) peak latency delays have been associated with ASD (see Miron et al., 2020). Fujikawa-Brooks et al. (2010) reported a significant ABR stimulation rate effect associated with ASD. This study expands on the use of high stimulation rate using Continuous Loop Averaging Deconvolution (CLAD) (Delgado & Ozdamar, 2004) to acquire ABRs at stimulation rates above 61/sec used by Fujikawa-Brooks et al.

Methods: ABRs were recorded from 16 ASD and 25 typically developing (TD) control subjects ages 2.7 to 5.9 years old. A 65 dB nHL 100 µsec click was presented at various stimulation rates (19.3, 39.30, 58.59, 195.31 and 234.38 Hz). The CLAD technique was used to deconvolve overlapping responses acquired at the stimulation rates above 39.30 Hz. The ABR system (Duet, Intelligent Hearing Systems Corp, Miami, FL, USA) bioamplifier filter settings were set to 70-3000 Hz with a gain of 100K times. The ABR peaks were labelled by two blinded ABR experts. ABR peak latency differences between the two populations were compared.

Results: Significant ABR peak latency delays were found at all stimulation rates for the ASD population: 19.3 Hz, 0.20 ms (p=0.00), 39.30 Hz, 0.30 ms (p=0.00), 58.59 Hz, 0.22 ms (p=0.00), 195.31 Hz, 0.18 ms (p=0.18) and 234.38 Hz, 0.18 (p=0.11). The mean peak V latency delay was 0.21 ms (SD = 0.05 ms) and was generally consistent across all rates. The I-V interpeak latency increased from 3.95 ms to 4.12 ms and from 4.02 to 4.51 ms for the TD and ASD groups respectively from 19.3 Hz to 58.59 Hz. As the stimulation rate was increased, the proportion of recordings with a recognizable ABR peak V dropped from 95% and 88% at 19.3 Hz for the TD and ASD groups respectively, to 69% and 44% at 234.3 Hz for the TD and ASD groups respectively. Signal-to-Nosie and Residual Noise measures were not significantly different for both groups.

Conclusion: The use of ABR high stimulation rates for early ASD detection is very promising. Although the absolute latency delay was consistent across rates, the proportion of recordings with recognizable responses and the I-V interpeak latency difference indicates a potentially valuable measure to differentiate TD and ASD groups. The latency delays found in this study are consistent with the previous study by Miron et al. (2020) conducted on a population of 138,844 newborns which included 321 ASD cases. Further work is needed in developing an ABR-based ASD screening tool that can be incorporated into ABR-based newborn hearing screening systems.

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FP-2

Simultaneous deconvolution of multiple auditory evoked potentials in a reduced representation space

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Keywords: Deconvolution, least squares estimation, multi-response deconvolution, latency-dependent filtering and down-sampling (LDFDS).

Background: Deconvolution algorithms allow the estimation of transient auditory evoked potentials (AEPs) that are overlapped. Least squares deconvolution can be formulated as a linear system of equations, or equivalently, as a matrix equation. The deconvolution of AEPs involves a matrix division with a J x J matrix (being J the length of the response, in samples) [1,2]. Multi-response deconvolution with M categories of responses requires a matrix division with a (J x M) x (J x M) matrix, and the computational complexity of the deconvolution increases in scenarios involving several different stimuli (i.e., a large M) or longer duration responses (i.e., a large J).

Multi-response deconvolution: A method is proposed to effectively achieve multi-response deconvolution when long-duration AEPs and/or several categories of stimuli are considered. The method relies on the dimensionality reduction that provides latency-dependent filtering and down-sampling (LDFDS) [3], a procedure that progressively reduces the filter bandwidth and the sampling rate as the AEP latency increases. In LDFDS, wider filter bandwidths and higher sampling rates are used in early latencies (appropriate for auditory brainstem components), and narrower bandwidths and lower sampling rates in later components (appropriate for middle latency and cortical components). De la Torre et al. (2020) showed that a full-range AEP comprising auditory brainstem, middle latency, and cortical components (which usually requires J = 10.000 samples at a constant sampling rate) could be correctly represented without information loss in the reduced representation space with only J_r = 120 samples [3]. The dimensionality reduction provided by LDFDS is appropriate for deconvolution. In fact, de la Torre et al. (2022) showed that performing deconvolution of a single-category response in the reduced representation space reduces noise and computational cost [4]. Here we show that reducing the dimensionality is critical to perform multi-response deconvolution, as this reduces the size of the squared matrix to be inverted to (J_r x M) x (J_r x M) (being $J_r \ll J$).

Method validation: [*Methods*] The performance of the proposed method was evaluated in terms of its capability to accurately estimate overlapping AEPs evoked by different stimuli and the time required to perform deconvolution. Four normal-hearing adults (1 female, 23–38 years) participated in a study involving 84.000 click repetitions presented with an inter-stimulus interval that varied randomly between 15–30 ms, in which the stimulus level was also randomised between 0–80 dB HL. The EEGs (Fz–combined mastoid) were filtered using a 20–3300 Hz bandwidth to let pass both brainstem and middle-latency components. This experimental design allowed click events to be categorised in terms of different level intervals. For example, we considered (i) 20 dB intervals leading to M = 4 categories; (ii) 10 dB intervals leading to M = 8 categories, (iii) 5 dB intervals leading to M = 16 categories; and (iv) 2.5 dB intervals leading to M = 32 categories. The AEPs from each category were estimated via multi-response deconvolution, which was performed both in the complete representation space (using J = 3277) and in the reduced representation space (using J_r = 91).

[*Results*] The morphology of the deconvolved AEPs was consistent with previous literature. The components of brainstem and middle-latency responses could be identified in all participants, and followed the expected amplitude reduction and latency increase as level reduced. Increasing the number of categories (or equivalently, reducing the level interval) led to higher resolution in level but since less events belonged to each category, the AEPs were more affected by noise. Performing deconvolution in the reduced space led to a substantial reduction

in processing time. For example, when 8 categories were considered, the multi-response deconvolution required 304 seconds in the complete space and 23 seconds in the reduced space. Importantly, deconvolution in the complete space could not be computed when more than 8 categories were considered due to memory overflow. However, multi-response deconvolution in the reduced space could be achieved in all scenarios.

Conclusion: Performing multi-response deconvolution in a reduced representation space significantly reduces processing time, and enables deconvolution when long-duration AEPs and/or several categories are considered. This overcomes an important technical barrier that has prevented a generalised use of this technology. Multi-response deconvolution is a tool that enables researchers design experiments with great flexibility, and may help advance knowledge in hearing neuroscience. For example, this tool may help understand how the human auditory system encodes complex sounds like real speech, binaural hearing processes, and characterise the well-known non-linearities of the auditory system.

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FP-3

The Clinical Evaluation of a Modified Fmp in Infant Auditory Brainstem Response Tests

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Objective: The performance of a modified calculation of Fmp in ABR tests in infants was evaluated using the Interacoustics Eclipse system.

Design: Using UK national guidelines published by the British Society of Audiology, the ABR threshold was established on 50 infant ears at 4 kHz and 41 infant ears at 1 kHz. A specificity-based Fmp criterion for response presence was established from the distribution of no-response values. This criterion was then applied to determine the sensitivity of Fmp in detecting responses which had met the BSA guidance for response presence.

Results: A 97.5% true negative rate in no-response waveforms corresponded to an Fmp of 2.2. Using the BSA method of waveform interpretation as the reference, this Fmp criterion detected 85% of 4 kHz and 68% of 1 kHz responses at 10 dB above the ABR threshold but only 51% of 4 kHz and 32% of 1 kHz responses at the ABR threshold.

Conclusions: Fmp has reasonable clinical utility at stimulus levels above the ABR threshold but is not an adequate replacement for strictly applied conventional waveform interpretation at the ABR threshold. A proposal is offered that should improve Fmp sensitivity.

FP-4

Revisiting the interleaved ABR: a relatively simple means of reducing test time?

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Keywords: interleaved ABR, second-generation ASSR, chirp

Background: In recent years the so-called "second generation" ASSR (90 Hz) has risen to prominence as perhaps the swiftest means to estimate hearing thresholds objectively (Sininger et al., 2020). However, many test protocols are still centred on the transient ABR, and some parts of the assessment (like auditory neuropathy screening) rely on interpreting waveform morphologies not available with ASSRs. Therefore, efforts to decrease ABR test time continue. One means is by interleaving multiple stimulus frequencies (Buran et al., 2020; Polonenko & Maddox, 2019). Similarly, a simple interleaving of stimuli between the two ears could offer a more accessible performance improvement. Interaural interleaving of ABR stimuli is not new (Plourde et al., 1988) but even so, a longer serial test sequence remains commonplace. Following on from previous work in our lab (Bencito, 2020; Lien, 2022; Nofal, 2022) we compared both test time and relative accuracy of threshold estimation between the interleaved ABR and second generation ASSR. We hypothesised that interaural interleaving would reduce or eliminate the time advantage of the ASSR with no meaningful difference in the accuracy.

Methods: A broadband "Don" chirp (0.1-8 kHz) was used to elicit both ASSRs and ABRs from 15 normally hearing adults in a counterbalanced order. Stimuli were delivered at 20, 30 and 40 dB nHL via ER3-A insert earphones. For the ASSR, binaural stimuli were delivered at rates of 87 and 93 Hz to left and right ears and for the ABR, interleaved stimuli were delivered at an overall rate of 33 Hz. Data were captured via a Biosemi ActiveTwo device using a high forehead-to-ipsilateral mastoid montage. Offline analysis and reconstruction of the response detection process was then performed. ASSR data were filtered (60-1000 Hz, 60 dB/oct), weighted averaged, and analysed in the frequency domain using Mardia"s modified q-sample statistic to determine when a response was resolved. Likewise, ABR data were filtered (80-1500 Hz, 60 dB/oct), weighted averaged, and the Fsp statistic was used to determine when an ABR was resolved. Threshold information was extrapolated from an amplitude-level function, by estimating the level where the signal-to-noise ratio would fall below that required to reach the 99% confidence level for a response to be considered clearly present.

Results: Clear responses were found in 86/90 instances for the ASSR in a mean time of 259 seconds (SD = 170) for all three levels of stimulation. For the ABR, clear responses occurred in 81/90 instances in a mean time of 244 seconds (SD=187), which was not statistically significantly different ($t_{14} = 0.2$; $p = 0.81$). The ASSR data indicated clear responses would be detected on average down to 10 dB nHL compared with 15 dB nHL for the interleaved ABR.

Conclusion: The option of delivering interleaved stimuli seems to offer a simple means of reducing ABR test time to the point where no differences can be found compared with the gold-standard ASSR. Further investigations using more frequency specific stimuli are a useful way forward.

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FP-5

Exploring across-frequency interaction in simultaneously recorded auditory brainstem responses

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Keywords: Electrophysiology, ABR, wave V, narrowband CE-Chirp, simultaneous ABR, band-interaction

Background: Currently, the gold standard procedure for objectively evaluating hearing in infants is the auditory brainstem response (ABR). This involves consecutively presenting frequency-specific stimuli to one ear at a time and determining the presence of wave V before moving on to the next stimulus or intensity. However, this approach is time consuming, which has led to the development of alternative methods such as the auditory steady state response (ASSR). In this study, we explored a new approach that involves recording multiple ABRs simultaneously in response to narrowband (NB) CE-Chirps [1] at frequency-specific clinical discharge levels [2]. We specifically investigated the impact on ABR morphology (amplitude and latency) when gradually increasing the presentation level of one NB CE-Chirp while keeping the remaining stimuli at their individual clinical discharge levels.

Methods: ABRs were obtained in response to NB CE-Chirps centered at frequencies 500, 1000, 2000, and 4000 Hz from 20 normal-hearing young adults at clinical discharge level (30 dB eHL) [2]. All NB CE-Chirps were simultaneously presented to both ears with a jitter relative to the nominal 40-Hz rate using IP30 insert earphones and alternating stimulus polarity. ABRs were recorded using a clinical Interacoustics Eclipse system with a MATLAB research interface. The Fz to M1 montage was used, and we employed dual stopping criteria: a residual background noise estimate of ≤30 nV and a minimum of 4500 averages. A total of 2080 ABRs were recorded and visually inspected to determine the peak latencies and amplitudes of wave V, following clinical guidelines [2].

Results: The results showed that there were no changes in the group mean amplitude or latency on the opposite ear when the level was increased for any of the four NB CE-Chirps. However, when the level of any of the four NB CE-Chirps was increased, we observed the expected reduction in mean latency of wave V and an increase in the mean amplitude of wave V in the corresponding ABR. We also observed band-interaction between the NB CE-Chirp with increased level and the neighbouring stimuli. This interaction resulted in a decrease in wave-V amplitude and a longer wave-V latency. For example, increasing the level of the 1000 Hz NB CE-Chirp affected the morphology of the ABR of the 2000 Hz NB CE-Chirp ABR at the discharge level. The effects of band interaction were observed both upwards and downwards in frequency, and successively more as level increased.

Conclusion: This study offers valuable insights into the effects on the morphology of ABR waveforms when recording multiple frequency-specific ABRs simultaneously. The findings indicate that band-interaction occurs, resulting in changes in the amplitude and latency of wave V in the mean ABR morphology when the level of one NB CE-Chirp is increased. Specifically, we observed a longer latency and smaller amplitude, which are similar to the results seen when the presentation level is reduced. For a clinical application, the results here demonstrate the importance of quantifying and accounting for band-interaction effects when recording multiple frequency-specific ABRs simultaneously.

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FP6

Optimal ASSR stimulus repetition rates in normal and hearing-impaired infants

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Background:

Since the introduction of newborn hearing screening, it is performed routinely in newborns to detect hearing loss. Objective measures, such as auditory steady state responses (ASSR), are often used in the screening and to determine the hearing loss after a failed screening. In the Eclipse® (Interacoustics A/S, Denmark) device, standard repetition rates around 90/s are used together with frequency-specific chirp stimuli centered at 500, 1000, 2000, and 4000 Hz, respectively (the narrow-band (NB) CE-Chirps). Detection of a response is done by means of an automatic detection algorithm, which evaluates harmonics of the stimulus-specific repetition rate.

This study investigates if the current ASSR measurement method can be improved by choosing repetition rates individually for the four NB CE-Chirps among the 20, 40, 65, and 90/s ranges. This is investigated by measuring NB ASSRs in infants using insert phones with two different combinations of the four stated repetition-rate ranges. It is expected that group mean ASSR detection times, detection rates, and signal-to-noise ratios (SNR) will be dependent on the repetition rate and NB stimulus" center frequency. We hypothesize that lower centre-frequency stimuli will have the same or lower detection times / higher detection rates / higher SNR for lower stimulation rates. For higher centre-frequency stimuli similar trends are expected for higher stimulation rates. . Reduction in ASSR detection time and increase in detection rates can be explained in terms of increases to SNR that might occur in either the fundamental or any of the higher harmonics of the stimulus repetition rate.

Methods:

ASSR measurements were performed in 20 normally hearing and 15 hearing-impaired infants aging from three to 12 months. Both ears were tested simultaneously using NB CE-Chirps. The stimulus level for the normally hearing infants was 40 dB nHL while for the hearing-impaired infants individualized levels of 10 dB SL (sensation level) were used. In the low frequencies (500 and 1000 Hz) the repetition rates of 20/s, 40/s, 65/s, and 90/s were tested while in the high frequencies (2000 and 4000 Hz) only the repetition rates of 65/s, and 90/s were tested.

Results:

Results were analyzed separately for each stimulus frequency in terms of the number of successful detections for each repetition rate tested. For the normally hearing infants, significant differences were found for the 1000-Hz frequency band, where using 65/s lead to more detections than the 20/s and 40/s rates; and in the 4000-Hz frequency band, where using 90/s lead to more detections than any of the lower repetition rates.

For the hearing-impaired infants, significant differences were found for the 500-Hz frequency band where 40/s lead to more detections than 90/s; for the 1000-Hz frequency band where 40/s lead to more detections then 20/s; and finally at 2000 Hz where one of the two 65/s was better than the other and the two repetition rates near 90/s.

No other comparisons indicated significant differences.

Conclusion:

We recommend using lower repetition rates like 40/s when stimulating in the low center frequencies (500 and 1000 Hz) and 65/s or the standard of 90/s for the higher center frequencies (2000 and 4000 Hz).

FP7

Reliability of the ASSR-based NHS for identifying children with suspected ANSD

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Keywords: objective measurement, auditory steady-state responses, automatic response detection, auditory neuropathy spectrum disorder

Background: Objective test methods are regularly used for hearing screening and hearing threshold determination. The detection of the response is usually carried out automatically and thus saves time that would be necessary for a visual evaluation. In everyday clinical practice, some patients show a discrepancy between the visually determined traditional auditory brainstem responses (ABR) and the hearing threshold determined using the automatic auditory steady-state responses (aASSR). A recent publication (Cebulla et al, 2022) showed that this discrepancy only occurs at relatively high stimulus levels (>60 dBnHL). It is suspected that children with auditory neuropathy spectrum disorder (ANSD) can have abnormal ABRs that maybe result in a pass when aASSR-based newborn hearing screening is performed. Therefore, the aim of the present retrospective study was to investigate this in children diagnosed with ANSD.

Methods: The study included clinical data from 21 children who were diagnosed with ANSD within the last 25 years in our clinic. The results of the newborn hearing screening (NHS), ABR and aASSR (PTA4) measurement were included in the evaluation. The ABR data was evaluated visually by locating the peak and latency of wave V and regarding the presence of CMs.

Results: Analysis of the NHS results shows that all children failed screening using the aASSR method, but 7 out of 9 children passed OAE (Otoacoustic Emission) based hearing screening. Cochlear microphonics could be identified in almost all ABR tracings (92.3%) of the investigated ears. The mean hearing threshold of the occurrence of CM was 76.5 dBHL and does not deviate significantly from mean PTA4 aASSR threshold (78.4 dBHL). The mean ABR threshold was highest with 96.0 dBHL.

Conclusion: From the results it can be concluded that NHS devices based on aASSR can be used without hesitation for a reliable NHS. Generally, if children fail the NHS and it is sent to follow-up it is important to perform primarily an ABR measurement along with other objective measurement like aASSR. The procedure avoids overlooking irregularly ABR as a possible indication for ANSD.

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FP8

A novel method to detect auditory evoked potentials – the Fmpi

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Background: Hearing screening is critical to early detection and intervention in the case of hearing loss. Auditory brainstem responses as well as auditory steady-state responses are well-established and standardized objective screening measurements. In addition to screening, auditory evoked potentials (AEPs)—subcortical and cortical—offer an attractive objective alternative to fit hearing-aid devices and to provide information beyond the simple detection of sounds (e.g., speech discrimination) in infants. Beyond direct clinical impact, AEPs continue to provide important basic understanding of auditory processing in the brain. Whilst the benefit of using AEPs and their impact are clear, their reliability and potential clinical implementation are dependent of the detection method used and the inherent properties of the background neural activity present in the test subject"s brain, which can vary across subjects. To solve this problem in real-time implementations, in which the cost of false detections can be high, a conservative approach, based on specific assumptions about the underlying noise, is typically used. Whilst this helps to control error rates, it leads to slower detection and potentially reduced sensitivity in detecting responses. Exhaustive bootstrapping methods offer a much more reliable and adaptive approach, but they come with a substantial computational burden, limiting their clinical impact. Here, we introduce and validate a novel approach for AEP detection, referred to as the Fmpi method. This approach provides improved detection and controlled error rates by exploiting the recording-dependent characteristics of the background neural activity.

Methods: Simulations of AEP responses under different background noise conditions (1 / f noise, with and without non-stationary events) were performed to compare several state-of-the-art detection methods, including the Hotelling-T2, F-test, and q-sample with bootstrapping. Following the results of the simulation, we analyse both brainstem and cortical recordings obtained from adults and infants.

Results: Simulations indicate that the novel Fmpi method leads to improved detection rates and better controlled false-positive rates, specially under 1/f non-stationary noise conditions. Employing real AEP recordings, we find that the Fmpi method outperformed or performed similarly to the best of the state-of-the-art detection methods used in this study, including bootstrapped q-sample statistics.

Conclusion: The new Fmpi method offers an adaptive approach to detect AEP responses with improved performance, which can be applied to multiple AEP recordings, including brainstem as well as cortical responses. Furthermore, the Fmpi method can be used in real-time with little computational cost, making it suitable for research and clinical environments.

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FP9

Evaluation of the fitting success of a hearing aids using ABR and a novel free-field headphone

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Introduction: In audiological diagnostics, hearing thresholds (HT) can be estimated using early auditory evoked brainstem potentials (ABR). So far, this measurement method is rarely used to evaluate the fitting outcome of hearing systems. In the presented study, using a free-field headphone (FF headphone, A2000, Acousticon Hearing Systems GmbH, Germany), the ABR are recorded during acoustic stimulation via a hearing aid (HA) and compared with the ABR in the listening situation without amplification. It is investigated whether the gain of a HA can be objectified by means of ABR.

Methods. Children and adults with and without hearing impairment are studied. Using the FF headphone, ABR are compared between both listening situations (with & without HA). First, the external transducer was calibrated for the click stimulus (2-4 kHz, 100 µs) using the ABR measurement system (Eclipse EP25, Interacoustics). Specifically, for calibration in dB nHL, correction values (so-called peRETSPL values) were determined using an adaptive subjective HS determination in adult normal hearing (NH) subjects. Subsequently, FAEP were registered in normal-hearing children (10.5±2.1 Y; N=6) and adults (31.9±8.1 Y; N=15) and acoustic stimulation via a test HA (Phonak Sky B50-P) to obtain norm data for both listening situations. ABR were evaluated with respect to stimulus response threshold and Jewett V wave latency (JV). Pure tone audiometry (PTA) was also performed, and a the subjective perception threshold (loudness scaling) was determined in both listening situations.

Results. The ABR comparison showed an HA effect for the normal-hearing children and adults, characterized by a delay in latencies and an increase in stimulus response thresholds for the listening situation with compared to without HA (Ø=14.8±4.9 dB nHL).

Conclusion. The measured transmission time of the HA (6.48±0.11 ms), which is consistent with the latency shift, demonstrates that the delayed ABR latencies can be explained by the signal processing of the HA. The increased stimulus response threshold for the listening situation with HA for the normal-hearing children and adults can be explained by the inherent noise of the HA, which leads to masking of the ABR. In general, the results showed good agreement between the ABR thresholds and PTA results or subjective perception thresholds for the normal-hearing children and normal-hearing adults.

The initial results of the normal-hearing children and adults show that measurement of HA in an HA provided ear using ABR measure and the FF headphones is possible in principle. This suggests that the amplification can be objectified in young HA provided children and adults. Preliminary results from children and adults with HA will be presented along with normative data from the NH.

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FP10

Free-field evoked auditory brainstem responses in Cochlear-Implant patients - an objective method for the analysis of aggregate system latencies

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Background: The importance of binaural information processing for the performance of auditory tasks, such as sound source localization and separation, is widely accepted. When providing a cochlear implant (CI), the peripheral auditory system is partially replaced, which leads to processing delays, that can eventually distort important interaural time differences. However, these effects are still poorly understood, thus optimal systematic binaural fitting strategies are still missing. The aim of this work was to develop a new and objective analysis method that is capable to investigate aggregate system latencies in CIs.

Methods: Free-field evoked auditory brainstem responses (ABRs) were measured and evaluated in 12 CI users and 12 normal-hearing (NH) people using two stimuli (chirps & clicks) at four intensities each. The ABRs were evaluated on the one hand based on the obtained mean value of 2,000 trials each and on the other hand on the resulting phase synchronization of the respective single trials.

Results: Differentiable ABR attributes and growth functions for both stimuli and all intensities could be determined in all groups.

Conclusion: In particular, the phase synchronization measures over the respective single trials seem to serve as a promising marker for the general identification of free-field evoked ABRs in CI patients and thus could enable an objective and manufacturer-independent evaluation of systematic latencies.

FP11

Gaussian Processes for efficient audiogram estimation with Auditory Brainstem Responses

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Background: The Auditory Brainstem Response (ABR) is widely used to determine hearing thresholds in newborns and other subjects who are unable to cooperate with behavioural testing. However, the test time tends to be long: even when estimating just 8 frequencies (4 per ear), average test times are typically in the 30 to 60 minute range for sleeping newborns. If the newborn wakes up or becomes restless, testing may need to be stopped, resulting in incomplete information. Improving test time could allow more clinical information to be gained in a given test session, allowing better clinical management of hearing loss.

Statistical detection methods are now widely applied to ABR measurements (such as with Fmp or Hotelling T squared) to determine the presence or absence of an ABR. These methods are sensitive compared to visual inspection and hence can reduce measurement time. However, they are designed to detect the ABR at a single stimulus level and frequency. As a result, they overlook the well-known correlation structure underlying ABR waveforms across different stimulus levels and frequencies, thereby neglecting valuable information. This contrasts with visual inspection by clinicians where information from a high-level measurement can be used to inform the likely presence of a response at a lower level.

Objective: The main objective for the current work was to reduce test time for audiogram estimation by exploiting the correlation structure underlying ABR waveforms using a Gaussian Process (GP): a Bayesian approach for non-linear regression. This is combined with active learning methods to efficiently sample the frequency-intensity input space and maximize the amount of information gained within limited test time.

Design: Audiograms were estimated to band-limited chirp stimuli at 4 frequencies in 22 normal-hearing and 9 hearing-impaired subjects using (1) a behavioural approach, which served as the gold standard (2) visual inspection of ABRs by examiners using guidelines provided by the British Society of Audiology (BSA), and (3) the newly developed GP approach applied to ABR. A bootstrap method to estimate the underlying peak-to-peak (P2P) amplitude of the ABR was used as the input to the GP. The GP aimed to estimate ABR P2P values along the amplitude-intensity growth function. The growth function was then used to estimate hearing thresholds. Comparisons were drawn between the GP and the standard BSA approach in terms of test time and test accuracy.

Results: Average test times for audiogram estimation were 31.2 minutes (std. 11.6) for the GP, and 57.1 minutes (std. 11.1) for visual inspection by clinicians. The average hearing threshold estimation error - defined as the difference between the estimated hearing threshold and the behavioural threshold - was 0.5 dB for the GP (s.d. 9.4) and 7.2 dB (s.d. 6.3) for visual inspection.

Conclusions: The GP reduced test time by approximately 45% compared to visual inspection by clinicians. Average hearing threshold estimation error was also lower for the GP, but the errors were more variable (and occasionally quite high), although there is scope to reduce this by optimising the threshold algorithm choice. Overall, results suggest that the GP has potential for reducing ABR measurement time and warrant further investigation.

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FP12

Cochlear contributions to the ABR to narrowband chirps versus 2-1-2 linear-gated tones: A high-pass noise/derived response study

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Background: In recent years, many researchers have recommended using narrowband chirp (NBchirp) stimuli for threshold ABRs instead of more-standard 2-1-2 cycles linear-gated tones, primarily because NBchirps often result in larger ABR wave V amplitudes. However, the acoustic frequency spectra of currently recommended NBchirps are wider than those for 2-1-2 tones (e.g., Adjekum et al., 2019), and it is currently not known whether ABRs to these NBchirps have similar (or poorer) cochlear place specificity compared to 2-1-2 tones. The current study used the high-pass noise/derived response (HP/DR) technique to assess the cochlear regions contributing to ABRs evoked by NBchirps versus 2-1-2 tones.

Methods: A total of 24 adults with normal hearing participated (N=12 for each stimulus frequency). Stimuli were 60-dB peSPL 500- and 2000-Hz NBchirps and 2-1-2 cycles linear-gated tones, mixed with broadband (pink) masking noise, and presented via ER-3A earphones. The level required to mask the ABR was determined individually. The broadband noise at this level was then HP filtered (effective slope: 100 dB/octave) using 10 cutoff settings (½-octave intervals). Three ABR replications (50-1500 Hz EEG filter) were obtained, with recordings stopped when the residual noise level (RNL) of each replication was reduced to 40 nanovolts. Wave V-V' amplitudes were measured from the grand average of the 3 reps; the waveform's RNL was entered for no-response results.

Results: 1-*octave-wide DR results:* amplitude profiles for the ABRs to 2-1-2 tones show good cochlear place specificity, as described in previous studies. DR results for the NBchirps are similar but show important differences. The profile for the 2000-Hz NBchirp shows significantly larger amplitudes in the 4- and 1-kHz derived bands compared to the 2-1-2 tone. Many more responses were seen 1-octave away for the 2000-Hz NBchirp compared to 2-1-2 tone (DR4kHz: 100% vs 25% present, p=.008; DR1kHz: 100% vs 58% present, p=.07). DR results for 500-Hz tones tended to show similar patterns but differences did not reach statistical significance. *HP noise masking results:* for both 500- and 2000-Hz stimuli, HP noise masking results demonstrate significant amplitude decreases occur 1 to ½ octave higher for ABRs to NBchirps versus 2-1-2 tones. The ABR amplitude advantage for NBchirps is substantially reduced (2000 Hz: 80% down to 25%) or removed (500 Hz: 46% down to 22%) after masking frequencies greater than ½-octave above the stimulus frequency. [Analyses of results for ½-octave-wide DRs are in progress.]

Conclusions: ABRs to narrowband chirps reflect wider cochlear contributions than those to 2-1-2 tones. Responses to NBchirps arise from cochlear regions as far as 1 octave away from the stimulus frequency (e.g., responses to 2000-Hz NBchirps have large contributions from the 4-kHz cochlear region). In contrast, responses to 2-1-2 tones arise from cochlear regions primarily within approximately ±0.5 octaves of the stimulus frequency. Although ABR amplitudes to nonmasked NBchirps may be larger than those to 2-1-2 tones, this comes at a significant cost in frequency and cochlear place specificity.

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Keywords: ABR, narrowband chirps, 2-1-2 tones, high-pass noise masking, derived response

FP13

Intraoperative ECochG in cochlear implantation: the ANN/CM-ratio as predictive measure of hearing preservation

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Background: To reduce possible intracochlear damage of hair cells and preserve existing residual acoustic hearing, surgical technique enhancements such as reducing speed of electrode insertion, studies have suggested that intraoperative recording of ECochG components, i.e. the compound action potential (CAP), summating potential (SP), cochlear microphonic (CM) and auditory nerve neurophonic (ANN) might be a tool to predict postoperative acoustic hearing preservation. Our previous study have reported that a drop of >30% of the intraoperative cochlear microphonic (CM) response seems to be associated with postoperative with hearing loss (HL). However, since CM seems to fluctuate due to non-trauma-based parameters, the present study investigated whether other neuro-sensory generators might play a role. For this reason, we have analyzed data based on our hypothesis that a decrease of the ratio of the ANN/CM during the drop of the CM is related to postoperative HL.

Methods: 78 subjects with residual low frequency hearing (i.e. ≤ 80 dBHL at 500 Hz), audiometric thresholds were included in this multicenter trial. ECochG data were obtained intraoperatively using a research tool developed by the University of Melbourne to evaluate ECochG variables pre- and 4-6 weeks postoperatively: ECochG components were obtained with 500 Hz tone burst stimuli of 6 ms duration at 110 dBHL and during electrode array insertion recorded by the most apical electrode of cochlear implant. ANN and CM responses and their ratio were analyzed for 35 subjects showing compromised CM responses during surgery.

Results: Intra- and postop patient data show that postop results show reliable and reproducible CM recordings that are perfectly time-locked to insertion time and speed within acceptable signal-noise ratios. The ANN/CM could be analysed for 27 subject ratio: in 18 subjects the ratio rose during CM drops, 9 subjects showed a decreased. At the follow up timepoint, patients with a decreasing ANN/CM ratio reveal a median hearing loss of 29.0 dB, significantly poorer than the group with increasing ANN/CM ratio at 13.3 dB (p = .0043). When comparing cochlear output during implantation with output measured immediately after implantation, the ANN/CM ratio decreasing group showed significantly poorer post-insertion growth, with a median post/peri insertion ratio of 0.98, compared with the ANN/CM ratio increasing growth of 1.38.

Conclusions: This data shows that it is possible to differentiate between CM drops that lead to a loss of residual hearing and those that do not. The ANN/CM ratio is easily measured and responds rapidly during a CM drop and seems to be a promising variable to predict postoperative hearing preservation.

FP14

The time course of auditory and audio-visual speech processing in cochlear-implant users revealed by cortical evoked potentials

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Keywords: Cochlear implant (CI), late cortical evoked potentials, electrical neuroimaging, audio-visual interaction, speech discrimination ability

Background: Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and CI users have to adapt to the new electrical input, resulting in experience-related cortical changes after implantation.

Methods: In order to better understand the high variability in the speech recognition ability with a CI, we registered late cortical evoked potentials to syllables presented in auditory, visual and audio-visual conditions. The participants performed a syllables-identification task. We compared the time course of cortical speech processing between normal-hearing (NH) controls and CI users, and between different subgroups of CI users (proficient vs. non-proficient; unilateral vs. bilateral hearing loss).

Results: The results revealed that non-proficient CI users showed an *enhanced* N1 wave (negativity around 100 ms) but a *reduced* P3 wave (positivity around 500 ms) when compared to proficient CI users [3]. Further, NH listeners and CI users (with unilateral and bilateral hearing loss) showed a multisensory effect, as indicated by shortened response times for the audiovisual compared to the two unisensory conditions [1, 2]. Multisensory integration was confirmed in NH listeners and CI users by electrical neuroimaging, showing a visual modulation of the auditory-cortex response at N1 and P2 latency (positivity around 220 ms). Nevertheless, CI users with unilateral and bilateral hearing loss showed a distinct auditory and audio-visual speech processing when compared to the NH listeners, as indicated by a *delayed auditory*-cortex activation and an *enhanced visual*-cortex activation at N1 latency.

Conclusion: In sum, our results demonstrate that cortical evoked potentials provide a useful tool to study the time course of auditory and audio-visual speech processing in CI users. CI proficiency can be distinguished on the basis of different objective measures, in particular the cortical N1 and P3 response. Furthermore, our results suggest that CI users with both unilateral and bilateral hearing loss have distinct cortical audio-visual speech processing compared to NH individuals, which might reflect a compensatory strategy that allows the CI users to improve speech performance with the limited CI signal. This conclusion is reinforced by the observation that CI users with both unilateral and bilateral hearing loss show enhanced lip-reading ability compared to NH individuals.

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FP15

Recording distortion product otoacoustic emissions (DPOAEs) using the adaptive noise cancelling algorithm

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Keywords: ambient noise, weighted averaging, specificity, screening, cochlea function

Background: A DPOAE signal must be detected in the presence of ambient acoustic noise and physiological noise arising from the patient. Short-time noise artefacts include swallowing, patient's movements, and rubbing of the probe cable. Continuous ambient noise may result from heating/air condition systems, traffic noise, or background conversations. Even a good probe fit does not eliminate external sounds entering the ear canal; therefore, it is desirable to measure DPOAEs in a sound booth to reduce the noise floor. For testing in an unquiet environment, e.g., clinic offices or schools, attaining an advisable signal-to-noise ratio (S/N) is challenging. One effective noise reduction approach to detect DPOAEs uses weighted averaging by giving quiet frames higher impact in the averaging. This reduces averaging time compared to using all frames treated with equal weights, particularly in varying noise conditions. A DPOAE probe of the PATH MEDICAL QSCREEN system features an extra microphone to capture noise outside the ear canal. An adaptive noise cancelling (ANC) algorithm [1] includes filtering outside noise and subtracting it from the inside signal, resulting in an improved S/N and a reduced testing time. The aim of the study was to collect DPOAEs with the QSCREEN system under simulated noisy environment conditions to evaluate whether applying the ANC: 1. decreases number of false positives, and 2. reduces testing time significantly.

Methods: DPOAEs were recorded in 26 ears of adults with normal hearing, with a subject seated comfortably in a reclining chair outside the audiometric booth. The tests were performed with the ANC turned off and on under three conditions: 1. without presenting any signals from loudspeakers of an audio system (ambient noise level ≈35 dBA); 2. with a cafeteria noise presented at 60 and 70 dBA, and 3. with Fastl noise [2] presented at 50, 60, and 70 dBA. The volume of the sound system was adjusted to reach the target level of the noise signal with a sound level meter placed close to the entrance of the ear canal. DP-grams were recorded for the f_2 frequency of 1, 1.5, 2, 3, 4, and 6 kHz with the primaries L_1=61/L_2=55 dB SPL. Minimum and maximum recording time per frequency was set at 2.1 and 15.2 sec, respectively. If S/N>9dB was not reached after the maximum averaging time, the data point was considered a "refer". The overall pass criterion required at least 4 "pass" results out of 6 frequencies tested.

Results: The ANC benefit increased with increasing noise level for both Fastl and cafeteria noise, with a minimal benefit in an ambient noise condition. Applying the ANC reduced testing time by up to a quarter, i.e., the median time benefit was up to 35 sec. For Fastl noise presented at 70 dBA, over 70% of initial overall "refer" changed to "pass" results after applying the ANC. The highest rate of "refer" to "pass" change, as well as the greatest decrease of testing time, occurred for f_2 = 1, 1.5, and 2 kHz with the ANC turned on.

Conclusions: The ANC algorithm was based on using the second microphone pointing outwards for capturing ambient noise and the primary microphone for capturing the DPOAE response in the ear canal; this decreased the impact of the environmental noise without influencing the DPOAE response. The benefits include: 1. reduced number of false positives, i.e., an improvement of specificity; 2. shorter testing time, and 3. a possibility of performing the screening of cochlea function based on DPOAE tests in adverse environmental conditions, e.g., at bedside, in pediatrician offices or in schools.

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FP16

Pulsed DPOAE latency as reference for ABR measurements?

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Background: Latency of ABR signals are considered an important indicator to differentiate between cochlear and neural or conductive causes of hearing loss. In the normal physiologic condition of hearing, dependence of latency of neural signals to tonal stimuli on frequency and level is thought to be dominated by the build-up of the correspondent traveling waves in the cochlea, whereas e.g. inter-neuron signal transmission latency is generally assumed to be almost constant. Latency of travelling waves can also be derived from otoacoustic emission measurements (OAE). Here, we present measurements of the nonlinear-distortion component of pulsed distorsion-product OAE (p-DPOAE) yielding directly an estimator of intracochlear travelling-wave build-up by recording the time elapsed between the f2-primary stimulus and the distortion-product pulse response, without the necessity to derive it from phase gradients of the DPOAE coherent-reflection component of different frequencies, as is sometimes done using chirped DPOAE [1].

Methods: Pulsed DPOAE were measured in 20 ears of ten normal-hearing subjects seven times within 3 months [2]. Here, we calculate the latency as time elapsed between the short-pulsed f2-primary and the pulse-response of the distortion product at 2f1-f2. Data are derived from the p-DPOAE input-output functions measured at 14 frequencies from 1–14 kHz presented in [2].

Results: Roughly consistent with literature, at low stimulus levels (L2=35 dB SPL), p-DPOAE latency was found to be ~13 ms at f2=1 kHz and drops exponentially to ~2 ms at f2=12–14 kHz. Converted to periods of the correspondent f2-frequency, the numbers rise from ~13 at 1 kHz to >25 periods above 6 kHz. Between ~3 and ~6 kHz there is a steeper rise in latency departing from a pure exponential relation between latency and frequency. Dependence of periods on level is ~ -7% per 10 dB level increase. Stability of latencies over the seven visits was high: The median of absolute differences between visits was <1 period for all frequencies except 14 kHz. A surprising finding was that level dependence was considerably variable between subjects. Some perfectly normal-hearing subjects show only -2% periods per 10 dB level increase, others showed a dependence of -12% periods per 10 dB level increase.

Conclusion: Data shown here support roughly the notion that tone-burst ABR wave V latency can be derived by halving OAE latency and adding 5 ms (1 ms for wave I generation and 4 ms wave I-V delay) [3]. Comparison of our (and others) results with ABR latency literature suggests that (1) probably not all parameters necessary to relate OAE delay to neural delay accurately are currently known, and that (2) OAE latency and thus possibly traveling-wave latency can be almost level-independent even in perfectly normal-hearing subjects. Test-retest accuracy of latency determination with p-DPOAE was found to be excellent. p-DPOAE might turn out to be a useful reference measurement when using ABR latency in differential hearing dignostics.

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FP17

Speech-in-noise recognition: Don"t forget cochlear tuning!

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Background: Stimulus frequency otoacoustic emissions phase delay of stimulus frequency otoacoustic emissions (SFOAEs) has been proposed as a non-invasive, objective, and fast method for estimating cochlear mechanical tuning. Cochlear filtering of complex acoustic signals is the essential first step for perceiving speech in noisy backgrounds. However, the evidence for the contribution of cochlear filter bandwidths to speech-in-noise recognition is extremely limited. The objective of the present study was to investigate the relationship between SFOAE delay-based tuning estimates and speech-in-noise recognition.

Methods: Twenty-four normal-hearing adults participated in this study. Swept-tone SFOAEs were recorded from 1000 to 4000 Hz with 40 dB probe level. Speech-in-noise recognition was measured using the Hearing-in-Noise Test (HINT). SFOAE data were cleaned using a 6-dB SNR criterion, and phase-gradient delays were computed using the peak-picking technique. Cochlear tuning (QERB) was estimated at one-half-octave intervals using a procedure described by Shera et al. (2010). Statistical analyses focused on examining the effect of probe frequency on QERB and predicting the HINT speech recognition threshold (SRT) from QERB.

Results: Analysis revealed an increase in QERB with frequency and showed a significant relationship between QERB and SRT.

Conclusion: The results are consistent with the literature showing increased cochlear tuning sharpness with frequency. Findings provide evidence that cochlear filter bandwidths can predict speech-in-noise recognition. This has direct implications for understanding speech-in-noise deficits despite a normal audiogram.

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FP18

Insights into the modulation of peripheral hearing by attentional level based on several experiments involving otoacoustic emissions and auditory evoked potentials

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Background: The medial olivocochlear (MOC) system is thought to be responsible for modulation of peripheral hearing through descending (efferent) pathways. This study investigated the connection between peripheral hearing function and conscious attention during several experiments involving different modalities – auditory and visual.

Methods: Peripheral hearing function was evaluated by analysing the amount of suppression of otoacoustic emissions (OAEs) by contralateral acoustic stimulation (CAS), a well-known effect of the MOC. The amount of MOC reflex-induced change in the TEOAE was calculated in terms of raw dB and also as a percentage change. Simultaneously, attention was evaluated by event-related potentials (ERPs).

Results: Although the ERPs showed clear differences in processing for different attentional states, not all experiments showed differences in the levels of OAE suppression. The most apparent effect in OAEs was when tasks of different difficulty were compared. The MOC reflex measure was slightly higher for the hard task. Furthermore, we observed that the inhibition of OAEs for easy and hard tasks was correlated with the magnitude of the P3 wave in the ERP. When the P3 amplitude increased because of a change from a hard task to an easy one, the change of the MOC reflex also increased.

Conclusion: The reported results may suggest that there might be some sort of mutual compensation between periphery and cortex, e.g. for subjects with lower MOC reflex involvement there might be greater cortical processing, and vice versa.

Keywords: attention, medial olivocochlear efferent system, otoacoustic emissions, contralateral acoustic stimulation, event related potentials, P3, EEG, suppression

FP19

The acoustic change complex as objective measure of speech perception in noise

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Background: Over the past two decades, the acoustic change complex (ACC), a cortical potential evoked by a change in an ongoing sound, has been widely studied in experimental settings. Although correlations between psychophysical outcomes and ACC measures have been reported, it has not resulted to implementation in clinical audiometry yet. We have investigated the clinical value of recording ACCs to frequency changes in normal-hearing and hearing-impaired subjects and the extent to which ACC measures can predict speech perception in noise performance [1, 2].

Methods: ACCs were recorded in 13 adult subjects with sensorineural hearing loss (SNHL) and 24 age-matched normal-hearing (NH) subjects with ages varying between 20 and 66 years. The stimuli consisted of a 3 s base tone, an upward frequency sweep of 3 ms towards a 300 ms target tone typically varying from 0.3% to 12% above the base. Base frequencies were 0.5, 1, 2 and 4 kHz. Responses were recorded using Ag/AgCl electrodes placed on Cz (active), contralateral mastoid (reference) and forehead (ground). Filtering was applied between 0.01 and 100 Hz, and waveforms were averaged over 100 recordings. ACC thresholds were compared to psychophysically assessed frequency discrimination thresholds (FDTs) and speech in noise reception thresholds (SRTs). Amplitudes and latencies of suprathreshold ACCs evoked by 12% frequency changes were compared to SRTs.

Results: In almost each subject we could record clear and large ACC waveforms with amplitudes around 5 to 10 µV. ACC thresholds had a moderate to strong correlation to psychophysical FDTs ($r=0.67$, $p<0.001$). ACC thresholds increased with hearing loss (HL), and SRTs were correlated with ACC thresholds ($r=0.54$, $p=0.005$). Interestingly, SRT correlations with ACC N1 latencies and N1-P2 amplitudes were even stronger ($r=0.65$-0.67, $p<0.001$). Using multiple regression analysis we found that when averaging the ACC latencies over 1, 2 and 4 kHz and average HL, SRT could be explained for 87% by ACC latency (35%) and HL (52%). Considering only the ACC measures over those three frequencies, SRT could be explained for 74% by latency (60%) and amplitude (14%).

Conclusion: The ACC to fast and large frequency changes (a few semi-tones) can be used to predict speech perception in noise. The predictive value using the latency is better than the ACC threshold; moreover, obtaining latency and amplitude is less time consuming than determining thresholds. A large-scale external validation study has been initiated to confirm the clinical value of this ACC prediction model (ACCEPT study).

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FP20

Acoustic Change Complexes to fundamental frequency shifts in elderly people with hearing loss

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Background: Auditory deprivation has a fundamental impact on the organization and functioning of the auditory cortex in elderly individuals, influencing neural reorganization and leading to functional deficits such as difficulty recognizing speech in noise. Currently, it is possible to effectively measure the capacity for auditory discrimination at the cortical level through modifications in the traditional methodology for eliciting the Cortical Auditory Evoked Potential (CAEP) and recording the Acoustic Change Complex (ACC). The ACC, generated in response to an acoustic change in an ongoing sound, indicates that the brain has detected changes within a sound and that the individual has the neural capacity to discriminate subtle differences in the sound information being processed. This study aimed to describe the CAEP and ACC measures in elderly individuals with hearing loss.

Methods: The study was approved by the research ethics committee under number 02848918.2.0000.5406. Ten elderly individuals, between 61 and 87 years old, participated in the research. All participants had a diagnosis of sensorineural, bilateral, symmetrical hearing loss, with tonal thresholds of up to 30 dBHL within 0.25 – 2kHz under 70 dBHL after 2kHz to ensure audibility of the stimulus; a speech perception score in quiet above 60% in quiet; type A tympanogram; and presence of wave V in the neurodiagnostic auditory brainstem response, without cognitive impairment determined by MoCA.

The CAEP and and ACC were measured with a Biologic Evoked Potential System (EP). A custom stimulus was created with an overall duration of 500 ms. The initial 300 ms consisted of a harmonic complex, with harmonics 1 – 12 of F0 = 150 Hz which then transitioned smoothly over 10 ms to a harmonic complex with F0 = 180 Hz (20% shift) having a duration of 190 ms. The transition consisted of frequency glides. The overall stimulus has a 10-ms rise time and a 40-ms fall time to facilitate an onset-evoked P1-N1-P2 complex but not an offset response. The stimulus was delivered to the right ear of the participant using an insert earphone at a level of 80 dB nHL. Participants were positioned in a reclining chair and were not required to perform any task. Electrodes were positioned at Cz, Fpz and A1. Latency and amplitude values were measured for the P1, N1, and P2 components of the onset CAEP and N1 of the ACC.

Results: The mean latency values obtained were P1 55.83ms (±13.77); N1 102.47ms (±7.94); P2 182.73ms (±18.11) and ACC 420.19 (±22.14). And the mean amplitude values were P1 3.52µV (±1.58), N1 -5.66µV (±2.09), P2 4.31µV (±1.45) and ACC -2.64µV (±1.23).

Conclusion: The typical values of P1, N1, P2 and N1 of the ACC for elderly individuals with hearing loss were observed and described in this study, enhancing our understanding of their central auditory function and auditory discrimination skills.

Keywords: ALR, Speech perception/discrimination, elderly.

FP21

Forward masking in speech-evoked cortical auditory evoked potential: Effect of masker-probe interval

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Keywords: Electrophysiology. Auditory Evoked Potentials. Noise.

Background: Forward masking is conceptualized as an enduring effect of masking in the auditory system that can last for tens of milliseconds after the masker offset and which may interfere with the subsequent perception of a target sound1,2. The magnitude of the forward masking effect diminishes as a function of the masker-probe interval (delta t)3. This phenomenon may occur because the neurons of the auditory system become adapted during the presentation of a stimulus and so are less responsive to a subsequent stimulus4. Forward masking studies using speech stimuli to evoke cortical potentials are promising for understanding speech discrimination in the presence of noise. The present study assesses the effects of delta t on speech-evoked cortical auditory evoked potentials.

Methods: Cross-sectional observational analytical study carried out with 32 young adults with normal hearing. Forward-masked cortical auditory evoked potentials were measured with delta t"s of 3, 10, 32 and 100 msec. A control condition without masking was also undertaken. For the comparative analysis of P1, N1 and P2 latency and amplitude values in the different interstimulus intervals, the ANOVA test of repeated measures and the Post Hoc Bonferroni test were applied. Latencies were referenced to the onset of the probe speech stimulus irrespective of delta t.

Results: P1 and N1 latencies differed between delta t"s of 3 msec, 32 msec and 100 msec. P2 latency differed between delta t"s of 3 msec, 10 msec, 32 msec and 100 msec. Differences were also found in P1 amplitude across the range of delta t"s, with a decreased amplitude at the smallest delta t.

Conclusion: As expected from other studies examining forward masking of evoked potentials2,3 a greater forward masking effect was observed for the shortest delta t, which in the present study, was 3 msec.

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FP22

Objective Measurement of Cortical Potentials with the Cochlear Implant Electrode

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Background: Measuring auditory nerve responses elicited by electrical stimulation with the cochlear implant is clinical practice to verify effective stimulation of the nerve and to support the fitting procedure. As this measurement only reflects the peripheral part of the auditory pathway, measuring more central responses (Cortical auditory evoked potentials, CAEP) could add more value and insides as they should better reflect the conscious perception. They also provide information about brain plasticity, which could help track auditory brain development.

Methods: The back telemetry of AB implants has been modified to allow for real-time streaming of measurement signals. Different experiments have been conducted to test the feasibility of measuring cortical potentials in response to acoustic stimulation, while experiments with contra-lateral and ipsi-lateral electric stimulation are ongoing. Usually a short stimulus (pure tones for acoustic, pulse train for electric) are presented and the recording over the implant starts. Different recording configurations have been tested and were optimised. For control, full EEG-cap recordings were also measured. In addition to evoked potentials, Aldag et al. presented acoustically a mixture of two speakers and tried to decode the auditory attention based on the EEG.

Results: In Attias et al. (2022) Acoustically evoked responses could be measured in most study subjects within a moderate time of around 3 minutes (100 averages), and the morphology matched to that recorded using single-channel scalp EEG. The accuracy of the auditory attention decoding in Aldag et al. (2022) was much poorer compared to the full EEG cap recordings, but was still above chance level in 3 out of 5 subjects. Ipsi-lateral electric stimulation followed by immediate recording presents levels of stimulation related artifact, and need to be further optimized.

Conclusion: The feasibility of recording CAEP over the cochlear implant electrode without additional equipment has been shown, but there is still a long way to go to improve the recording quality, especially the artefact suppression for ongoing electrical stimulation. After improving the technical challenges, this could be used for tracking brain development as effectiveness of CI, automated fitting (setting levels, closed-loop fitting, just-noticeable differences in electrode, level, timing) or auditory attention decoding.

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FP23

Mismatch responses and the ability to objectively index sound discrimination in infants with normal hearing

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Background: The Mismatch Response (MMR) has the potential to offer a clinically feasible objective index of sound discrimination, which is a long-standing goal in infant hearing aid fitting applications. However, a prerequisite for clinical applications is the reliable identification of MMRs in individual infants with good hearing and discrimination. Due to the low signal-to-noise ratio (SNR), maturational changes, and paradigm differences, findings that positively identify responses at the individual level in infants have been mixed (e.g. Kushnerenko et al., 2002; Gupta & Bhardwaj, 2022). Recent work in our lab has focused on strategies to maximise SNR such as use of complex tones (Bardy et al., 2015), weighted averaging, a narrow filter passband and the Hotelling"s T2 objective detection tool. An interleaved oddball paradigm featuring three deviants interleaved with the same standard helps minimise test time whilst maintaining robust discriminative responses. We demonstrated MMR detection sensitivity of around 98% in adults using this approach (Maslin et al., 2023). The objective of this present study was to extend this investigation to infants as infants with hearing loss are our target population.

Methods: An oddball paradigm featuring four spectrally complex tonal signals was used to elicit MMRs in 16 normally hearing infants (aged 3-13 months). Infants had passed newborn hearing screening and passed DPOAEs on the day when MMRs were recorded. The standard was centred at 0.5 kHz and occurred with a probability of 70%; three deviants centred at 1, 2 and 4 kHz and each occurred with a probability of 10%. Signals were delivered through the soundfield at 70 dB SPL using a Genelec 6010A speaker, and responses were captured using an Interacoustic Eclipse EP device using a nasion-to-mastoid montage. Artifact rejection was disabled during online recordings. Responses were analysed offline by filtering (2-10 Hz) and weighting each epoch by the inverse of its noise power before averaging. Response presence or absence was determined objectively via the Hotelling"s T2 statistic applied to the difference waveforms.

Results: The presence of a reliable waveform was confirmed by the Hotelling"s T2 statistic for 88% of the recordings to the standard and deviants. For the 40 deviants with reliable responses the Hotelling"s T2 statistic applied as a "one shot" test at the end of the 28-minute run revealed a reliable MMR in 39 instances (97.5%). We also performed the test sequentially at pre-determined residual noise intervals. Using this approach, responses were detected on average after 13.5 minutes, a significant shortening of test time. After correcting for multiple comparisons the number of clear responses dropped to 92.5% but was still clinically acceptable.

Conclusion: Results indicate that complex tones in conjunction with optimised recording and analysis parameters offer the potential to elicit robust MMRs, supporting future utilisation of MMRs for clinical audiological applications. However, further investigations involving infants with hearing loss are required, and clinical applications would benefit from further exploration of stopping criteria that could be used to optimise efficiency whilst not compromising MMR detection specificity and sensitivity.

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FP24

Cortical auditory evoked potentials as biomarkers to detect the presence of chronic tinnitus

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Question: The current limited understanding of tinnitus neurophysiology is one of the major obstacles in developing effective treatments for chronic tinnitus. As such, there is an urgent need for knowledge on underlying neural and/or neurobehavioral correlates that might function as potential biomarkers for tinnitus. We aimed to develop a model for the detection of tinnitus cases based on such potential biomarkers.

Methods: In a first step, data from twenty patients suffering from chronic tinnitus, but no concurrent hearing loss or psychological complaints, were compared to data from twenty matched controls. Cortical auditory evoked potentials (CAEP) were elicited using a standard oddball paradigm. Source estimation and brain signal variability were analyzed to investigate putative differences between tinnitus patients and controls. Other examinations included standard audiometry, speech understanding in quiet and noisy conditions, and cognitive testing using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). In a second step, a logistic regression model to detect tinnitus cases was constructed based on CAEP activity, brain signal variability and RBANS scores.

Results: The P300 component, a response to unexpected but relevant stimuli, was significantly reduced in the tinnitus group. Source estimation revealed that the response of tinnitus patients was characterized by a decreased activity in temporal cortex, parahippocampus and insula. Brain signal variability on fine time scales was significantly higher in the tinnitus group, suggesting that tinnitus patients rely more strongly on local information processing. Furthermore, tinnitus was associated with a decreased cognitive performance, especially on tasks measuring delayed memory. The logistic regression model performed significantly above chance level when detecting tinnitus cases in an unseen dataset (accuracy of 75%, area under the ROC curve of 0.86).

Discussion: The successful classification between tinnitus cases and controls demonstrates the potential value of the proposed combination of biomarkers. Moreover, the identified associations between tinnitus, auditory evoked activity and cognitive performance point towards a significant contribution of top-down information processing in the perception of tinnitus.

FP25

Frequeny following responses for phase-time analysis of the auditory pathway

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Background: Frequency Following Responses (FFR) are electrical responses measured from the scalp by surface mounted electrodes and evoked by acoustic signals presented to the ear. FFR are electric far-fields generated by the simultaneous triggering of action potentials of the VIII th cranial nerve (hearing nerve) [1]. The amplitudes of the Jewett V component of the Brainstem Electric Response Audiometry (BERA) are proportional to the number of synaptic ribbons of inner hair cells and cell bodies of the spiral ganglion nodes of the hearing nerve. The generators of the Auditory Steady State Responses (ASSR) are believed to be in the brainstem (Jewett V) and the auditory cortex. All electric responses are superimposed in the measured far-field, and for a diagnosis of the hearing function an acoustic stimulation $70\ \text{Hz} < f < 500\ \text{Hz}$, reducing low frequency high level EEG activity and high frequency ($f > 500\ \text{Hz}$) basilar membrane movement induced nerve responses is recommended.

Methods: The former measurements of FFR of normal hearing subjects were reproduced [2] at considerably high stimulation levels (95 dB SPL) using stationary acoustic stimulation around 300 Hz. The signal processing of the measured time series and numerical generated data allow a phase-time analysis of the FFR by identifying the time delay of responses starting with the hair cell response Electrocochleography (ECOG) or Jewett I, and further on superior olivary complex, brainstem and others. The main problem is the low signal to noise ratio S/N < - 40 dB which requires high measurement times and low artefacts of quiet, at best sleeping and not snoring subjects.

Results: Numerical studies with S/N ratios > - 20 dB already permit the study of phase distributions of single frequency generators. A difficulty is the singularity of the Fisher information matrix due to multiple eigenvalues at one Eigenfrequency, which require Singular Value Decompositions (SVD) and extensions of former developed Eigenvalue, MUSIC and ESPRIT algorithms.

Conclusion: The FFR recording of auditory generated electrical responses is not new and possible even at low frequencies < 500 Hz. The phase analysis of the FFR response should allow a tonotopic analysis of the auditory pathway starting from initial responses of auditory hair cells. The spatial resolution is limited by the Signal/Noise ratio of measurements.

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FP26

Supra-threshold Envelope-following Responses in the Ageing Population: Relationships with Hearing Sensitivity and Speech Intelligibility

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Background: Envelope-following-responses (EFRs) evoked by supra-threshold amplitude-modulated sounds are promising markers of age-related or ototoxic-induced cochlear synaptopathy (CS) in research animals. A direct translation of these findings to EFR-based CS-quantification in humans is complicated by possible combinations of CS, inner-, outer-hair-cell damage or central deficits that can also affect EFR markers. To work towards a sensitive CS-marker for use in humans, we focus on an EFR stimulus that -in computational model simulations- is maximally sensitive to CS [1] and investigate how this marker declines in an ageing population with or without OHC damage.

Methods: 108 subjects participated in this study and were divided into two groups: (i) an ageing group with normal audiograms (i.e., 4-kHz-thresholds < 20 dB HL, n=89, 18-65 years old) and (ii) older adults with impaired audiograms (n=19, 45-75 years). We collected EFRs to 120-Hz-modulated 4-kHz pure tones, along with extended high-frequency (EHF) audiograms, distortion-product otoacoustic emissions and speech reception thresholds (Flemish Matrix test).

Results: EFRs to rectangularly-modulated stimuli were generally larger than EFRs to sinusoidally-modulated stimuli and showed the largest variability across listeners in the normal-hearing group below the age of 40. Above that age, generally lower EFRs are observed with response sizes that do not relate to age nor EHF thresholds. These results show resemblance to human temporal bone histology that shows largest synapse declines below the age of 45 followed by overall lower counts that were subject-dependent but not age-dependent [2]. When subjects had clinical hearing damage, their EFRs were overall low and did not show an age-related trend. This finding supports observations made in animal research showing that CS precedes OHC damage in the progression of age-related sensorineural hearing lastly. Lastly, we studied relationships between (EHF) thresholds and EFR markers with speech reception thresholds in the normal-hearing population and show that depending on the considered age-group, different mechanisms (CS or OHC damage) have their influence.

Conclusion: Using a sensitive EFR marker of CS in humans, this study investigated the functional consequences of CS with age. Our results improve our understanding of (i) the occurrence of CS in the aging population with or without clinical hearing loss, and (ii) its impact on speech intelligibility. The latter is important with a view on the development of future sensitive treatments for CS, OHC damage or combinations thereof.

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FP27

The role of attention and memory in understanding conversation in noise in adults: neural tracking study

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Background: There is interest in the role that cognition, such as attention and memory, plays in speech in noise understanding, especially as we age. This research aimed to explore the role of working memory and attention to speech understanding and to determine the effects of age and noise on cortical speech encoding as measured by Temporal Response Functions (TRF) models and their predictive values.

Participants and Methods: Twenty-seven normal hearing participants underwent measures of attention and working memory. The younger (n=14, aged 20.8-36.6 years) and older adults' (n =13, aged 43.3-75.4 years) completed the SSQ, Test of Everyday Attention, Digit Span, Spatial Span, and Picture Peabody Vocabulary Test (PPVT). Participants underwent EEG to conversational speech (podcasts) in quiet and in 8-talker babble noise at two SNRs (+5 dB and +15 dB). The EEG included comprehension questions related to the content of a podcast.

Data Analysis: Data was analysed to determine if prediction accuracy (as measured by TRFs) of conversational speech in varying SNR was mediated by cognition. TRF forward encoding models were used to examine how well the speech envelope explained variance in the EEG response. Exploratory Factor Analysis was completed for the six measures of cognition to determine the highly inter-correlated measures. The reduced factors, executive functioning, memory, and attention switching were correlated to the SSQ, PPVT, Speech understanding scores, and TRFs with age as a covariate.

Results: There was no significant difference between age groups on any measure. Only speech understanding scores at +5 dB SNR significantly correlated with executive functioning ($r = 0.52$, $p=0.008$). The TRF predictive values were above chance for all conditions with no difference between them. The TRF morphology was different in noise. The time of maximum predictive accuracy was delayed in noise.

Conclusion: The findings show that executive functioning is relevant when listening to speech in noise. Reliable TRF models can be obtained for younger and older participants and may be the objective measure of noise effects to conversation with minimal contribution of cognition.

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FP28

Audiovisual speech processing in the first months of CI use

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Individuals with severe to profound hearing loss can be provided with a cochlear implant (CI) to partially restore their auditory function. CIs are the first sensory prosthesis used in the clinical context and they provide limited auditory information compared to normal acoustical hearing. Therefore, CI patients may compensate for this limitation by enhanced visual abilities and a stronger interaction between the visual and auditory system. To get a better understanding of the audiovisual speech perception in this kind of individuals, our study used electroencephalography (EEG) and a word identification task in a visual, auditory and audiovisual condition. Postlingually deafened CI users were tested five weeks and six months after the first fitting of their CI. Additionally, an age and gender matched group of normal hearing (NH) listeners was tested with the same paradigm. Besides the behavioural data of all three conditions, the event-related potentials (ERPs) are compared between the conditions and time points. Our aim is to explain the multisensory processing in the course of the CI usage, as well as the cortical responses for a simultaneous processing of auditory and visual stimuli. The results may be of clinical relevance, as they indicate the importance of assessing the CI outcome in audiovisual speech conditions instead of purely auditory.

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FP29

The effect of binaural unmasking on speech envelope tracking

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Background
Neural tracking of the speech envelope is a promising method for objectively estimating speech understanding. However, previous research often confounds speech understanding with changes in the signal-to-noise ratio (SNR) of the speech signal. As a result, we cannot determine whether changes in neural tracking of the speech envelope result from the physical change of the speech signal or the change in speech understanding. To disentangle this, we used the binaural system to manipulate speech understanding while maintaining the speech envelope to address this issue.

Methods
We conducted two experiments involving the presentation of speech in noise stimuli to participants while recording their electroencephalogram (EEG).

In the first experiment (N=8), speech and noise signals were presented binaurally. We presented the speech signal to both ears with an opposing phase: the phase in one ear was flipped compared to the other. We mirrored this binaural phase difference for the noise signal (SπNπ) or presented it with an identical phase in both ears (SπN0). When the noise has the same phase in both ears, speech understanding is easier than when the phase is flipped due to binaural unmasking. The speech consisted of a story or standardised speech material, the Matrix sentences.

In the second experiment (N=12), a monaural speech signal was presented alongside a binaural noise signal. We manipulated the correlation of the noise signal between the ears, ranging from uncorrelated (SmNu) to binaural noise with a phase difference (SmN0), to change the level of speech understanding continuously. The speech signal was presented at 3 dB SNR (high speech understanding) or around -10 dB SNR (low speech understanding). As in the first experiment, the speech signal consisted of either a story or the Matrix speech material.

For both experiments, we used a linear decoder to reconstruct the presented signal's envelope and correlated it with the actual envelope to estimate the level of neural tracking.

Results
Both experiments demonstrated a correlation between neural tracking levels and speech understanding across participants and within a participant. When participants could exploit binaural differences, speech understanding and neural tracking increased. However, we did not find increased neural tracking when the SNR was already high enough for high speech understanding.

Conclusion
Our study confirms the value of neural tracking of the speech envelope in estimating speech understanding. Using the binaural system to manipulate speech understanding without affecting the speech envelope, we observed corresponding changes in neural tracking in both experiments. This finding suggests that the neural tracking of the speech envelope is closely tied to speech understanding, not merely a response to changes in the physical signal. Furthermore, this method can serve as an objective test of the binaural system

FP30

Decoding of Speech Envelope in Co-located and Segregated Noise in Infant and Child EEG Data

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Background: Infants and children rely on understanding speech in noisy environments to acquire language and to learn, but they show difficulty listening under such complex acoustic conditions. One method that can be used to study the development of speech perception under complex acoustic conditions is the use of electroencephalography (EEG) recordings to measure the cortical tracking of the speech envelope. In this study, we recorded EEG to continuous speech in quiet and two different background noise conditions to simulate real-world listening demands.

Methods: To assess the neural processing of speech, we used the Temporal Response Function (TRF) approach (1,2), which combines linear modelling and machine learning to analyze EEG data recorded to continuous speech. Participants in this study included 40 typically-hearing infants (20 7-month-olds, 20 11-month-olds) and 19 7-to-10-year-old children. We recorded neural responses to continuous speech presented via speakers at 0°, +90°, and -90° azimuth in three conditions: Quiet, Co-located Noise, and Segregated Noise. For infant participants, the target stimuli consisted of infant-directed speech (IDS) produced by two female speakers while the target stimuli for children was an age-appropriate audiobook, also read by a female speaker. The noise stimuli consisted of four-talker babble and was constructed from four audiobooks read by 2 male and 2 female speakers. The target talker was always presented at 0° azimuth. In the Co-located Noise condition, the four distracting talkers were also presented at 0° azimuth. In the Segregated Noise condition, two of the distracting talkers were presented at +90° and two distracting talkers were presented at -90° azimuth. The EEG data were recorded using a 32-electrode Biosemi Active Two EEG system and each condition consisted of 10 one-minute IDS/audiobook segments, for a total recording time of 30 minutes. EEG signals were pre-processed and analyzed offline using the decoding model of the Multivariate Temporal Response Function (mTRF) toolbox in MATLAB. The speech envelope was extracted via Hilbert transform and decoding prediction accuracies were calculated for each condition. Spatial release from masking was calculated as the difference between the prediction accuracies obtain from Co-located and Segregated Noise conditions.

Results: Preliminary analyses revealed that decoding prediction accuracies greater than chance were observed in most participants in all three age groups and all conditions. Prediction accuracies were higher in Quiet than in Co-located or Segregated Noise for both infants and children. However, spatial release from masking was variable across all three age groups.

Conclusion: These results demonstrate the feasibility of using the envelope model and the mTRF method for investigating the development of speech-in-noise perception in infants and children. Our preliminary results suggest that the speech envelope can be decoded from the recorded EEG signal in Quiet, Co-located, and Segregated Noise for 7-month-olds, 11-month-olds, and 7-to-10-year-old children.

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FP31

Decoding Selective Attention From Single-Trial EEG Data in Cochlear Implant Users with Ipsilateral Residual Hearing

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Background: Cochlear implant (CI) users with ipsilateral residual hearing receive electric and acoustic stimulation (EAS). The combination of both stimulation modalities results in significant benefits in terms of speech understanding when listening to EAS in comparison to electric stimulation (ES). This benefit is typically measured through behavioural speech understanding tests. These tests are time consuming, require sufficient experience by the audiologist and are not possible to measure in very young children or subjects with missing behavioural response. Recently, it has been suggested that neural tracking to speech from electroencephalography (EEG) can predict speech understanding in normal hearing listeners. Moreover, it has been shown that it is possible to decode selective attention in CI users, even if the continuous CI electrical artifact may obscure the neural responses in the EEG [1,2]. The main goal of this work is to investigate selective attention (SA) decoding in EAS subjects listening to ES only, acoustic stimulation (AS) only and to combined EAS. The hypothesis is that SA decoding will be larger with EAS than with ES or AS and that this difference may correlate with the speech understanding benefit provided by EAS in comparison to ES or AS.

Materials and Methods: Seven MED-EL EAS subjects participated in the study. First, behavioural speech understanding performance was measured with ES, AS and EAS listening modes. Second, cortical auditory evoked potentials (CAEPS) were recorded by presenting broadband clicks with ES, AS and EAS listening modes. Third, selective attention (SA) was measured through EEG by monaural presentation of two concurrent speech streams with EAS, ES and AS. During the SA task, subjects were asked to attend to one of the two concurrent speech streams. Stimuli were provided through Presentation (Neurobehavioral Systems, California) and EEG was recorded using a high-density EEG cap with 96 electrodes (Easycap, Germany) linked to the recording system BrainAmp (Brain Products, Germany). SA was decoded using a backward model to reconstruct the envelope of the attended speech stream from EEG. SA performance was estimated based on the correlation coefficient between the attended or unattended speech streams and the reconstructed one.

Results: The N1-P2 complex of CAEPs elicited by EAS was larger than the response elicited by ES or AS. A significant effect of listening mode (ES, AS or EAS) on the correlation coefficient difference between the attended and unattended speech stream was observed. Moreover, selective attention decoding with EAS obtained higher values than with ES or AS, showing a SA EAS benefit. However, no significant correlation between the SA benefit and the speech understanding benefit was found, although the dataset was small.

Conclusion: This work shows that 1) it is possible to decode selective attention in CI users even if continuous artifact is present; 2) SA at EAS is larger than with ES or AS demonstrating that the electrical artifact does not obscure the neural signals in the EEG. The results demonstrate that it is possible to decode SA in CI users opening the possibility for future automated fitting applications.

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FP32

Acoustically evoked compound action potentials recorded from cochlear implant users with preserved acoustic hearing

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Keywords: Compound action potential, Electro-acoustic stimulation, Electrocochleography, Cochlear implant, Hearing preservation

Background: Less traumatic electrode design and the introduction of the "soft surgery" technique allow for the preservation of residual acoustic hearing in many cochlear implant (CI) users. New electrophysiologic methods have been developed that allow acoustically evoked peripheral responses to be measured in vivo from an intracochlear electrode. These recordings provide clues to the status of peripheral auditory structures. Unfortunately, responses generated from the auditory nerve (auditory nerve neurophonic, ANN) are somewhat difficult to record because they are smaller than the hair cell responses (cochlear microphonic, CM). Additionally, it is difficult to completely segregate the ANN from the CM, complicating the interpretation and limiting clinical applications. The compound action potential (CAP) is a synchronous response of multiple auditory nerve fibers and may provide an alternative to ANN where the status of the auditory nerve is of primary interest. This study is a within-subject comparison of CAPs recorded using traditional stimuli (clicks, 500 Hz tone bursts) and a new stimulus (chirp). We hypothesized that the chirp stimulus might result in a more robust CAP than that recorded using traditional stimuli, allowing for a more accurate assessment of the status of the auditory nerve.

Methods: Nineteen adult Nucleus L24 Hybrid CI users with residual low-frequency hearing participated in this study. CAP responses were recorded from the most apical intracochlear electrode using a 100 µs click, 500 Hz tone bursts, and chirp stimuli presented via the insert phone to the implanted ear. The chirp stimulus used in this study was CAP chirp generated using parameters from human-derived band CAPs (Chertoff et al. 2010). Additionally, nine custom chirps were created by systematically varying the frequency sweep rate of the power function used to construct the standard CAP chirp stimulus. CAPs were recorded using all acoustic stimuli, allowing for within-subject comparisons of the CAP amplitude, threshold, percentage of measurable CAP responses, and waveform morphology.

Results: Considerable variation in response morphology was apparent across stimuli and stimulation levels. Clicks and CAP chirp significantly evoked identifiable CAP response more compared to 500 Hz tone bursts. At relatively high stimulation levels, chirp-evoked CAPs were significantly larger in amplitude and less ambiguous in morphology than click-evoked CAPs. The status of residual acoustic hearing at high frequencies influenced the likelihood that a CAP could be reliably recorded. Subjects with better preserved hearing at high frequencies had significantly larger CAP amplitudes when CAP chirp was used. Customizing the chirp stimulus by varying the frequency sweep rates significantly affected the CAP amplitudes; however, pairwise comparisons did not show significant differences between chirps.

Conclusion: CAPs can be measured more effectively using broadband acoustic stimuli than 500 Hz tone bursts in CI users with residual low-frequency acoustic hearing. The advantage of using CAP chirp stimulus relative to standard clicks is dependent on the extent of preserved acoustic hearing at high frequencies and the stimulus level. The chirp stimulus may present an attractive alternative to standard clicks or tone bursts for this CI population when the goal is to record robust CAP responses.

FP33

Validation of a newly developed SPL Chirp for intracochlear ECochG measurement

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Indtroduction

Intracochlear electrocochleography (ECochG) records electrical potentials generated in the inner ear in response to acoustic stimuli. Previous studies have demonstrated that ECochG recordings are related to the remaining inner ear function. Recently intracochlear ECochG measurement tool was applied during CI surgery to gain a better understanding of the impact of the implant on the inner ear function. For the stimulation, a newly developed SPL Chirp will be applied.

Aim:

The aims of this study were to validate SPL Chirp and secondly, to perform real time intracochlear EcochG recordings during the electrode advancement and maneuvering during the cochlear implantation.

Methods: Ten patients implanted with the Flex electrodes, with various degree of hearing preservation were tested for SPL Chirps and tone bursts of 250, 500, 1000, 2000 and 4000 Hz. The recordings was performed for each active electrode. The frequency specific response amplitudes of tone bursts were compared with those of SPL Chirp. In addition, ten subjects were monitored with intracochlear EcochG by use of SPL Chirps.

Results: In every subject we obtained response to tone bursts and SPL Chirp responses. Generally, SPL Chirp frequency specific amplitudes were equal or lower than those for tone bursts obtained at the same stimuli level. In every subject we were able to record real time intracochlear EcochG responses during the cochlear implantation. The frequency specific amplitudes varied from 0.25 to 45uV.

Conclusions:

SPL Chirps are useful stimuli to be used during the intraoperative monitoring of hearing preservation cochlear implant surgery. Such stimuli may provide additional information of cochlea specific information related to hearing preservation.

FP34

Continuous intracochlear ECochG measurement to preserve residual hearing in CI surgeries

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Background: In order to preserve residual hearing during CI insertions, it is desirable to perform intraoperative monitoring of the cochlea. A promising approach is the recording of electrochleography (ECochG).

Methods: During the insertion of hearing preservation CI electrodes, ECochG was recorded intracochlearly via the CI electrode on contact 1. After insertion, EcochG was recorded in all contacts.. The stimulation was done acoustically using 500 Hz tone bursts. For recording a research software from the company MED-EL was used, which enables a continuous measurement of the potentials during the insertion. So far, four patients have been included in the study.

Results: In the cases measured so far, a high level of accordance between the measured amplitudes during and after insertion was found. There also seems to be a good relation to the later preservation of residual hearing, but this needs to be further investigated.

Conclusion: In principle, the continuous intracochlear ECochG measurement works and seems to provide consistent results on residual hearing preservation, but the patient group must be significantly enlarged for further conclusions.

FP36

Preoperative assessment of auditory nerve function in challenging cases using round-window eABR (rw-eABR)

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Keywords: eABR, round window, cochlear implantation, electric stimulation

Recording of electrically evoked auditory brainstem responses (eABR) provides a useful tool for the preoperative evaluation of auditory nerve function in challenging Cochlear Implant (CI) candidates. In addition, measures of electrically evoked responses can support the CI indication and evaluate the auditory function during the rehabilitation process.

Especially in challenging clinical cases like malformations of the cochlea and/or auditory nerve, neurofibromatosis, acoustic neuroma surgery or auditory synaptopathy/neuropathy (AS/AN) a preoperative eABR recording with transtympanic, electrical stimulation at the promontory, the round window niche or intracochlear in the basal turn can provide important indication criteria for CI-surgery or prognostic factors regarding the rehabilitation outcome after cochlear implantation.

Compared with promontorial, electrical stimulation in the round window niche provides much more reliable and reproducible eABR (rw-eABR). The rw-eABR technique and results from different clinical cases will be presented. For electrical stimulation we used a free programmable neurostimulator “ISIS” (inomed company, Germany). In comparison to the mostly used promontory stimulation, the best and most reliable results can be obtained with round window stimulation, alternating stimulus polarity and eABR recording with broad filter settings (0.5 Hz – 3 kHz) from the contralateral side.

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FP37

Electrically-evoked cortical potentials in cochlear implant users: Towards an objective fitting measure of central auditory detection

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Question: Objective measures such as cortical auditory evoked potentials (CAEP) constitute useful tools to objectively evaluate auditory cortical maturation and development of auditory skills in cochlear implant (CI) users. More recent approaches include the use of electrically evoked auditory cortical responses (eACR) through direct stimulation of intra-cochlear electrode channels, which provide a better control and timing of stimulation parameters. However, further research efforts are yet to be done to better understand the relationship between eACRs and behavioral fitting parameters, as well as their true applicability in clinical settings. The main objective of this work is to propose and validate an eACR setup based on individual stimulation parameters (e.g., intensity level, phase duration, and rate) directly derived from the user"s own fitting map. A secondary objective is to analyze differences in amplitude and latencies of eACR responses upon stimulation of different cochlea sites and at different intensity levels.

Material and Methods: eACR responses were obtained in 25 CI adults using individual stimulation parameters derived from their own fitting map. eACRs were elicited by direct stimulation of apical, medial, and basal electrodes thorough a 50-ms alternating biphasic pulse train equal to that used in clinical fittings. Different stimulation intensities at 0, 20, 40, 60, 80, 90 and 100% individual maximum comfortable levels (MCL) were also investigated. A Strapi database and a Matlab-based software tool have been specifically designed to automatically import, collect and analyze eACR responses derived from the Interacoustics® Eclipse EP 25 system.

Results*:* Higher eACR amplitudes were obtained upon apical and medial stimulation. Lower N1 latencies were seen in CI users with lower MCL and shorter phase duration values upon apical stimulation. Experienced CI users showed earlier N1 latencies and larger N1-P2 amplitudes upon apical and medial stimulation. Generally, a linear increment was observed in N1-P2 amplitude as the stimulation intensity increased, although with some dependence on subject and electrode. A significant decrease in N1-P2 amplitude was seen at 20% MCL for all users and electrodes tested.

Conclusion: An eACR setup based on direct intra-cochlear stimulation is proposed and validated in this study. eACR responses seem to be a consistent and reliable objective measure to better understand the individual effect of fitting stimulation parameters in CI users at central level.

FP38

The effect of intracochlear electrode design on electrically evoked compound action potential growth and spread of excitation functions

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Keywords: Electrically-evoked compound action potential (ECAP), Spread of excitation, Channel interaction, Cochlear Implant

Background: Cochlear implant (CI) electrode design has changed over the years. Perimodiolar electrode, a traditional design with electrode contacts positioned closer to the modiolus, has been transformed to be slimmer and softer. The lateral wall straight electrode, a relatively newer design with electrode contacts seated further from the modiolus, has been used with an increasing interest in less traumatic surgery and preserving residual acoustic hearing. Changes in intracochlear electrode design might influence the spread of neural activation and the number of independent channels. This study aimed to objectively characterize the influence of the intracochlear electrode design on neural excitation of the peripheral auditory system.

Methods: Fifty-two adults who were implanted with Nucleus CI participated in this study and were divided into three groups by the design of intracochlear electrode arrays. Twenty-three subjects were implanted with the lateral wall straight electrode (i.e., Nucleus CI522, 622). Thirty-nine subjects were implanted with perimodiolar electrodes; eighteen were implanted with the slim perimodiolar electrode (i.e., Nucleus CI532, 632), and eleven were implanted with the old perimodiolar electrode (i.e., Nucleus CI24RE(CA)). Electrically-evoked compound action potential (ECAP) was recorded via neural response telemetry from three electrodes (E6, 11, 17) across various levels to generate ECAP growth function and the spread of excitation (SOE) function. ECAP threshold and slope of the growth function, width at half of the peak amplitude of the SOE function ("half width"), and electrode impedance were compared between groups.

Results: ECAP thresholds and slopes were not significantly different between groups. SOE half widths quantifying channel interaction were significantly larger in subjects implanted with the lateral wall straight electrode, indicating a wider spread of neural excitation compared to those with perimodiolar electrodes. Electrode impedance was considerably lower in subjects implanted with the slim or old perimodiolar electrode compared to those with the lateral wall straight electrode.

Conclusion: Results suggest that the difference in the design of the intracochlear electrode arrays had an impact on neural excitation patterns at the peripheral level. Perimodiolar electrode groups yielded significantly narrower SOE half widths than the lateral wall electrode group. This indicates that the electrode array that hugged the modiolus had less overlap in neural excitation between adjacent electrodes, which results in reduced channel interaction and potentially better spectral resolution than the electrode array positioned more laterally. These findings may expand our understanding of the response of the auditory nerve per the design of the electrode array and help inform the decision to select an optimal electrode regarding each CI user"s characteristics.

FP39

Covariates of facilitation in electrically evoked compound action potentials.

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Question: Electrically evoked compound action potentials (ECAPs) objectify the auditory nerve's response after stimulation with a cochlear implant (CI). They are usually stable over years but exhibit great interindividual variability. High-rate stimulation of the auditory nerve can be investigated by applying double pulses with very short inter pulse intervals. In this way facilitation (temporal summation) can be measured by utilising ECAPs. In previous ECAP studies, a dependency of facilitation effect was found with the ECAP threshold. In this study, we aim to resolve the impact of local covariates of the CI measurements with facilitation. These are ECAP thresholds, dynamic range, amplitude growth function, interphase gap, spread of excitation, electrode impedances as well the overall psychoacoustic outcome.

Methods: ECAP measurements containing facilitation and recovery as well amplitude growth and spread of excitation were obtained in 12 postlingually implanted CI patients (Cochlear Ltd., CI 5xx, 6xx, 24RE(CA)). Further, electrophysiological measurements were correlated to psychoacoustic findings.

Results: High facilitation amplitudes are associated with high ECAP threshold, low amplitude growth function slopes, broader spread of excitation and a decreased dynamic range of the electrodes. Regarding the impedances and the interphase gap no significant differences were found.

Conclusion: Electrophysiological features of facilitation do exhibit converse stimulus-response patterns than the expected. While electrode channels with high ECAP thresholds, low amplitude growth function slopes and decreased dynamic ranges are associated with poor neural health, high facilitation amplitudes can be found here. Local inhomogeneities were observed in several patients and may be an expression of inadequate stimulus transmission.

FP40

The electrically evoked compound action potential with varying pulse phase duration and assessment of auditory nerve health

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Background: Hearing of deaf patients with a cochlear implant (CI) relies on the condition of the auditory nerve. For optimization of CI parameter settings and prognosis of hearing performance assessment of the auditory nerve is therefore important. An approach to assess neural health is recording of electrically evoked compound action potentials (eCAPs). Relative eCAP measures by varying electrical pulse parameters can be useful in reducing confounding factors such as electrode position and intrascalar tissue growth. The inter-phase gap (IPG) of the biphasic pulse appeared to be a suitable parameter revealing strong correlations of relative eCAP measures with neural survival in animals [1] and with hearing performance in CI users [2]. The pulse phase duration (PD) has a similar effect of separating phases as the IPG, and may therefore be another interesting parameter to derive relative measures. Here we examine in guinea pigs the effect of PD on the eCAP, its relation to neural survival, and the interaction of PD and IPG in their effect on the eCAP.

Methods: Nine normal-hearing and 31 ototoxically deafened guinea pigs were equipped with a short four-contact electrode array (MED-EL, Innsbruck, Austria) as previously reported [1]. eCAPs were obtained by stimulating the most apical electrode and recording from the most basal electrode. Fixed-charge biphasic current pulses of 30, 50 or 100 µs/phase and IPG of 2.1 or 30 µs were presented, with alternating polarity to reduce stimulation artefact. Charge was varied from 0 to 24 nC. eCAP outcomes included amplitude, slope and level at 50% of the input/output function, dynamic range, threshold, and latency. Following the eCAP recordings the animals were sacrificed, and their cochleas were processed for histological quantification of spiral ganglion cells (SGCs).

Results: All eCAP measures significantly depended on PD, most notably the latency, which increased by about 1.5 times the increase in PD. Overall, these PD effects were less prominent than the IPG effects. A significant interaction of PD and IPG was found in that the IPG effect decreased with increasing PD, and the PD effect either decreased (amplitude, slope, dynamic range) or increased (threshold, level at 50%) with increasing IPG. The IPG effect and to a lesser extent the PD effect were both correlated to SGC survival; these correlations were typically largest when the other parameter was shortest.

Conclusion: The best relative eCAP measures for assessment of auditory nerve health can be obtained with varying IPG using short PDs.

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FP41

Live demonstration of a portable, affordable, and versatile auditory evoked potentials recording system mostly based on off-the-shelf electronics

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Keywords: Shielded booth, portable, robust, cost-efficient, common-mode, electromagnetic interference.

Motivation: The high cost of commercially available auditory evoked potential (AEP) recording systems and their susceptibility to electromagnetic interferences such as the electrical-power network (50/60 Hz and harmonics) create obstacles that restrict the use of AEPs in specific clinical, research, education, and dissemination scenarios. To address this issue and encourage the utilization of AEPs in these fields, we have developed a low-cost AEP recording system that is highly robust against electromagnetic interferences. This system also offers the required flexibility for conducting advanced AEP experiments using complex stimuli.

System description: The fundamental principle of the proposed AEP system is the synchronous recording of both (1) a differential-mode electroencephalogram (EEG), i.e., the signal resulting from the difference between the active and reference electrodes (containing AEPs contaminated by electromagnetic noise), and (2) a common-mode EEG, i.e., the average signal of both electrodes (from which it is feasible to estimate the common mode noise, mainly associated to the power line electromagnetic interference). By appropriately scaling and subtracting the common-mode EEG from the differential-mode EEG, a denoised EEG can be obtained. To implement this functionality, our research team has developed a specific hardware device, complemented by affordable consumer electronics components such as a personal computer, an audio interface, and audio cables. The system operates on Matlab software (The Mathworks Inc., Natick, MA), and its estimated cost is approximately one-tenth of the price of other commercial alternatives.

System performance: Experiments conducted in non-laboratory settings, such as living rooms or university lecture rooms, have shown that by suppressing the common-mode EEG from the differential-mode EEG, the level of electromagnetic noise is significantly reduced. This results in AEP recordings of comparable quality to those obtained in traditional shielded booths within a lab environment. In addition, Matlab software offers the necessary flexibility to conduct advanced AEP experiments, allowing for the presentation of complex stimuli and the application of sophisticated methodologies like deconvolution [1,2] and latency-dependent filtering and down-sampling [3] to process the recorded EEG. The proposed system was presented at the "2023 International Workshop on Advances in Audiology" in Salamanca, Spain (May 25-27, 2023) [4]. A video showcasing a live demonstration of a recording session during the workshop is available [5].

Conclusion: Suppressing the common-mode EEG from the differential-mode EEG is a strategy that substantially increases the robustness of the system against electromagnetic interference. Importantly, this feature alleviates the need for an electromagnetic shielded booth, thus enabling AEP experiments to be conducted in non-laboratory settings. The improved portability, combined with the system"s affordability and flexibility, opens up new opportunities for research, education, and clinical diagnostic. For instance, this system could be particularly suitable for applications such as remote assessments, animal research, training, science-dissemination, education purposes, and for research groups with limited budgets interested in AEP technologies.

Live demonstration: The upcoming IERASG conference will feature a demonstration highlighting the proposed system´s ability to perform AEP experiments without the need for a shielded booth. During this demonstration, click-evoked auditory brainstem and middle latency responses will be recorded simultaneously at different levels. In addition, this demonstration will also include an analysis of the noise affecting the EEG, including myogenic noise and interference from the electrical-power network.

Disclaimer: Technology patent under evaluation. *Title*: Devices and methods for common mode noise reduction in biopotential acquisitions. *Priority date*: 10-05-2023. European patent application EP23382433.3. *Applicant*: University of Granada. *Contact*: [Principal investigator] Prof. Ángel de la Torre Vega (atv@ugr.es); [University of Granada] Knowledge Transfer Office (otri@ugr.es).

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Poster

P1

A Bayesian sequential test for Auditory Brainstem Response detection

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Background:

The Auditory Brainstem Response (ABR) is routinely used in the clinic to evaluate hearing function. Detecting the ABR, however, can be a challenging and time-consuming task. This is usually carried out by highly trained clinicians who visually inspect the accruing data until an ABR is deemed present or absent. When doing so, the examiners can be assisted by statistical detection methods, which help to confirm or refute the presence and/or absence of an ABR. The overarching aim for the detection method is to reduce subjectivity from the examiner, whilst also increasing test accuracy and reducing test time. To also provide prompt feedback to the examiners, it is important that these methods are applied repeatedly to the accruing ABR data, i.e., a sequential test strategy is adopted. The challenge, however, is that repeated hypothesis testing increases the probability of making an error, and in order to control the error rate, the critical thresholds for determining "ABR present" and "ABR absent" need to be chosen carefully. To find these critical thresholds, current sequential tests impose limits on how often and when data can be analysed. That is, the stage-wise ensemble sizes need to be fixed at the outset. This is problematic for ABR detection, as the signal-to-noise ratio (SNR) is unknown prior to the test, and any predetermined sample size will tend to result in either an over- or an under-powered test.

Objective: The main objective for this work was to develop and evaluate a flexible Bayesian sequential test for ABR detection. The approach revolves around the Bayes Factor (BF), and offers great flexibility in terms of how often and when data data can be analysed.

Design: The BF approach was evaluated extensively in simulations and in a chirp-evoked ABR threshold series from 22 subjects with normal-hearing. In simulations, comparisons were drawn between the BF approach and an existing, non-adaptive sequential test, called the "convolutional group sequential test", or "CGST". In the subject-recorded data, comparisons were drawn between the BF approach, the CGST, and visual inspection results from examiners.

Results: In simulations, the mean test time for determining "ABR present" was 26.6 seconds for the BF approach, whereas for the CGST this was 30.5 seconds. However, when determining "ABR absent", this was 192.7 seconds for the BF approach versus 73.9 seconds for the CGST. Note that both methods were optimised to have equal test specificities and sensitivities, i.e., the comparison in test time was fair. In the ABR threshold series, mean test times were 68 seconds (std. 65) for the BF approach, 52.7 seconds (std. 35) for the CGST, and 170.7 seconds (std. 125.9) for visual inspection by examiners. Contrary to the simulations, test specificities and test sensitivities were now not equal across methods, meaning caution should be exercised when interpreting these results.

Conclusions: The BF approach can be used to provide timely feedback to examiners, even as frequently as every second, for as long as they require. This can help to bring ABR examinations to a definitive outcome in terms of "ABR present" or "ABR absent", whilst also accommodating for variability amongst examiners in terms of how much data they need before making a decision. This flexibility comes at the cost of an increased mean test time when compared to the non-adaptive CGST approach. It is thus envisaged that the BF approach may be advantageous in aiding examiners with response detection, but that some alternative methods may be more powerful for fully autonomous decision making without the involvement of clinicians.

P2

An ABR study of central gain in individuals with chronic tinnitus

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Keywords: hearing, tinnitus, evoked potentials, auditory brainstem response

Background: Chronic tinnitus is a symptom that can be present in subjects with or without changes in auditory thresholds. A hypothesis of neural deafferentation, in which changes in the auditory pathway cause alterations in multiple areas of the auditory and cerebral nervous system, explains why tinnitus is associated with central gain. Such changes would lead to neuroplastic reorganization, increased neural responsiveness, and, due to increased spontaneous neural activity, be experienced as unpleasant. The aim of this work was to check whether the presence of chronic tinnitus was associated with changes in click-ABR responses, which would support the neural deafferentation hypothesis.

Method: This was an analytical, cross-sectional, and quantitative study approved by the Ethics Committee of the University, opinion number 56038322100005346. There were 51 ears in our study, which were divided into two homogeneous groups regarding sex and age: a) A study group (EG), consisting of 25 ears, with chronic tinnitus and mean age of 23.7 years; b) A control group (CG) of 26 ears without tinnitus and the same mean age. Exclusion criteria were pharmacological treatment, noise exposure, dizziness, objective tinnitus of a pulsatile type, and diagnosed or evident neurological, psychiatric, or cognitive impairment. All subjects had previously submitted to an ABR with a click stimulus. They also underwent an anamnesis, basic audiological assessment, transient otoacoustic emission test, and behavioral assessment of central auditory processing. For data analysis, a Mann–Whitney *U*-test was used, adopting a p-value ≤ 0.05.

Results: There was a statistically significant difference between the groups in terms of the amplitude of wave I, with the EG presenting higher values.

Conclusion: Chronic tinnitus appears to cause a change in the amplitude of wave I of the ABR, a finding which suggests that chronic tinnitus may be associated with neural changes in the distal part of the auditory nerve. To confirm these findings, electrocochleographic studies should be carried out.

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P3

ABR & OAE change in transplantation with mesenchymal stromal cells from human placenta in sensorineural hearing loss animal model

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Background: Hearing loss is a common chronic disorder characterized by decline of auditory function. The global population have suffered from deafness and the transplantation of stem cells is regarded as a therapeutic strategy for this disease Methods: We collected placenta from a total of 13 samples of full term pregnant women and isolated MSCs derived from human placenta and transplanted MSCs on deaf animal model. The normal group and the sensorineural hearing loss (SNHL) group and the experimental (transplanted MSCs) group were compared and estimated hearing level using auditory brainstem response (ABR) recordings and the otoacoustic emission (OAE) test Results: ABR threshold value and DPOAE level showed that MSCs transplantation groups was improved than the SNHL group. And the number of spiral ganglion neurons were increased in all turn of the cochlea. And there was no evidence of acute immunological rejection and inflammation response was not observed. Conclusion: This study is to evaluate regenerative efficacy of hearing loss by transplanting mesenchymal stromal cells (MSCs) derived from human placenta (amnion and chorion) in deaf animal model. We identified that MSCs transplantation restored auditory impairment and promoted cell regeneration. We hope to overcome sensorineural hearing loss by transplanting stem cells such as mesenchymal stromal cells (MSCs) from easily accessible adult stem cell source in placenta

P4

Measurement of Reference Equivalent Thresholds Sound Pressure Level (RETSPL) & Difference between Auditory Brainstem Response (ABR) & Puretone Audiometric Thresholds -(PTA) at 3, 6, and 8 kHz

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Keywords: Ototoxicity, Reference Equivalent Thresholds Sound Pressure Level, Auditory Brainstem Response, Puretone Audiometry, Early detection of Ototoxic hearing loss

Background: Ototoxicity refers to the harmful effects of certain substances on the inner ear and its components, leading to functional impairment and cellular damage and it is a growing global concern1, especially in new-borns who are admitted to the NICU. One significant aspect of ototoxicity is that it is typically detected earlier at higher frequencies. However the absence of Reference Equivalent Threshold Sound Pressure Level (RETSPL) values for tone pips at 6 kHz and 8 kHz in international standards presents notable limitations in the accuracy of electrophysiological assessments particularly affecting individuals who cannot undergo standard audiometry, such as new-borns or those with cognitive impairments.

To address this gap, this current study aims to measure thresholds for pure tones and tone pips at 3 kHz, 6 kHz, and 8 kHz using appropriate psychoacoustic measures. The focus will be on young adults with normal hearing, as they serve as a suitable population for establishing normative data. By utilizing psychoacoustic measures, accurate and reliable threshold determination can be ensured.

Method: To meet the requirements of the British Standard (BS EN ISO 389-9:2009)2, which defines the procedure for measuring RETSPL values, a total of 25 young adults between the ages of 18 and 25 with normal hearing are being recruited. A British-standard questionnaire will be used to screen candidates to ensure they meet these criteria. Behavioural thresholds will be obtained at 1, 3, 4, 6, and 8 kHz using PTA and tone pip ABR thresholds, and normative data (RETSPLs) will be measured using psychoacoustic measures. (4 kHz behavioural threshold will be measured and compared to normative data already available.) Finally, ABR and behavioural thresholds will be compared.

Results: The results presented will be Reference Equivalent Threshold Sound Pressure Level at 3, 6, and 8 kHz and relationship between the tone pip ABR and behavioural thresholds at these frequencies.

Conclusion: Overall, the study addresses some of the limitations of high frequency auditory electrophysiological assessments. Subsequently, the established reference values may facilitate early detection of ototoxic hearing loss in new-borns and individuals with cognitive impairments.

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P5

Correlation of hearing thresholds measured by puretone audiometry and by tone-burst auditory brainstem response.

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Background: Tone-burst auditory brainstem response (ABR) is considered to be a more accurate representation of auditory threshold and a more correlation with pure tone audiometry (PTA) threshold than ABR using click sound. However, in certain cases, the tone-burst ABR threshold did not match with PTA results, especially slope type hearing. This study aimed to identify the reliability of tone-burst ABR in measuring the slope type hearing, and to find the characteristics of hearing in mismatched cases between tone-burst ABR and PTA.

Methods: A total of 420 ears that underwent tone-burst ABR were included in the study. 1 kHz and 3 kHz tone-burst sound were used. Thresholds that were not measured as scaled-out were excluded in both ABT and PTA. The results of 180 ears were included for analysis. The threshold inclination of PTA and tone-burst ABR between 1 kHz and 3 kHz was calculated by the difference of PTA between two frequencies and categorized into down-sloping (≥ 20 dB), flat (-20 dB < difference < 20 dB), and ascending (≤ -20 dB) type. The mismatched result between ABR and PTA was categorized into three types at each specific frequency: higher ABR threshold group (PTA-ABR ≤ -15 dB), normal (-15 dB < PTA-ABR < 15 dB), and higher PTA threshold group (PTA-ABR ≥ 15 dB). The absolute values of the differences were calculated between the tone-burst ABR at each frequency and corresponding PTA, or SRT. Then comparisons of these audiological results were performed to assess the correlation among the results in each group.

Results: The concordance of down-sloping type PTA with ABR was 84.615 % and in ascending type of PTA was 71.429%. The mean differences between tone-burst ABR and PTA at 1 kHz and 3 kHz were significantly different among groups classified by either 1kHz (1 kHz P<0.001, 3 kHz P<0.001) or 3 kHz (1kHz P<0.001 / 3kHz P<0.001). The 1 kHz ABR threshold exhibited a higher correlation with the 1kHz PTA rather than with the SRT in both the higher ABR threshold group (P=0.003) and normal group (P<0.001) at 1kHz. A similar trend was observed in the higher ABR threshold group at 3kHz (higher ABR threshold group P<0.001 / normal group P<0.001). In contrast, the higher PTA threshold group at 1 kHz exhibited higher consistency between 1 kHz ABR threshold and SRT than between 1 kHz ABR threshold and the 1 kHz PTA (P<0.001), and the same trend was observed in the higher PTA group at 3 kHz (P<0.001).

Conclusion: The sloping type of tone-burst ABR could represent the sloping type of PTA and down-sloping type had the highest concordance. When interpreting PTA results more than 15dB higher compared to tone-burst ABR threshold, it is important to consider that the correspondence of tone-burst ABR threshold with SRT is better.

P6

Auditory Brainstem Response in Normal Hearing in new equipment available in Brazil

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Keywords: Evoked Potentials, Audiology, Evoked Potential, Adult

Background: Auditory brainstem response (ABR) potential is important for audiological diagnosis, reflecting the integrity of the structures of the auditory system up to the brainstem. The click stimulus is the best known and is most used in clinical practice. However, different devices and examiners may yield distinct results, and each institution tends to use its own parameters. We aimed to analyze the latency values of wave I, III, V, and interpeak intervals I–III, III–V, I–V values obtained in assessing ABR using a new device available in Brazil. Material/Methods: We performed a cross-sectional study of 73 participants with normal hearing thresholds and no hearing problems. All underwent basic audiological (air and bone conduction, Speech Recognition Threshold, Speech Recognition Index, acoustic reflex, and tympanometry) and electrophysiological evaluation (ABR assessment).

Results: Absolute latency and interpeak values from ABR showed earlier responses in women, faster than international standards suggest. The responses were similar to other studies carried out previously, with the exception of wave I values, which were a little earlier in females.

Conclusions: We assessed normative data from measurement of latency values of wave I, III, V, and interpeak intervals I–III, III–V, and I–V applying 2 standard deviations in the assessment of ABR using the new Neuro-Audio/ABR device created by Neurosoft available in Brazil.

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P7

Evaluation of sound-working memory therapy in autism spectrum disorder children using auditory brainstem response (ABR) with psychological task

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Questions: Does sound-working memory therapy effective in improving auditory sensory gating of ASD children? **Methods:** Twenty-three ASD children were randomly divided into 3 experimental groups and 1 control group. The experimental groups underwent sound working memory training (SWMT) in which different sounds (waterfall, white noise and Quranic recitation) were assigned during session while they were trained with working memory training. Pre- and post-intervention was measured using ABR with Stroop task in four Stroop conditions: no cognitive load, congruent, incongruent and neutral. Stroop interference (SI) and ABR sensory gating was calculated by subtracting the result in the incongruent from the neutral condition. Gain score for ABR wave V, Stroop effect, SI and ABR sensory gating were also measured to compare the influence of different sound. **Results:** RM ANOVA were used to investigate the improvement of SMWT in all Stroop task condition for all groups. ANOVA was used to compare SI and ABR sensory gating results between experimental and control groups after the intervention at 95% confidence levels. Only participants in Quran SWMT show improvement in the percentage score and response time, while those in white noise SWMT shows improvement only in response time results after the intervention. However, the gain score for SI shows each stimulus provide different influence on the Stroop task condition. Furthermore, participants underwent white noise and Quran SWMT demonstrated significant increase in the SI percentage score following intervention. In contrast, participants underwent waterfall and white noise SWMT shows a decrease in the SI response time following intervention. The highest SI percentage score was obtained from participants who underwent white noise SWMT followed by Quran SWMT. The lowest response time was obtained from waterfall and white noise SWMT. None of the wave V ABR and ABR sensory gating results were significant. Overall, this finding suggests an improvement in the auditory sensory gating abilities among ASD children following SWMT. **Conclusion:** Waterfall and white noise are effective in SWMT to address the sensory gating issue in ASD children. Stroop task tool has the potential to effectively measure the changes that occur from the SWMT and provide useful information on the status of the cognitive function in ASD children. The ABR under the influence the Stroop task did not show any changes in post SWMT intervention.

P8

BRAINSTEM AUDITORY EVOKED POTENTIAL IN NEONATES WITH HEARING RISK FACTORS

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Introduction: Brainstem Auditory Evoked Potential (BAEP) is an electrophysiological evaluation that holds considerable significance in the field of speech therapy. This examination is a short latency potential characterized by its brief duration and objective nature in recording the response. In neonates, especially those identified with a risk indicator for hearing impairment, the combined application of two auditory stimuli - the click and the tone burst, have been recommended to facilitate a precise and early audiological diagnosis (1,2). However, such an integrated approach has yet to become standard practice in Brazil.

Objective: To characterize BAEP diagnostic examination with different sound stimuli, applying them to newborns with auditory risk factors.

Methods: BAEP was performed with both click and tone burst stimuli in 14 neonates with normal hearing, premature and full-term neonates delivered in a Brazilian hospital, with auditory risk indicators such as maternal syphilis infection (40% of participants) and low Apgar score.

Results: The tone burst and click stimuli showed different values and brought additional information. There were no differences in BAEP measures of term and preterm neonates for both stimuli and ears. When gestational age was correlated to BAEP using tone burst stimulus at 500 Hz-recorded at 40dB nHL, a significant difference was found, showing a negative correlation: the lower the gestational age, the longer the wave V latency.

Conclusion: The click and tone burst stimuli in BAEP recordings have proven to be complementary, confirming the advantage of the combined application of these stimuli in clinical practice to obtain a complete audiological diagnosis and to study the auditory pathway maturation.

P9

Towards ASSR-based hearing assessment using natural sounds

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Keywords: ASSR, electroencephalography, hearing assessment

Background: The auditory steady-state response (ASSR) enables hearing threshold estimation, which is crucial for fitting/re-fitting of hearing aids. ASSR can be recorded from electroencephalography (EEG) electrodes placed on the scalp and in the ear (so-called ear-EEG) of the test subject [1]. Ear-EEG can potentially be integrated into hearing aids, which would enable automatic hearing threshold estimation and re-fitting of hearing aids in daily life. The conventional stimuli employed to estimate hearing thresholds based on ASSR, like pure tones and chirps, are monotonous and tiresome, making them inconvenient for repeated use in everyday situations. There, use of ecologically valid natural sounds, though less effective, would be more suitable. In this study, we introduce a new approach for estimation of the ASSR vs. presentation level relation using sub-band amplitude modulation (AM) of continuous speech.

Methods: EEG was recorded from 22 normal hearing subjects from four scalp electrodes (M1, M2, Afz, Fpz) and 12 ear electrodes (six in each ear). Each subject was monaurally stimulated with 180 minutes of speech stimulus. The speech stimulus was modified by applying a 40 Hz amplitude modulation (AM) to an octave frequency sub-band centred at 1 kHz. Each 50 ms sub-interval (containing two periods of the modulation signal) in the AM 1 kHz sub-band was scaled to match one of 10 pre-defined levels (from 0 to 45 dB SL, with 5 dB steps). The amplitude scaling function was adapted to the stimulus resulting in stimulation lengths of 30, 24, 20, 20, 18, 18, 14, 12, 12 and 12 minutes at levels of 0, 5, 10, 15, 20, 25, 30, 35, 40 and 45 dB SL respectively. The apparent latency for the ASSR was estimated as the maximum average cross-correlation between the envelope of the AM sub-band of the speech stimulus and the recorded EEG and was used to align the EEG signal with the audio signal. The EEG was then split up into sub-epochs of 50 ms length and sorted according to the stimulation level. Finally, ASSR was estimated for the different stimulation levels for three electrode configurations: Scalp (M1 and M2 with reference to Afz), CrossEar (applying a spatial filter to all 12 ear electrodes) and InEar (applying a spatial filter to the six electrodes of each ear individually).

Results: The estimated apparent latencies were found to be 43.6 and 42.4 ms for ipsilateral (IL) and contralateral (CL) Scalp ASSRs respectively. For ear-EEG configurations the apparent latencies were found to be 22.4 ms for CrossEar, and 26.4 (IL) and 20.4 (CL) ms for InEar. For all three electrode configurations, ASSR increased with increasing presentation level. The slope of the Scalp ASSR as a function of the presentation level was 0.42 dB/dB at levels of 0-15 dB SL and 0.23 dB/dB at levels of 15-30 dB SL, whereas the ASSR saturated at levels of 30-45 dB SL.

Conclusion: The apparent latencies found in scalp-EEG were in agreement with the existing literature [2]. The latencies for ear-EEG configurations were shorter than for Scalp, suggesting higher relative sensitivity of these configurations to sources earlier in the auditory pathway. The slope of the scalp ASSR vs. presentation level relation was comparable with existing literature at levels of 0-30 dB SL [2]. The results of the study showed that ASSR as function of the presentation level can be estimated using a partly AM running speech signal from both scalp- and ear-EEG. Incorporated into a hearing device, the approach introduced in the current study would enable hearing assessment in everyday life.

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P10

Reliability of interaural difference of SP/AP ratio in Meniere's disease

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Keywords: electrocochleography, endolymphatic hydrops, Meniere's disease, interaural difference

Background: Extratympanic electrocochleography (ECoG) can offer objective information in diagnosing Meniere's disease. The sensitivity and specificity of extratympanic ECoG is variable according to the criterion of an SP/AP ratio, and furthermore, the ECoG results were frequently inconsistent with audiometric data and side of disease. Few studies have compared SP/AP ratio and interaural difference of SP/AP ratio regarding pure tone average to determine the presence of endolymphatic hydrops. We evaluated those results to determine the reliability for the diagnosis of Meniere's disease.

Methods: A retrospective analysis of 84 patients who diagnosed with definite and possible Meniere's disease in our department was performed. They were divided into 2 groups: the definite and possible Ménière"s disease groups, and their ECoG results and audiometric data were analyzed. To analyze the correlation with the SP/AP ratio and interaural difference of ECoG results of Meniere"s disease, the SP/AP ratio of diseased ear and the interaural ratio of SP/AP in the definite Meniere"s disease group were compared. In the possible Meniere's disease group, the higher SP/AP ratio was compared with the interaural ratio.

Results: Eighty-four patients of Meniere"s disease were included in this study. Forty-two percent were men whereas 58% were women. Mean age was 46.69±17.75 years. According to the AAOHNS guidelines, 54 patients were classified as having definite Meniere's disease, and 30 as having a possible Meniere's disease. An elevated SP/AP ratio (>0.3) was noted in 70.4% (38/54) of definite Meniere's disease, 55.9% (19/34) of possible Meniere's disease. The correlation coefficient of the SP/AP ratio and interaural difference was 0.638 in definite Meniere's disease group. By multivariate linear regression analysis, ECoG results were not affected significantly by mean hearing level.

Conclusion: Both the SP/AP ratio and interaural difference of SP/AP ratio can play a role in the diagnosis of Ménière's disease with unilateral hearing loss. In addition, the disease side may be determined by using interaural difference in possible Meniere's disease.

P11

Multi-Frequency ECochG Monitoring through the AIM System

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Background: Today"s Cochlear Implant (CI) candidates often have significant residual hearing. With the electro-cochleography (ECochG) measurements it is possible to monitor the insertion process of the electrode array in real time and adapt the insertion speed, depth and angle with the aim to minimize the insertion trauma. Currently it is investigated how to differentiate drops of the response caused by damage/trauma (as shown in Koka et al. 2018) and ones caused by changes of recording position.

Methods: A research version of the AIM (Active Insertion Monitoring) system has been developed to monitor cochlear microphonics (CM) during the insertion for several frequencies simultaneously. This has been used by Saoji et al. (2023) during 10 cochlear implantations in subjects with residual hearing. Post-insertion electrode scans were also analysed for phase changes. Buechner et al. (2022) used a single frequency (usually 500Hz) for monitoring the insertion in 47 patients and analysed the recordings for amplitude and phase changes.

Results: Results from Saoji et al. do show frequency-specific responses for all subjects. In some cases post-insertion electrode scans do show different peak locations for different frequencies. There was no correlation between CM amplitude drop and post-operative drop in pure tone thresholds. Buechner et al. also looked at residual hearing preservation and the course of intra-operative CM monitoring. There was no correlation when looking only at the amplitude, but there was a significant finding when additionally also considering the phase.

Conclusion: The current findings suggest that measuring multiple frequencies or considering also the response phase might add valuable information for differentiating amplitude drops caused by damaging cochlear structures or by passing the generator site.

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P12

Potential Presence of Cochlear Synaptopathy in Patients fully Recovered from Sudden Sensorineural Hearing Loss

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Keywords: sudden hearing loss; synaptopathy; hidden hearing loss; auditory brainstem response

Background: Cochlear synaptopathy, commonly referred to as "hidden hearing loss," is a subtle hearing impairment that can account for hearing difficulties within the normal hearing threshold. This condition is believed to involve dysfunction in the synaptic connections of the cochlea. The present study hypothesizes that a temporary threshold shift experienced in sudden sensorineural hearing loss (SSNHL), similar to the effects observed in noise exposure, also affects synaptic function. The aim of this study was to investigate the presence of cochlear synaptopathy in patients who had fully recovered from unilateral SSNHL.

Methods: Nineteen patients who had completely recovered from SSNHL between January 2018 and June 2021 were included in the study. Complete recovery was determined using pure tone audiometry (PTA) conducted three months post-treatment, in accordance with the American Academy of Otolaryngology–Head and Neck Surgery criteria. The participants underwent pure tone audiometry, speech audiometry, and auditory brain stem response (ABR) tests. In addition, a questionnaire regarding hidden hearing loss after recovery was assessed. The ABR amplitudes of wave I and wave V, along with the ratio of wave I/V, were measured for both ears (recovered and healthy sides). Subjective hearing difficulty was assessed using a visual analog scale (VAS) and a hidden hearing loss questionnaire.

Results: Analysis of ABR wave amplitudes revealed that wave I amplitudes were significantly lower in the recovered ears compared to the healthy ears ($p = 0.002$). However, no significant differences were observed in wave V amplitudes ($p = 0.985$) or the wave I/V ratio ($p = 0.107$). Some patients reported mild hearing difficulty despite having normal PTA results. However, there was no clear correlation between the VAS score, wave I amplitude, and speech recognition scores.

Conclusions: The findings of the study suggest the potential presence of cochlear synaptopathy in ears that have fully recovered from unilateral SSNHL. The study implies a possible shared etiology between cochlear synaptopathy and idiopathic sudden hearing loss. The observed discrepancy between objective PTA results and subjective hearing difficulties highlights the importance of considering synaptic function in understanding hidden hearing loss. Further research is needed to elucidate the underlying mechanisms and clinical implications of cochlear synaptopathy in the context of SSNHL recovery.

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P13

Transtympanic electrically evoked auditory brainstem response in local anesthesia (= LA-TT-EABR) using the MED-EL stimulation and Nihon Kohden recording system vs. an Inomed stimulation and recording setup

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Question: In the last years, the electrically evoked auditory brainstem response (= EABR) got a revival in several scientific works, especially using a pre-operative setup (Gibson, 2017; Baljić et al., 2021a+b) for auditory nerve assessment in cochlear implant (CI) candidacy. In these studies, a transtympanic (= TT-EABR) placement of the stimulation electrode in the round window niche has become the gold standard (Pau et al., 2006). In contrast to TT-EABR in general anesthesia just before cochlear implantation, a pre-operative setup in local anesthesia (= LA-TT-EABR) became of high interest in current research in checking cochlear implant (= CI) candidacy (Polterauer et al., 2018+2022a). This LA-TT-EABR has been investigated in several studies mostly using the "MED-EL PromStim System" stimulation system being a CE-certified system and therefore usable also outside of studies in the clinical testing; for recording, a Nihon Kohden Neuropack S1 MEB-9400 as EP system was used. The goal of this study is to verify these results using simultaneously another stimulation and recording system to verify the results (compare Polterauer et al., 2022b; Dutt et Kumar, 2019).

Methods: Within this study group, thirteen subjects have been tested by LA-TT-EABR using the MED-EL stimulation and Nihon Kohden recording setup (called MED-EL/NK setup). As the positive stimulating electrode, a round-bent tip "golf club" electrode manufactured by MED-EL ("PromStim Electrode") was placed in the round window niche. Ground stimulation as well as recording non-invasive electrodes "ambu neuroline 720s" were used. The negative stimulation electrodes were placed on the mandible angle and zygomatic bone. The recording electrodes were applied on the contralateral mastoid (inverting), high forehead (non-inverting), and lower forehead (ground). After completing the LA-TT-EABR with the established MED-EL/NK setup, stimulation as well as recording connectors were switched to the "Inomed ISIS xpert" system (called Inomed setup). The Inomed setup offers stimulation as well as recording for LA-TT-EABR using a custom configuration.

Results: With the MED-EL/NK setup, we found a secure response in four subjects, eight subjects had an insecure response, and one subject had no response. With the Inomed setup, we found a secure response in six subjects, six subjects had an insecure response, and one subject had no response. With both systems, in four subjects, LA-TT-EABR showed a secure response; in six subjects, LA-TT-EABR showed an insecure response and in one subject, LA-TT-EABR showed no response. In two subjects, the MED-EL/NK setup showed a different result. The analysis of the artifact length, detection of eII/III, and detection of eIV/V showed good results for the MED-EL/NK setup as well as for the Inomed setup.

Conclusion: MED-EL/NK and Inomed setup seem to be reliable when performing LA-TT-EABR. Regarding LA-TT-EABR, the two setups seem to offer similar results. Looking at the wave complexes eII/III, eIV/V, and the stimulation artifact further research is needed to validate these preliminary findings. The advantages and disadvantages of both setups are discussed in detail.

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P14

Transtympanic electrically evoked auditory brainstem response in local anesthesia (= LA-TT-EAMLR) as a pre-operative tool for checking cochlear implant (= CI) candidacy in an intrasubject comparison to established equivalent measurements of the auditory brainstem (= LA-TT-EABR) and auditory cortex (= LA-TT-EALR)

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Question: The LA-TT-EABR can be used to evaluate CI candidacy pre-operatively in doubtful cases (Meyer et al., 1984; Gibson, 2017; Polterauer et al., 2018+2022a; Baljić et al., 2021a+b). In addition, LA-TT-EALR can be helpful to check the auditory cortical areas. In post-lingual subjects with short periods of deafness, the auditory cortical status is expected to be normal, and therefore LA-TT-EALR can be used to verify the LA-TT-EABR. Kileny and his research group investigated the LA-TT-EAMLR (Kileny et al., 1987+1989) using an experimental setup, where 19 out of 22 ears showed a positive response. They chose EAMLR instead of the EABR mainly due to electrical artifacts induced by the stimulation between the needle electrode in the round window region and the ipsilateral earlobe. This AEP measurement was not yet investigated with the approved setup used for LA-TT-EABR. Therefore, it was of scientific interest to investigate it by integrating it in our pre-operative CI candidacy check, adding a little extra time.

Methods: LA-TT-EAMLR was tested using the "MED-EL PromStim System" for stimulation and "Nihon Kohden Neuropack S1 MEB-9400" for EP recording. For the positive stimulation electrode, a round-bent tip "golf club" (PromStim) electrode manufactured by MED-EL was placed in the round window niche (as in Pau et al., 2006). For negative stimulation as well as recording non-invasive electrodes "ambu neuroline 720s" were used. The negative stimulation electrodes were placed on the mandible angle and zygomatic bone. The recording electrodes were applied on the contralateral mastoid (inverting), high forehead (non-inverting), and lower forehead (ground). First, the established LA-TT-EABR test was performed, and, independent from the results, the LA-TT-EAMLR was done. In addition to the brainstem and middle latency responses, we also performed LA-TT-EALR to evaluate the late responses from the auditory cortex, not the object of this study (Polterauer et al., 2022b). This combination of LA-TT-EABR, -EAMLR, and -EALR was tested in patients with insecure LA-TT-EABR results during the recording session.

Results: LA-TT-EAMLR was performed in n=5 subjects. We found a secure response in one subject, three subjects had an insecure response, and one subject had no response. These results were compared to those in LA-TT-EABR as well as LA-TT-EALR. For LA-TT-EABR, we found an 80% match to LA-TT-EAMLR results. For LA-TT-EALR, we found a 60% match to LA-TT-EAMLR results. The results of the established LA-TT-EABR and LA-TT-EALR were matching in 40% of this study group.

Conclusion: These preliminary results of LA-TT-EAMLR need to be evaluated in a larger study group to allow a descriptive statistical analysis. However, these subjects showed that the additional testing time of LA-TT-EAMLR can help to check insecure results from LA-TT-EABR and offers an auditory midbrain analysis.

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P15

Correlating the intraoperative electrically evoked auditory brainstem response with postoperative high-resolution computed tomography scans

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Keywords: cochlear implant, electrically evoked auditory brainstem response, flat-panel volume computed tomography, insertion depth

Background: During cochlear implantation, the surgeon has no information about the insertion depth of the cochlear implant (CI) electrode, besides the visual feedback. Determination of the correct electrode position is only possible by postoperative imaging, which can mean additional radiation exposure for the patient, while possible electrode malpositions can only be corrected in a second operation. To overcome these shortcomings, it would be desirable to have an electrophysiologic tool for estimating the depth of insertion during the initial surgery. Studies have shown that the latency and the morphology of the electrically evoked brainstem response (eABR) varies for different locations of the stimulating electrode contact within the cochlea, with more apical contacts showing shorter and more basal contacts showing longer latency of wave eV (Firszt et al., 2002). In order to investigate the potential of eABR recordings as an electrophysiological tool for estimating the insertion depths of CI electrodes, an ongoing study correlates the latency of eV evoked from three different stimulating contacts and recorded during surgery with the insertion depth of the same determined from postoperative high-resolution computed tomography (CT) scans.

Methods: Intraoperative eABR recordings will be collected from 33 patients right after electrode insertion. The intraoperative test setup consists of a MAXbox CI interface controlled via the software MAESTRO (MEDEL, Innsbruck, Austria) for stimulation and an Eclipse AEP system (Interacoustics, Middelfart, Denmark) for recording. The eABRs will be recorded with surface electrodes placed on the mastoids and the forehead of the patients. Biphasic stimulation pulses will be emitted in monopolar mode and with alternating polarity from an apical, medial, and basal electrode contact location. Different stimulation levels for each electrode contact will be used. Insertion depths of the apical, medial, and basal contacts will be determined from postoperative high resolution flat panel volume CT scans with secondary reconstruction (fpVCTSECO) using the surgical planning software OTOPLAN (CAScination AG, Bern, Switzerland). The insertion depths of the three electrode contacts are thereafter correlated with the wave eV latency of their corresponding eABR.

Results: The data acquisition is ongoing and final results are pending. Preliminary results showed the suitability of the test setup and procedure for the planned study. Comparable to previous reports in the literature, the data collected so far show that the wave eV evoked by an apical contact has a shorter latency than that evoked by a basal contact.

Conclusion: Prior to the start of the study, the experimental setup was validated and the parameters for stimulation and recording of the eABRs as well as the testing procedure were successfully determined. In agreement with previous studies (Firszt et al., 2002), the preliminary results of the eABR recordings showed a dependency of the latency of wave eV from the intracochlear location of the stimulating contact. We are optimistic that as the data set progresses, we will be able to demonstrate that intraoperative eABR measurements can provide valuable information for the surgeon to estimate the depth of insertion of the CI electrode.

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P16

Feasibility of Extracochlear Stimulation to Induce Hearing and Reduce Tinnitus

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Question: Previous studies have demonstrated positive effects of stimulation via a cochlear implant (CI) on tinnitus, the underlying mechanisms how electrical stimulation can relieve tinnitus remain unclear [1].In this study, the use of extracochlear electrical stimulation inside the middle ear was investigated for alleviating tinnitus and inducing a hearing perception. The latter could be beneficial for hearing impaired persons to use combined electric and acoustic hearing. A method was developed to produce a hearing perception and/ or reduce tinnitus in patients with normal cochlear function by utilizing extracochlear electrical stimulation of the cochlea and the auditory nerve.

Methods: Six patients with normal bone conduction thresholds underwent medically indicated mastoidectomy and were temporarily implanted with extracochlear electrodes at various locations in the middle ear. Biphasic electric stimuli (53.3 µs phase duration, 34 Hz pulse rate, alternating polarity) were applied. Electrophysiological recordings and subjective feedback were collected to assess the impact of extracochlear stimulation on hearing perception. The impact of extracochlear stimulation on tinnitus perception before and after the measurements was evaluated through standardized tinnitus questionnaires (Tinnitus Functional Index & Tinnitus Handicap Inventory). During electrical stimulation, the perception of tinnitus, hearing thresholds, hearing impression as well as other perceptions (e.g. vibration, change in taste, pain) were reported.

Results: Subjective feedback on hearing impressions during extracochlear stimulation was collected in four patients. Extracochlear stimulation successfully induced a hearing impression in all four patients, although these impressions were not loud enough to be detected by objective audiometry. Additionally, two patients reported suffering from tinnitus. Although no difference was found in the tinnitus questionnaires before and after stimulation, the perceived tinnitus was successfully reduced during extracochlear stimulation.

Conclusions: These preliminary results suggest that extracochlear stimulation may have the potential as a treatment option for hearing loss and tinnitus. The results also provide a foundation for further investigation.

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P17

Cortical auditory evoked potentials (P1 latency) in children with cochlear implants correlated with clinical language tests

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Keywords: Cochlear implants, children, CAEP, P1, central auditory pathways, language test, binaural function, speech perception

Background: Cochlear implantation has become a well-established method in habilitation of children with severe to profound hearing impairment, and for more than 15 years, it has been recommended to provide bilateral cochlear implants (CIs) to children. At an individual level, there are large variations in outcomes in speech and language development in children with CIs. Implantation before 12 months of age seems to promote language development more resembling that of normal hearing children compared to the outcome of surgery at 1-3 years of age. A delay in language development is often seen in children with hearing impairment, and this delay seems to be applicable even for children with a CI. The P1 wave is the first positive peak appearing within the CAEP as a cortical response to sound stimulation, and it reflects the sum of accumulated synaptic delay and neural conduction between the ear and the primary auditory cortex. Measuring the latency of the P1 potential of cortical auditory evoked potential could indicate the matureness in the central auditory pathways. Our aim was to study the correlation between P1 latency and results of clinical language tests (Reynell III and TROG-2), the latter was used according to the Swedish national guidelines to follow-up children with cochlear implants (CIs).

Methods: The study cohort consisted of 49 children with cochlear implants who were recruited when coming for a yearly follow-up at the Cochlear implant program during 2017-2019. The children had been implanted at ages ranging from 0.8 to 6.9 years (mean 2.4 years). All children were reportedly daily CI users. The appointment included a clinical language test in addition to the P1 measurement. The recordings took place in an anechoic chamber at the Department of Otorhinolaryngology, Linköping University Hospital. A clinical multichannel evoked potential system, Cascade® Elite (Cadwell Lab Inc., WA, USA), was used. The sound stimulus was presented by a custom-made sound generator activated by the main unit through a trigger output interface box. The synthetic sound /ba/, a consonant-vowel combination, was presented with speakers at a level of 75 dB SPL.

Results: Out of the included 49 children, 39 (80%) had a reproducible P1 latency that could be measured. For all children tested, there was a significant negative correlation (Spearman"s rho=-0.403, p=0.011) between hearing age and P1 latency. A significant correlation between P1 latency and the Reynell III result (Spearman"s rho -0.810, p=0.015) was found. In the TROG-2 group, there was no significant correlation between their P1 latency, and their language test results (Spearman"s rho -0.239, p=0.196).

Conclusion: This method seems to be feasible and easily accepted. The study was conducted in a heterogeneous group of children that we meet daily in our clinic. The results indicated that P1 latency has a negative correlation with language development among our youngest patients fitted with CIs and might be a clinical tool to assess the maturation of central auditory pathways.

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P18

Cochlear Implant Outcomes in the Elderly Patients: Experience over 10 years in Asan Medical Center

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Objectives: To evaluate hearing outcomes of cochlear implant (CI) in the elderly patients who underwent surgery in Asan medical center and demonstrate factors which affect postoperative speech performance.

Methods: Ninety-three elderly patients (60~80 years of age) with post-lingual sensorineural hearing loss (SNHL) who underwent CI were classified into two groups according to the speech performance scores: the poor performance group (monosyllabic word scores <70%, n=55), and the good performance group (monosyllabic word scores ≥70%, n=38). The distribution and contribution of the potential factors related to post-CI outcomes were analyzed. We also identified how outcomes in speech performance could be predicted according to the causes of SNHL.

Results: The duration of hearing deficit was significantly related to post-CI speech performance (the poor performance group: 26.64±21.34, the good performance group: 13.05±13.99, $p<0.001$*). Elderly SNHL patients with more than 20 years of hearing loss duration showed significantly poorer speech performance than those with less than 20 years of hearing loss duration. There was no significant difference between the two groups regarding age at implantation, pre-operative residual hearing level, hearing level of the opposite ear, the cause of hearing loss, vestibular function, presence of associated symptoms (tinnitus, dizziness), education, region of residence(urban/rural), presence of job, and other comorbidities. Most of the patients (84%) had no postoperative complications and the most common complication was dizziness (4%).

Conclusion: From these results, we can expect better hearing performance in the elderly SNHL patients with less than 20 years of hearing loss duration. Nevertheless, CI is still considered as the only audiologic rehabilitation regarding SNHL in these patients, because other individual factors, such as age at implantation or coexisting diseases, did not affect surgical outcomes and cause serious postoperative complications.

P19

Electrophysiological Testing for an Auditory Processing Disorder and Reading Performance in students.

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Keywords: Auditory Cortex, Cognition, Evoked Potentials, Stimulation Training, Speech Perception

Background: Learning to read and write depends on the effective functioning of various sensory systems, including the auditory system. Auditory information processing involves behavioral and electrophysiological processes. Electrophysiological procedures are used to investigate activity in the auditory pathway in response to sound stimuli, and the associated cortical activity in discrimination, integration, and attention. The study evaluated electrophysiological testing for an auditory processing disorder and reading performance in 54 school students aged between 8 and 12 years.

Material/Methods: The study involved 54 public school students aged between 8 and 12 years, who were divided into a study group and control group. All children underwent basic audiological assessment, rating of reading and writing ability, non-verbal intelligence, auditory brainstem response, long-latency auditory-evoked potentials (LLAEP), frequency following responses (FFR), and auditory training (AT).

Results: The basic audiological evaluation showed a statistically significant difference between groups only for the frequency of 6 kHz. The LLAEP response had a statistically significant difference between groups for N1 latency, P300 latency, and amplitude. Finally, there was a statistically significant difference between pre-AT and postAT to LLAEP for latencies of P2, N2, and P300 and amplitudes of N2 and P300, and to FFR for latency of wave C.

Conclusions: This study showed that electrophysiological tests are sensitive tools for identifying deficits in the auditory pathway. Moreover, latency measures can detect improvements from an auditory training program. In this way, an auditory intervention program might help children with reading and writing difficulties.

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Auditory Evoked Responses as Predictors of Decreased Sound Tolerance in Tinnitus Patients

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Keywords: tinnitus, auditory brainstem response, decreased sound tolerance, distortion product otoacoustic emissions.

Background: We aimed to investigate whether there exists an auditory evoked response that could serve as a predictive factor for decreased sound tolerance in patients with tinnitus, and to elucidate the clinical implications of the findings.

Methods: We reviewed the individual patients" records among the patients who visited the tinnitus clinic between March 2020 and June 2023, and various tests including distortion product otoacoustic emissions (DPOAE), auditory brainstem response (ABR), and loudness discomfort level (LDL) were retrospectively analyzed. Decreased sound tolerance was defined as an LDL test result of up to 77 dB when evaluated using the mean of frequencies ranging from 250 Hz to 8 kHz in the left ear.

Results: Of the total 434 tinnitus patients, 115 (26.5%) exhibited decreased sound tolerance. It was prominent significantly in patients with higher DPOAE response ($p < 0.001$), shortened latency of ABR wave V in both ears ($p < 0.05$), shortened latency of ABR wave III in the left ear ($p < 0.05$), and decreased ABR threshold ($p < 0.05$). Gender, age, tinnitus discomfort questionnaire, and visual analog scale pure tone audiometry did not show any significant differences. The multiple regression analysis revealed that higher DPOAE response at 3152 Hz in the left ear, lower DPOAE response at 598 Hz, and better ABR threshold in the right ear were significant factors.

Conclusion: Several measurement parameters of DPOAE and ABR, as auditory evoked responses, are associated with decreased sound tolerance. The DPOAE response and ABR threshold at specific frequencies can play a crucial role in predicting decreased sound tolerance, thereby aiding in the treatment and management of tinnitus patients.

P21

Revisiting the transient-evoked otoacoustic emissions passing criteria used for newborn hearing screening

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Keywords: transient-evoked otoacoustic emissions, signal to noise ratio, signal detection theory, newborn hearing screening

Background: Newborn hearing screening (NHS) has become a standard part of neonatal care. Most NHS programs in Europe use transient-evoked otoacoustic emission (TEOAE) technology. With more stringent passing criteria, more infants with hearing loss will be detected, though at the expense of more false positives. Signal to noise ratio criteria commonly used today are based on early landmark studies to balance the sensitivity and specificity of the screen. However, in the last 20 years NHS programs have worked to reduce the number of false positives using alternative strategies. At the same time, evidence is growing for early intervention for children with mild hearing loss. It is now time to re-evaluate TEOAE criteria for newborn hearing screening.

Methods: TEOAE data were extracted from the NHS registry for children who were diagnosed with a hearing loss and enrolled for intervention before 8 years of age, and either failed TEOAE in both ears or passed TEOAEs in both ears. TEOAE data were excluded if hearing thresholds were ≤ 25 dB HL, if hearing loss was conductive, or if etiology pointed to an acquired cause. TEOAE data were also extracted for two groups of children with normal hearing: those who failed TEOAE in both ears and those who passed in both ears.

Results: From 2006 to 2020, 260 children passed TEOAE screening and were diagnosed with hearing loss and enrolled for intervention before age 8. Most children with hearing loss who passed TEOAE screening had mild hearing loss. Logistic regression analysis will be performed using the TEOAE response and noise across frequency bands. Receiver operating characteristic curves will be drawn to demonstrate the optimal cut-off.

Conclusions: A considerable number of suspected false negatives were observed in the sample of children with hearing loss. Increasing the cut-off levels for TEOAE criteria may detect more children with hearing loss, particularly with mild degree. This can affect specificity, though the extent to which overall specificity would be affected in a field setting is unclear. Findings will be relevant for NHS leaders and technology innovators who are considering altering their TEOAE protocol to detect more children with hearing loss.

P22

Evaluation of sound and working memory therapy using suppression transient otoacoustic emission among autism spectrum disorder children

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Question: Children with autism spectrum disorder (ASD) has been associated with problem to regulate emotion because of their inabilities to resolve simultaneous stimulations. A combination of sound and working memory task can be done simultaneously to promote changes in the brain neural networks that further lead to improvement social communication skill, behavioural skill, independent functioning and psychomotor functioning. To date, there is no study to our knowledge that investigated the influence of sound and working memory therapy to the ASD children emotional regulations abilities. In addition, the outcome measure of sound-working memory therapy to date was conducted from the perspective of the clinicians, psychiatrist, parents, caregiver or the teachers using self-report instruments, informant reports, naturalistic observation or behavioral coding, physiologically by physicians, and through open-ended questions to caregivers. To measure the physiological changes that occurs in the ASD auditory system following sound intervention, an auditory electrophysiology test such as Suppression Otoacoustic Emission (Suppression OAE) can be used. Suppression OAE is a test to access the function of efferent auditory system especially the medial olivocochlear bundle (MOCB) region by measuring the by-product of the outer hair cell which is suppressed from sound stimulation that is presented at either ipsilateral or contralateral ear. This study aims to evaluate the effectiveness of sound and working memory therapy using Suppression Transient-Evoked Otoacoustic Emissions (TEOAE) as the outcome measure tool.

Methods: A total of 20 ASD children aged 6 to 14 years participated. All participants were assigned into four groups (n=5); one control group and three experimental groups. The participants from the control group did not receive any intervention while the other three experimental groups were trained with sound therapy using three different stimuli for each group (waterfall, white noise and Quranic Recitation) and required to do working memory training concurrently. A pre and post TEOAE suppression were done to investigate the changes between pre and post intervention. The therapy session took about once per week for 6 weeks including the pre and post therapy evaluation with 45 minutes to 1 hour duration per session. As for the pre and post therapy evaluation, the TEAOE suppression of participants were recorded in two conditions on their right ear with white noise suppressors were presented on the left ear. The first condition is a baseline OAE recording without the contralateral suppressors (CS) and the second condition is the OAE recordings with CS using white noise. One minute break was given after the baseline recording. Then, the TEOAE were recorded again after 30 seconds of white noise presentation as a forward masker. TEOAE recording were automatically stopped after 260 responses had been recorded and were only accepted when the stimulus stability was at least 90% and recording reproducibility was 70%. The tested frequencies were 1000Hz, 1400Hz, 2000Hz, 2800Hz and 4000Hz. A signal was considered as present with the signal – to – noise ratio (SNR) more than 6dB and wave reproducibility of 60% or above.

Results: RM-ANOVA found no significant main effect of training among frequency tested but largest effect size was found at 2kHz between the pre and post intervention. At 2khz, only participants who underwent white noise and working memory training had significantly higher TEOAE suppression amplitude in post intervention as compared to the pre intervention with large effect size and medium effect size for other groups. Participant underwent white noise and working memory training group has a significantly higher gain than other groups followed by waterfall and Quranic recitation group. The 2kHz of TEOAE frequency has been identified as the main contributor that affecting both emotional aspects and triggering the medial olivocochlear bundle (MOCB). Besides, the amplitude of TEOAE suppression improved in white noise group only possibly because of its large bandwidth that improved the overexictation of the MOCB function.

Conclusion: This study suggests that the sound therapy can be best conducted using white noise together working memory training. This combination has the potential to improve emotional regulation but also improve the function of MOCB in ASD. The finding suggests by an improvement in the function MOCB revealed by TEOAE suppression following sound-working memory therapy can lead to more regulated emotions in individuals.

P23

The Feature of Extended High-frequecy and Distortion Product Input-Output of Auditory Neuropathy Patients

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Keywords: Auditory Neuropathy; Extended High-frequec; distortion product otoacoustic emissions

Background: Auditory Neuropathy (AN) was first proposed by Professor Starr in 1996, and after continuous in-depth research, experts proposed a concept of "Auditory Neuropathy Spectrum Disorder (ANSD)" at the 2008 Como International Newborn Hearing Screening Conference, that is, internal hair cells, auditory neuropathy synapses/ or hearing impairment due to poor functioning of the auditory nerve itself . The main characteristics of ANSD are that pure tone audiometry is mainly low-frequency decline, and the speech recognition rate is disproportionately reduced to the pure tone hearing threshold, the distortion product otoacoustic emissions (DPOAE) is normal, and the auditory brainstem response (ABR) is not induced or is seriously abnormal. At present, there are various tests to assist in the diagnosis of AN, but the application of extended high-frequency pure tone audiometry and DP I/O in ANSD is relatively rare, and we all know that the hearing curve of typical auditory neuropathy patients shows a low-frequency rising type, is extended high frequency and DPOAE the same as normal people? In previous studies, the DPOAE amplitude of AN patients is often higher than that of normal people, and the author hopes to further understand the Extended High Frequency Audiometry (EHFA) to improve and monitor the progression of ANSD.

Methods: In this study, divided into an experimental group and a control group, the experimental group was given auditory neuropathy spectrum disorders conventional pure tone audiometry, extended high frequency pure tone audiometry (8kHz-20kHz), distortion otoacoustic emission (DPOAE), DP I / O curve. The control group was given normal young people without ear disease with the experimental group the same test, and the results were compared and statistically analysed.

Results: he extended high frequency pure tone audiometry, the difference between normal and ANSD, ANSD hearing threshold than normal hearing threshold worse, especially in 18-20kHz differences more obvious. Extended high frequency pure tone audiometry and DP I / O with no significant difference in the course. DP I / O 0.5kHz 50, 55, 60, 65, 70 SPL was significant difference(P <0.05); 1kHz 40, 45, 50, 55, 60, 65, 70 SPL was significant difference(P <0.05); 3kHz 40, 60, 65, 70SPLwas significant difference(P <0.05); 4kHz 45, 50, 55, 60, 65, 70SPL was significant difference(P <0.05); 6kHz 60, 65, 70 SPL was significant difference(P <0.05). ANSD group DPOAE DP amplitude and extended high frequency pure tone threshold to hear a negative correlation.

Conclusion: Although the extended high frequency pure tone audiometry was no difference between the different courses, but any course may ANSD periodic testing of outer hair cells.

P24

Study of acquired cochlear synaptopathy in young adults

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Background: Exposure to noise has been significantly increasing in the young adult population, especially during leisure activities, which can result in hearing damage. The harmful effects caused by exposure to high levels of sound pressure (SPL) are not immediately identified, but rather observed in the long term in the auditory system. Studies in animal models have already demonstrated that noise exposure can permanently damage the synapses between inner hair cells and auditory nerve fibers, even when outer hair cells are intact and there is no clinically relevant permanent threshold shift. This synaptic loss is known as cochlear neuropathy, "hidden hearing loss," or acquired cochlear synaptopathy, and has gone unnoticed because synapses are not visible in routine histological samples, and the final loss of spiral ganglion cells occurs slowly. Despite being considered the gold standard for identifying hearing loss and used as the main clinical strategy to monitor noise-induced damage in humans, conventional tonal audiometry is not sensitive to early cochlear and retrocochlear changes. The complete identification of changes in functions directly related to hidden synaptic damage requires a battery of tests that includes electrophysiological and behavioral tests for diagnosing hidden hearing loss in humans. The limitation of current technologies poses a challenge, and therefore, a combination of diagnostic results between direct detection methods, such as electrophysiological tests (including Auditory Brainstem Response – ABR, ECochG, among others), and indirect detection methods, such as behavioral tests (including speech-in-noise testing), along with the traditional battery of tests, which includes otoscopy and tympanometry for evaluating the external and middle ear, and Distortion Product Otoacoustic Emissions (DPOAE) to infer the health of the cochlear population, may lead to a more accurate clinical diagnosis of cochlear synaptopathy. Furthermore, in order to extend the findings to humans with normal hearing, correlation with self-reported history of noise exposure with electrophysiological measures is also important. The objective of the study was to verify whether there is a correspondence between audiological and electrophysiological exams with their previous history and hearing complaints in young adults in order to determine the occurrence of acquired cochlear synaptopathy in this population.

Methods: An observational cross-sectional study approved by the Research Ethics Committee of the educational institution was conducted with a convenience sample of 44 young adult volunteers of both sexes, aged between 18 and 30 years. Participants completed a questionnaire and underwent basic audiological evaluation, as well as electrophysiological evaluation of hearing with ABR and physiological evaluation with recording of distorition product otoacoustic emissions (DPOAE) with and without contralateral suppressor stimulus.

Results: Questionnaire responses revealed that the majority of participants use headphones (91.3%). 30.4% of participants reported difficulty to communicate in noisy environments, and 11 individuals (24%) reported symptoms after using headphones, with ear fullness and tinnitus being the most recurrent. All participants presented normal auditory thresholds in tonal audiometry (better than 20dBNA in all tested frequencies). Absence of acoustic reflexes was identified in two or more tested frequencies, with ipsilateral reflexes absent in 9.6% of individuals in both the right and left ears, and contralateral reflexes absent in 19.6% of individuals in the right ear and 26.1% in the left ear. ABR results showed values within the expected range for normal hearing. The efferent inhibitory effect (EIE) was absent in 25.6 to 47.7% in at least two tested frequencies. A significant statistical association was observed regarding reduction in the amplitude of wave I of ABR and absence of efferent inhibitory effect from DPOAE at the frequency of 6000 Hz in the left ear. No relationships were observed between sound exposure level and EIE, amplitude of wave I of ABR and EIE, amplitude of wave I with sound amplitude, frequency of headphone use, and symptoms of hearing difficulty.

Conclusion: Despite normal audiograms, findings such as the absence of acoustic reflexes and the absence of the efferent inhibitory effect (EIE) in individuals with normal hearing already indicate possible retrocochlear alterations. The results obtained indicate the need for the development of more sensitive diagnostic protocols for the identification of synaptopathy in humans, since ABR results showed normal patterns of response and were not associated with auditory complaints and symptoms and also recreational exposure.

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POSTER

P25

Simultaneous Acquisition of Speech Frequency Following Responses and Cortical Auditory Evoked Potentials

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Background: Currently, the auditory neural pathways are evaluated in a fragmented approach using different protocols and recording sessions. This is due to several factors: Current commercial systems typically record data using small data buffers (e.g., 1024 data points). Due to the frequency composition and duration of the various neural responses, the higher sampling rate required to acquire subcortical responses does not allow recording CAEPs in the same acquisition buffer. Similarly, the low sampling rate used to record CAEP responses is not sufficiently high for subcortical responses and requires different high and low pass filters. In addition, the response amplitudes and signal-to-noise (SNR) characteristics differ greatly from early (small amplitude requiring more averaging) to late potentials (large amplitude requiring fewer averages). The new methods developed allow simultaneous recording of subcortical frequency following responses (FFR) and cortical auditory evoked potentials (CAEP) by combining the continuous loop averaging deconvolution (CLAD) technique (Delgado & Ozdamar, 2004) and the use of simultaneous high resolution, long acquisition data buffers. The CLAD technique allows the recording of CAEP responses at the higher stimulation rates typically used for FFR recordings.

Methods: Data were recorded from 10 adult subjects with normal hearing. An 80 dB SPL, 170ms, synthetic /da/ speech stimulus was used for all recordings. Standard CAEPs were acquired using a stimulation rate of 1.1/s and a sampling period 1ms providing a 512ms acquisition window. 200 sweeps per recording were acquired. Standard FFRs were acquired using a stimulation rate of 4.35/s and sampling period of 75us providing a 230ms acquisition window. 1024 sweeps per recording were acquired. Simultaneous FFR-CAEPs were acquired using a modified CLAD method at stimulation rates of 1.95/s and 3.91/s with sampling periods of 1ms and 0.5ms respectively for the CAEP CLAD acquisition buffers and 50us for the FFR acquisition buffers. The system hardware amplifier was set from 1 to 3000 Hz and digitally filtered from 1 to 30 Hz for the CAEP buffers and from 30-3000 for the FFR buffers. 200 CLAD buffer sweeps were acquired, yielding 200 CAEP sweeps and 800 FFR sweeps.

Results: Simultaneous FFR-CAEP recordings were successfully recorded. Preliminary data showed the expected moderate changes in the CAEP latency and amplitude as a result of the increased stimulation rate. For example, in one subject, the comparison standard CAEP recordings at a stimulation rate of 1.1/s yielded a P1at 36ms and 4.02uV and a P2 at 205ms and 3.50uV. The simultaneous FFR-CAEP technique at a stimulation rate of 1.95 yielded a P1 at 52ms and 3.18uV and P2 at 216ms and 2.27uV. At a stimulation rate of 3.91/s yielded a P1 at 53ms and 2.92uV and a P2 at 221ms and 3.14uV. There was no significant difference in the FFR recordings obtained using the standard and new simultaneous method.

Conclusion: Preliminary results demonstrate the feasibility of the proposed simultaneous FFR-CAEP technique. The new method will allow clinicians to obtain information about subcortical and cortical neural processing simultaneously and reduce the overall testing time.

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P26

Frequency Following Responses to speech stimuli from birth to age 11 years: preliminary data

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Keywords: hearing, electrophysiology, evoked potentials, children, speech perception

Introduction: The Frequency Following Response (FFR) is an objective neurophysiological marker that can provide measures of how well a human subject is coding for speech. However, although it shows promise, this assessment method is still not commonly used in clinical practice. Most recent studies have focused on recording the FFR in different pathologies. However, it is also important to have information on how the FFR develops in normal children as they mature.

Objective: The purpose of this study was to investigate the electrophysiological coding of a speech sound in the Central Auditory Nervous System (CANS) as children develop from infancy to adolescence.

Method: We recruited 120 healthy neurotypical participants of both genders, aged from 1 day to 11 years. All subjects had normal otoacoustic emissions and audiograms (play or conventional), immittance, and brainstem auditory evoked potentials. They underwent a Frequency Following Response test using the Smart Ep module from Intelligent Hearing Systems based on the syllable /da/. Stimuli were of 40 ms duration and delivered monaurally and with alternating polarity at 10.9/s in the right ear at 80 dBHL through insert headphones. Bandpass filtering was 100–2000 Hz and an 80 ms analysis window was used. Surface electrodes were at Fz, Fpz, M1, and M2 and impedance was

Results: The largest differences between groups were seen in the mean latencies and slopes of children in the youngest group compared to the others. Latencies and slopes of those aged 5 to 8 years were all about the same.

Conclusion: The data here give electrophysiological evidence on how the Frequency Following Response is affected by maturation from birth to 11 years. Data so far show that the coding of a speech sound follows the maturation of the CANS: as the child ages, the wave latencies tend to decrease. These results provide reference values for testing the Frequency Following Response in children.

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Differences in auditory processing of vowels preceded by another vowel versus a consonant, a study using frequency-following responses

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Background: Frequency-following responses (FFR) are distinguished from other evoked potentials by precisely reflecting the neural encoding of a sound's acoustic features. The FFR helps us understand how complex acoustic information is processed in the auditory system, and is increasingly considered a valuable tool to index the functional state of the auditory system. In a recent study by Arenillas-Alcón et al. (1), it was revealed that the FFR elicited to the vowel /a/ was weaker when preceded by the vowel /o/ in the syllable /oa/, compared to when the /a/ was preceded by the consonant /d/ in the syllable /da/. The main objective of this methodological study is to further investigate this phenomenon and elucidate the underlying potential factors contributing to the observed differences in FFR amplitudes.

Methods: This collaborative research project involves the University of Barcelona (Spain) and Antwerp University Hospital (Belgium). Each research center is recruiting 20 normal-hearing subjects, aged between 18 and 40. FFRs are recorded using the Compumedics Neuroscan at the University of Barcelona and the Duet system by Intelligent Hearing Systems at Antwerp University Hospital. This allows us to investigate whether results remain stable when comparing between a full electrode cap of 32 electrodes with a 4-electrode set-up in a vertical montage. Five different speech stimuli (/da/, /dao/, /doa/, /ao/, and /oa/) have been designed in the Praat software, and equated for loudness. Each stimulus is presented in three blocks of 1000 trials, with randomized block order. Analyses of measurements are carried out using MATLAB scripts (Mathworks) and statistical analyses are performed in IBM SPSS Statistics 27. The primary outcome measures include the fundamental frequency (F0) and temporal fine structure of the region where /a/ is pronounced in each stimulus.

Results: Data acquisition has been completed at the University of Barcelona. FFR analysis is being performed at the time of writing this abstract. Data acquisition at the Antwerp University Hospital is scheduled to start in July. The results will be presented and discussed at the IERASG23 conference.

Discussion: This study aims to expand our understanding of the enhanced FFR amplitudes observed in response to the vowel /a/ when preceded by the consonant /d/ in the syllable /da/, compared to when preceded by the vowel /o/ in the syllable /oa/. By investigating the auditory processing of vowels and consonants, this research contributes to our knowledge of how these acoustic elements are encoded in the auditory system, and will help to establishing and optimal stimulus for obtaining the FFR in patients with sensorineural hearing loss.

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P28

Comparing Cortical Responses to Continuous Speech and Speech Modulated Noise During Passive Listening

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Background: In recent years, there has been growing interest in measuring neural responses to continuous speech (speech entrainment), but a lack of data exists on whether these measurements are clinically feasible for aided speech perception, especially for infants. One issue is the difficulty of controlling attention in infants. Another is whether speech intelligibility is essential or if a speech-like stimulus, such as modulated noise that is not language-specific, can be used instead. This study aims to compare the detection of cortical responses to natural speech and speech-modulated noise during passive listening to measure speech perception.

Methods: EEG data were collected using a 32-channel Biosemi system from 22 English-native subjects with normal hearing thresholds. Participants listened to speech and speech-modulated noise stimuli at 65 dB A for 15 minutes each while watching a silent movie. Neural responses were detected using single channels, either through a cross-correlation approach (XCOR) or the temporal response function (TRF) between the speech envelope and the EEG (TRF-COR).

Results: The study found that 19 out of 22 subjects showed a significant cortical response. The detection rate for the modulated noise stimulus was higher (mean 81.68%) than for the speech stimulus (mean 62.45%). The means of detection time using the Cz channel were lower for modulated noise (XCOR=7.95 mins, TRF-COR=8.18 mins) than for speech (XCOR=11.36 mins, TRF-COR=12.68 mins), with only TRF-COR showing a significant difference ($p<0.05$).

Conclusion: The higher detection rate and lower detection time with the non-language-specific stimulus (speech-modulated noise) suggest that it could be a more practical option for clinical use as a universal stimulus. However, since the maximum detection rate with passive listening is less than 100%, further research is needed to explore the impact of attention on detecting cortical responses to continuous stimuli.

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Evaluating the effectiveness of audiovisual interaction mechanisms in improving speech resolution in noisy environments of hearing impaired patients using auditory evoked potentials: a preliminary study

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Question:

Hearing loss is a prevalent condition that affects a significant portion of the global population, with an estimated prevalence of around 15% among adults worldwide. With the aging of the population, the incidence of hearing loss is expected to rise further, presenting a growing concern for public health. Hearing impairment can severely impact an individual's ability to effectively communicate, especially in challenging auditory environments, such as noisy settings. The inability to resolve speech signals in these environments is a common complaint among individuals with hearing impairment, and it can have a profound impact on their overall quality of life.

In recent years, researchers and clinicians have been exploring various interventions aimed at improving speech resolution in hearing impaired individuals, particularly in noisy environments. One promising approach that has gained attention is the utilization of audiovisual interaction mechanisms. Audiovisual interaction refers to the integration of auditory and visual information by the brain, which can enhance speech perception and comprehension. This integration becomes particularly crucial in noisy environments where auditory signals may be degraded, making it difficult for individuals with hearing impairment to understand speech.

Studies have shown that incorporating visual cues, such as lip movements, facial expressions, and gestures, into the communication process can significantly improve speech recognition accuracy for individuals with hearing impairment in challenging auditory conditions. Visual information acts as a supplement to the degraded auditory cues, providing additional context and enhancing the individual's ability to decode speech signals. The brain's ability to combine these auditory and visual cues through audiovisual interaction mechanisms has been demonstrated to improve speech perception, even in noisy environments.

However, while the benefits of audiovisual interaction in improving speech resolution are well-documented, the specific mechanisms underlying this improvement are still not fully understood. Additionally, there is a need to objectively assess the effectiveness of audiovisual interventions and quantify the outcomes in hearing impaired individuals. In this regard, auditory evoked potentials (AEPs) have emerged as a valuable tool for evaluating the neural responses associated with speech resolution.

AEPs are electrical responses generated by the auditory system in response to auditory stimuli, reflecting the neural processing of sound. By analyzing the AEPs, researchers can gain insights into the neural mechanisms involved in speech perception and resolution. AEP-based assessments provide objective measures of the brain's response to speech stimuli and can serve as a valuable tool for evaluating the effectiveness of interventions targeting speech resolution in individuals with hearing impairment.

This research aims to evaluate the effectiveness of audiovisual interaction mechanisms in improving speech resolution in noisy environments for hearing impaired patients using auditory evoked potentials. By combining audiovisual cues and analyzing the neural responses captured through AEPs, we aim to gain a deeper understanding of the underlying mechanisms and assess the outcomes of audiovisual interventions in enhancing speech perception. The findings of this study have the potential to contribute to the development of targeted interventions and personalized treatment strategies that can improve communication outcomes and quality of life for individuals with hearing impairment in challenging auditory environments.

Methods：

1.Participants:
A total of 80 individuals with hearing impairment, aged between 40 and 70 years, were recruited for this study. Participants were selected based on the following inclusion criteria: diagnosed with sensorineural hearing loss, no significant cognitive or neurological impairments, and proficiency in the native language. Exclusion criteria included a history of middle ear pathologies, use of cochlear implants, or other hearing aids that could potentially interfere with the study procedures.

2.Experimental Design:
The study utilized a randomized controlled trial design. Participants were randomly assigned to two groups: the experimental group and the control group. Each group consisted of 40 participants.

3.Experimental Group:
Participants in the experimental group underwent audiovisual interaction training aimed at improving speech resolution in noisy environments. The training involved the integration of auditory and visual cues to enhance speech perception. Visual cues included lip-reading, facial expressions, and gestures. The training sessions were conducted in a sound-treated room with calibrated audio and visual stimuli. The training duration was standardized to ensure consistency across participants.

4.Control Group:
Participants in the control group did not receive any specific intervention or training. They were provided with standardized speech perception tests in noisy environments to serve as a baseline comparison for the experimental group.

5.Auditory Evoked Potential (AEP) Assessment:
To evaluate the effectiveness of audiovisual interaction mechanisms, AEPs were recorded during the speech perception tasks. The AEPs were measured using a multi-channel electrophysiological system. Electrodes were placed on the participant's scalp according to the international 10-20 system to capture the neural responses. A reference electrode was placed on the vertex, and a ground electrode was positioned on the participant's earlobe.

6.Speech Perception Tests:
Standardized speech perception tests were administered to both the experimental and control groups to assess speech resolution in noisy environments. The tests consisted of sentences or words presented in the presence of background noise at varying signal-to-noise ratios. The participants' responses were recorded and scored to determine their speech recognition accuracy.

7.Data Analysis:
The recorded AEP data were preprocessed using digital filters to remove artifacts and noise. The AEP waveforms were then segmented based on the speech stimuli and synchronized with the corresponding audiovisual cues. The amplitude and latency of specific AEP components, such as N1 and P2, were analyzed to assess the neural responses associated with speech resolution.Statistical analysis was conducted using appropriate statistical tests, such as t-tests or analysis of variance (ANOVA), to compare the speech perception performance and AEP measures between the experimental and control groups. The significance level was set at $p < 0.05$.

8.Ethical Considerations:
Ethical approval was obtained from the research ethics committee before initiating the study. Informed consent was obtained from all participants, and confidentiality of personal information was maintained throughout the study. Participants were provided with detailed information about the study objectives, procedures, and potential risks, and they had the right to withdraw from the study at any time.

Results:

1.Participant Characteristics:
A total of 80 participants with hearing impairment were enrolled in the study, with 40 participants in the experimental group and 40 participants in the control group. The two groups were matched in terms of age, gender distribution, and degree of hearing loss.

2.Speech Perception Performance:
The speech perception performance in noisy environments was evaluated using standardized speech perception tests. The experimental group, which received audiovisual interaction training, demonstrated significantly higher speech recognition accuracy compared to the control group ($p < 0.001$). The mean speech recognition score for the experimental group was 75.2% (SD = 8.6), while the control group scored an average of 58.3% (SD = 9.2).

3.Auditory Evoked Potentials (AEP) Analysis:
The AEP recordings were analyzed to investigate the neural responses associated with speech resolution. The amplitude and latency of the N1 and P2 components were examined as indicators of neural processing. AEP analysis revealed significant differences between the experimental and control groups.

4.Amplitude Analysis:
The experimental group showed larger N1 and P2 amplitudes compared to the control group, indicating enhanced neural responses to speech stimuli. The mean N1 amplitude in the experimental group was 6.8 µV (SD = 1.2), while the control group exhibited an average N1 amplitude of 4.3 µV (SD = 0.9) ($p < 0.001$). Similarly, the mean P2 amplitude in the experimental group was 4.2 µV (SD = 0.8), whereas the control group had an average P2 amplitude of 2.9 µV (SD = 0.6) ($p < 0.001$).

5.Latency Analysis:
The latency of the N1 and P2 components was also analyzed. The experimental group demonstrated shorter latencies compared to the control group, indicating faster neural processing of speech stimuli. The mean N1 latency in the experimental group was 150 ms (SD = 8.4), while the control group had an average N1 latency of 164 ms (SD = 9.1) ($p < 0.001$). Similarly, the mean P2 latency in the experimental group was 220 ms (SD = 10.2), whereas the control group exhibited an average P2 latency of 235 ms (SD = 11.5) ($p < 0.001$).

6.Correlation Analysis:
Correlation analysis revealed a significant positive correlation between the speech recognition accuracy and the amplitude of both the N1 ($r = 0.65$, $p < 0.001$) and P2 components ($r = 0.58$, $p < 0.001$). Additionally, a significant negative correlation was found between the speech recognition accuracy and the latency of both the N1 ($r = -0.48$, $p < 0.001$) and P2 components ($r = -0.37$, $p < 0.01$). These findings suggest that individuals with larger amplitude and shorter latency of AEP components exhibit better speech perception in noisy environments.

Conclusions:

The results of this study provide strong evidence for the effectiveness of audiovisual interaction mechanisms in improving speech resolution in noisy environments for individuals with hearing impairment. The experimental group, which received audiovisual interaction training, demonstrated significantly higher speech recognition accuracy compared to the control group. These findings support the notion that integrating visual cues with auditory stimuli enhances speech perception abilities.

The AEP analysis further elucidated the underlying neural mechanisms associated with speech resolution. The experimental group exhibited larger amplitudes and shorter latencies of the N1 and P2 components, indicating enhanced neural processing of speech stimuli. These findings suggest that audiovisual interaction mechanisms facilitate more efficient neural encoding and integration of auditory and visual information, resulting in improved speech perception.

The positive correlation between the amplitude of AEP components and speech recognition accuracy suggests that individuals with stronger neural responses to speech stimuli have better speech resolution abilities.

Similarly, the negative correlation between the latency of AEP components and speech recognition accuracy indicates that faster neural processing of speech stimuli is associated with improved speech perception.

Overall, the results of this study provide empirical support for the effectiveness of audiovisual interaction mechanisms in improving speech resolution in noisy environments for individuals with hearing impairment. The findings highlight the importance of incorporating visual cues in auditory rehabilitation programs and suggest that AEP measures can serve as objective indicators of the effectiveness of such interventions. These findings have significant implications for the development of targeted interventions and personalized treatment strategies to enhance speech perception abilities in individuals with hearing impairment.

Keywords:

Speech recognition, Speech perception, Hearing impaired, Noisy environments, Audiovisual interaction,Auditory evoked potential

P30

Analysis of the correlation between hearing loss and cognitive impairment

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Background and Objectives:

The prevalence of dementia among people aged 60 and older is expected to be 5 to 7 percent, doubling every 20 years worldwide. More than 35 percent of people in their 60s and 50 percent of those in their 70s have problems in their daily activities because of hearing loss. We performed a CMC-CDW based evaluation of the association between hearing loss and cognitive disorders.

Material and Methods:

The retrospective data were collected from the Catholic Medical Center clinical data warehouse (CMC-CDW). The survey was taken by 801 participants aged over 60 years. Speech audiometry was measured in both ears. The Korea -mini mental state examination(K-MMSE) and Seoul Neuropsychological screening battery (SNSB) were also evaluated.

Results:

The average age was 77.1±9,7 years and the sex ratio was 313:488 (M:F). The average speech recognition threshold (SRT) was 39.6±4.8 dB and the speech discrimination score(SDS) was 74.3±29.9%. The average of K-MMSE was 25.1±4.3. The distributions of cognitive impairment were normal (n=205), mild cognitive impairment (n=438), and dementia (n=158). In logistic analysis, age, gender and hearing loss showed a significant association with cognitive impairment ($p<0.05$).

Conclusion:

It is thought that the prevention of hearing loss progress and cognitive impairment are necessary from the period of mild hearing loss.

P31

Cortical auditory evoked responses in post-concussion adolescents: implications of injury, maturation, and background noise

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Background: Accumulated evidence from our lab and others has shown that a significant number of adults (over 18 years) with mild traumatic brain injury (mTBI or concussion) have functional auditory processing problems and central auditory changes in the long-term post-concussion (e.g., Vander Werff & Rieger, 2017, 2019a, 2019b). Adolescents may account for nearly 1/3 of concussions, with a rate nearly doubling in recent years (Zhang et al. 2016). Even more critically, high school athletes may take significantly longer to recover from a concussion than even college-aged athletes, with prolonged neurocognitive effects (e.g., Field et al. 2003). The central auditory system continues to mature and develop through the late teenage years, potentially increasing vulnerability to auditory-specific deficits.

In our previous research in adults 3-18 months post-concussion (Vander Werff & Rieger 2019a, 2019b), we found that a significant proportion of participants had both abnormal behavioral performance on central auditory tests and significant differences in cortical auditory evoked responses. Specifically, neural processing at the early stage (P1-N1-P2) was more affected by noise in the mTBI group. We have also shown in non-concussion studies (Vander Werff et. al., 2021) that speech babble with different numbers of talkers alters the morphology of all component peaks of the cortical auditory evoked response in a significantly different way than does spectrally matched noise that is enveloped to match the temporal variations in multi-talker babble from these same number of talkers.

The current study addresses a lack of data on peripheral and central auditory processing in the adolescent population, who are still in the process of neuronal and cognitive development and under learning and academic stress. As a preliminary first step, we evaluated cortical auditory evoked potentials in an adolescent group with recent concussion compared to a control group of adolescents without concussion. Further, we investigate these responses recorded in background noise of 4-talker babble compared to 4-talked enveloped noise to evaluate not only the effects of concussion, but of maturation, in comparison to our previous work in adults. These results will provide a foundation for studying the time course of recovery of central auditory processing deficits in adolescents who are still undergoing neural maturation and may ultimately highlight factors that may predict which individuals may be more vulnerable to long-term problems and possibly at increased risk due to second impact.

Methods: Adolescents aged 13-18 who had experienced a recent concussion and continued to be symptomatic were referred for the study from a concussion management clinic. A control group without concussion were age and sex-matched to the concussion participants. Participants completed case history interviews and hearing history self-report questionnaires assessing symptoms including tinnitus, hyperacusis, dizziness, and difficulty hearing in noise. They were also evaluated using a concussion assessment tablet-based system to assess cognitive and balance function and concussion systems. The audiometric test battery included including pure tone thresholds for standard and extended high frequencies, loudness discomfort testing, and QuikSIN speech in noise test performance. Click-evoked ABRs (using a tiptrode to enhance wave I) were also completed.

The primary outcome measures were cortical auditory evoked potentials (i.e., auditory late responses, P1-N1-P2 complexes), recorded in response to a naturally produced speech syllable "ba" under quiet and two background noise conditions (4-talker speech babble vs. nonspeech enveloped noise) for comparison to data from our from adults with and without concussion. Responses were recorded at Fz, Cz, and Pz using the Neuroscan recording system with standard recording methods and parameters similar to our previous studies.

Results: To date, 12 adolescents aged 13.7 to 17.1 years (M = 15.8 years) ranging from .7 to 4.7 months (M = 1.6 months) post-concussion have participated. Controls were matched and were similarly aged from 13.0 to 16.9 years, with no significant differences in age by t-test. Hearing thresholds were within normal limits (PTA 7.5 dB for concussion participants and 7.1 dB HL for controls) at all standard test frequencies and did not differ between groups for any of the standard or extended high frequencies. Despite this, participants with concussions reported increased functional difficulties including difficulty understanding fast speech, problems following auditory instructions, needing more time to process spoken information, and paying attention when people talk. There were no differences in any of the other audiometric tests, including the QuikSIN SNR loss (3.2 dB concussion, 2.0 dB controls, with 0-3 dB interpreted as normal/near normal). There were no differences between groups in ABR latencies or interpeak latencies.

Morphology of the P1-N1-P2 was similar between groups of adolescents with and without concussion but differed from results from previous studies in adults. P1 and N1 peaks were later in adolescents than previously observed in adults. Most notably, the effect of speech babble (4-talker) on the adolescent P1-N1-P2 was notably different in adolescents, with a preserved P1, but absent P2 response. There was a trend toward a larger effect (reduced amplitude of N1 and P2) in the group with the concussion. By contrast, non-speech noise with the same temporal envelope as speech resulted primarily in prolonged latency but still present P1, N1, and P2

Conclusion:

These preliminary results suggest that adolescents with concussion had normal peripheral auditory function, but experienced functional auditory consequences. The P1-N1-P2 in adolescents showed a different morphology compared to adults from previous studies (with and without concussion) in both quiet and in noise, but the change in morphology with 4-talker babble compared to non-speech noised with a matched temporal envelope shows distinctive characteristics compared to our previous adult data. There was a trend for larger reductions in amplitude in noise for adolescents with concussion compared to their matched control counterparts. Maturational effects, therefore, have implications for interpreting the effects of concussion on central auditory processing and outcomes in this age group. These results will be further discussed and compared to previous mTBI and P1-N1-P2 in noise data. Ongoing data collection will include evaluation of short-term recovery-related changes in these responses.

P32

The effect of forward masking on cortical auditory evoked potentials in adults: assessing central auditory processing disorder

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Keywords: Central auditory processing disorder. Electrophysiology. Auditory Evoked Potentials. Noise.

Background: Speech understanding in the presence of competitive noise is one of the most important aspects of hearing to be assessed, as several listening situations require the listener to perceive speech information degraded or distorted by noise1,2. In this way, the masking caused by noise means that the speech perception by the listener is not in ideal conditions, and this situation requires the listener to 'separate' the speech they want to hear, that is, the target message, from the competitive noise3. The central auditory processing is directly related to the most fundamental abilities of attention, detection and discrimination. The possibility of assessing forward masking from the cortical auditory evoked potential, which reflects the synchronous activity of the structures in the thalamus- cortical part of the central auditory system4, can provide valuable information to help understand the effects of noise on speech processing in the cortex. The present study assesses the effect of forward masking on speech-evoked cortical auditory evoked potentials in adults with and without central auditory processing disorder.

Methods: Cross-sectional observational analytical study composed by two groups of adults aged between 18 and 37 years: 1) Control Group - 30 adults without central auditory processing disorder; 2) Study Group - 30 adults with central auditory processing disorder. Cortical auditory evoked potentials evoked by the speech stimulus /ba/ was performed in two test conditions: without masking and with masking with a masker-probe interval (delta-t) of 3 msec. Student T test for paired samples was performed to compare P1, N1 and P2 wave latencies and amplitudes in the different intragroup conditions. For the intergroup analysis, Student T test was applied for independent samples.

Results: The intragroup analysis revealed an increase in latency values for waves P1, N1 and P2 for both groups in the masking stimulus condition. The intergroup analysis revealed higher latency values for P1, N1 and P2 waves for the study group, both in the unmasked condition and in the masking condition.

Conclusion: Adults with central auditory processing disorder had longer P1, N1 and P2 wave latencies in the speech-evoked cortical auditory evoked potentials compared to adults without central auditory processing disorder.

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P33

Noise reduction algorithms measured by ACC in pediatric hearing aid users

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Keywords: speech in noise, noise reduction algorithms, Acoustic Change Complex

Background: The inability to understand speech in noise is one of the main complaints of people with sensorineural hearing loss as well as many people who wear traditional hearing aids (HAs). In children, difficulties to communicate in environment with unfavorable acoustics can further lead to delay in speech and language development, academic difficulty, increased listening effort and cognitive load. Noise reduction algorithms are implemented in hearing aids to reduce annoyance caused by noise, improve speech intelligibility, and increase listening comfort. In this domain, speech recognition in noise tests are traditionally used to measure performance of hearing aid users. In young children and in those who are difficult to test behaviorally, electrophysiological testing can be applied. This research addresses the clinical value of ACC test in documenting performance of pediatric HA users when noise reduction algorithms are functional.

Methods: ACC was recorded in children with moderate or moderately severe sensorineural hearing loss, in the binaural aided condition, using vowel /o/ in pink noise at 0 and +8 SNR, presented through 2 loudspeakers at zero and 180 degrees azimuth. Three HA microphone/algorithm settings were evaluated; namely, omnidirectional microphone, directional microphone and dynamic noise cancellation. Speech recognition using Arabic sentences in multi-talker babble was performed using similar SNR and HA settings.

Results: As regards ACC parameters, the majority of children showed shorter latency and larger amplitude in directional microphone and dynamic noise cancellation compared to omnidirectional microphone. Correlation with behavioral testing will be discussed.

Conclusion: ACC elicited by speech in noise stimuli can be effectively used in clinical setting to document the benefit of using noise reduction algorithms in pediatric hearing aid users.

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Effects of forward masking and signal-to-noise ratio on speech-evoked cortical auditory evoked potentials

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Keywords: Electrophysiology. Auditory Evoked Potentials. Noise.

Background: Forward masking at different signal-to-noise ratios (SNR) in cortical auditory evoked potentials can reveal important information about the underlying processes involved in speech perception in noise1.

Methods: Cross-sectional observational analytical study carried out with 38 young adults with normal hearing. Cortical auditory evoked potentials were elicited with and without masking at SNRs of 0 dB, -10 dB, -20 dB and -30 dB. Latencies and amplitudes of waves P1, N1 and P2 were compared across the five test conditions using a repeated-measures ANOVA and the post hoc Bonferroni test.

Results: The P1, N1 and P2 latencies increased as the SNR becomes more negative. This increase was not significant between the -10 dB and -20 dB SNR conditions. The N1 wave amplitudes were the only ones that decreased as the SNR became more negative. This phenomenon was significant between the no-masking condition and the -10 dB, -20 dB and -30 dB SNR conditions, and between the 0 dB and -30 dB SNR conditions.

Conclusion: This study complements a prior study that examined forward masking of cortical auditory evoked potentials1,2. In that study, the target stimulus and the noise were presented at the same intensity (SNR = 0dB) and it was found that there was an increase in latencies and a decrease in P1, N1 and P214 amplitudes. Two other studies that analysed simultaneous masking in cortical auditory evoked potentials at different SNRs showed that these waves can be affected in different ways by noise, depending on the referred SNR3,4. In the present study, the forward masking effect on speech-stimulated cortical auditory evoked potentials gradually increased at P1, N1, and P2 wave latencies and gradually decreased at N1 amplitudes as the SNR became more negative.

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P35

EFFECT OF AÇAI ON HEART RATE AND AUDITORY CORTICAL RESPONSE

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Background: açai (*Euterpe oleracea*), a popular fruit in Brazil, composed of anthocyanins, has an inhibitory effect on the oxidation processes generated by free radicals and oxidative stress. Scientific evidence that these antioxidant effects of açai can also cause the processing of auditory information.

Objective: To verify the effects of açai supplementation on auditory perception.

Method: the study will be carried out in women from 18 to 30 years old. It will not be mandatory, with cardiorespiratory, neurological disorders, as well as those you earn under medication that influences the autonomic nervous system. The volunteers were examined on two different days with an interval of seven days between them. On the first day, an initial and audiological evaluation were performed. Then, were recorded Long-latency auditory evoked potentials. After the collection of these variables, the volunteers ingested açai capsules (750mg) or placebo, controlled by a third researcher, the volunteers and responsible researcher did not know about the capsules, characterized a blinded experiment. The order of execution was paid through a randomization process and managed by a third researcher. Half an hour after taking the capsules, the above procedures were repeated. On the second day, the same procedures performed. The heart rate variability expressed in the time domain – RMSSDS and potential measurements were compared before and after capsule ingestion. To analyze the relationship of differences between the pre and post evaluation moments, the correlation test was performed with a significance level of 5% using the SPSS software (version 22.0).

Results: There was a negative correlation between the latency of the P1 and N1 components and the heart rate variability indices in the açai condition. In other words, the decrease in the latencies of these components of the auditory evoked potentials was correlated with the increase in the heart rate measurements.

Conclusion: In this study, it was not possible to confirm the positive effect of acai supplementation, however, the study proved the relationship between heart rate and auditory cortical response during acai ingestion.

P36

Amusia and its electrophysiological correlates in neurofibromatosis type 1: an in-depth analysis

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Background: Neurofibromatosis type 1 (NF1) is a rare genetic disease which often results in different cognitive problems. In one of our previous studies, we found that 70% of people with NF1 had a deficit in music perception, described in the literature as amusia. It was also observed that the worse this deficit was, the greater the latency for the occurrence of a long latency auditory evoked potential, known as Mismatch Negativity (MMN), which is an objective marker of auditory sensory accuracy and assesses the pre-attentive cognitive operations of hearing. The objective of this study is to investigate in a larger sample if there really is a correlation between the occurrence and latency of MMN and the degree of musical perception in people with NF1.

Methods: 34 patients with NF1, aged between 14 and 35 years, were invited and agreed to participate. They were submitted to the assessment of musical perception through the Montreal Battery Evaluation of Amusia (MBEA) – short version. The integrity of the cortical primary auditory processing areas was assessed using the MMN with a frequency paradigm (1000Hz frequent and 900Hz rare) (Figure 1)

Results: Although we did not find a statistically significant correlation between the absence of MMN and the degree of musical perception impairment among the evaluated subjects, there was a trend toward higher MMN latency values for lower MBEA scores ($p = 0.039$) (Figure 2).

Conclusions: The present study corroborates our previous findings about a possible correlation between MMN latency and music processing in people with NF1. Our next steps will be to evaluate possible correlations between this auditory evoked potential and other cognitive functions in NF1.

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Figure 1. Mismatch negativity (MMN). Graphic record o long latency auditory evoked potentials of a patient with NF1. The MMN is the additional negative peak after N1, occuring here near 150 ms during a rare stimulus trace (B-RARE) and its absence during a frequent stimulus trace (B-FREQ). The MMN is more evident in the trace corresponding to the subtraction (SUB) of the standard stimulus from the deviant stimulus.

Figure 2. Scatter plot graphic: Correlation between Montreal Battery Evaluation of Amusia (MBEA) and mismatch negativity (MMN) latency in patients with NF1.

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Impact of Aging on Masseter Vestibular Evoked Myogenic Potentials

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Background: Masseter vestibular evoked myogenic potentials (mVEMPs) are short-latency responses, generated from the active masseter muscles (Deriu et al., 2005; de Natale et al., 2015). mVEMPs are known to be effective in studying the vestibulo-trigeminal pathway (Deriu et al., 2005) in various brainstem pathologies such as rapid eye movement sleep behavior disorder (de Natale et al., 2018), Parkinsonism (de Natale et al., 2015), multiple sclerosis (Magnano et al., 2014; Sangu et al., 2022), and amyotrophic lateral sclerosis (Liu et al., 2019). Previous studies done on cervical vestibular evoked myogenic potentials (cVEMPs) and ocular vestibular evoked myogenic potentials (oVEMPs) show that although these potentials can be recorded throughout the lifespan of an individual, responses are often smaller in amplitude, or altogether absent in older individuals, with a shift seen in the optimal frequency tuning of the response. The present study endeavors to define the optimal frequency tuning for mVEMP response for young and old adults, while examining the effect of age-related degeneration on different parameters of the mVEMP response.

Methods: Forty normal-hearing individuals bifurcated into 20 young adults (age range – 18 to 35 years) and 20 old adults (age range ≥55 years) participated in this investigation. Each group had an equal proportion of males and females. The mVEMP responses were recorded for all participants at six different tone burst frequencies that included 250 Hz, 500 Hz, 750 Hz, 1000 Hz, 1500 Hz, and 2000 Hz. Self-monitoring biofeedback was given during the procedure to confirm the tension of the masseter muscle between 49.9 rms and 150.6 rms. Further, the EMG scaling was done to avoid any muscle-related irregularities.

Results: Investigations to understand the ear effect revealed invariant responses for all parameters of the mVEMPs at six stimulation frequencies. No significant gender effect was observed for both age groups. Older adults were found to have significantly prolonged latencies, reduced peak-to-peak amplitude, and a larger inter-aural asymmetry ratio than younger adults. Further, it was observed that older individuals had a shift in their frequency tuning towards 750 Hz and 1000 Hz, whereas younger adults had it centered at 500 Hz.

Conclusions: The present study revealed prolonged latenciesand reduced amplitude in older adults with normal hearing. This could have resulted due to age-related degenerative changes in the vestibular end organ and the higher centers (Johnsson & Hawkins 1972). Also, older adults were found to have a shift in frequency tuning towards higher frequencieswhich were suggestive of the age-related changes in vestibukar hair cell counts and densities bringing changes in the mechanical resonance of the otolith organ (Merchant et al., 2000). Therefore, the current study suggests taking these factors into account when assessing mVEMP parameters in older adults.

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A preliminary study on the mechanism of cross-modal plasticity between vestibular myogenic evoked potentials and auditory cortical evoked potentials induced by noise stimulation

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Question:

The human sensory system is a remarkable network that allows us to perceive and interact with our environment. Among the various sensory modalities, the vestibular system and the auditory system play crucial roles in our perception of balance, spatial orientation, and sound. Traditionally, these systems have been studied independently, with the vestibular system primarily associated with balance and the auditory system with hearing. However, emerging evidence suggests that these systems are intricately interconnected and can influence each other's functioning through a phenomenon known as cross modal plasticity.

Cross modal plasticity refers to the brain's ability to reorganize and adapt its sensory processing in response to changes or deficits in one sensory modality. It involves the recruitment and functional changes in brain regions associated with different sensory modalities. Understanding the mechanisms underlying cross modal plasticity between sensory systems is a topic of great interest in neuroscience and has implications for clinical practice, rehabilitation, and our understanding of sensory perception.

In recent years, research has focused on investigating the interaction between the vestibular system and the auditory system. One aspect of this interaction is the cross modal plasticity between vestibular myogenic evoked potential (VEMP) and auditory cortical evoked potential (ACEP). VEMP is an electrophysiological technique that measures muscle responses, typically in the neck or eye muscles, in response to specific stimuli that activate the vestibular system. It provides valuable information about the functioning of the vestibular system and its connections to the brain.

On the other hand, ACEP refers to the electrical activity recorded from the auditory cortex in response to auditory stimuli. It reflects the processing of sound information in the brain and is widely used in audiology and neuroscience research. The cross modal plasticity between VEMP and ACEP suggests that these two sensory modalities, vestibular and auditory, may influence each other's neural processing and responses.

Furthermore, noise stimulation is a critical factor that can affect both the vestibular and auditory systems. Noise exposure has been shown to influence sensory processing, including balance and hearing abilities. The effects of noise on sensory systems can be particularly challenging in real-world environments, where individuals often encounter complex auditory and spatial information simultaneously.

Therefore, the purpose of this study is to investigate the cross modal plasticity mechanism between VEMP and ACEP under noise stimulation. By examining the interaction between these two sensory modalities and the influence of noise, the study aims to provide insights into the neural mechanisms underlying sensory integration and adaptation.

Understanding the cross modal plasticity between VEMP and ACEP under noise stimulation has both theoretical and practical significance. The findings can deepen our understanding of sensory processing and integration in the brain, contribute to the development of diagnostic tools for balance and hearing disorders, inform the design of targeted rehabilitation interventions, and provide insights into the brain's adaptive capabilities in response to sensory challenges.

Methods

Participants:
A total of 30 healthy adult participants (15 males and 15 females) between the ages of 20 and 35 years were recruited for the study. Participants with a history of vestibular or auditory disorders were excluded.The sample size was determined based on statistical power calculations to ensure adequate representation and reliable results. Participants' demographic information, medical history, and baseline sensory assessments were recorded to characterize the sample and evaluate potential confounding factors.

The study utilized a controlled experimental design to examine the cross modal plasticity between VEMP and ACEP under noise stimulation. The design incorporated multiple conditions to compare the responses of the vestibular and auditory systems under different experimental manipulations.These conditions included:

a. Baseline Condition: Participants underwent baseline assessments of VEMP and ACEP in a controlled environment without noise stimulation to establish their individual sensory profiles.

b. Noise Stimulation Condition: Three types of noise stimuli were used: white noise, narrowband noise, and speech-shaped noise. The white noise had a frequency spectrum spanning 20 Hz to 20 kHz, while the narrowband noise was centered around 1 kHz with a bandwidth of 200 Hz. The speech-shaped noise was generated to resemble the acoustic characteristics of human speech.

c. Combined Stimulation Condition: This condition involved the simultaneous presentation of vestibular and auditory stimuli to investigate how the vestibular and auditory systems interact and integrate sensory information. It aimed to assess whether the cross modal plasticity between VEMP and ACEP is influenced by noise stimulation.

Data Collection:

a. VEMP Recording:
Surface electromyography (EMG) electrodes were placed over the sternocleidomastoid (SCM) muscles on both sides of the neck. Participants were instructed to maintain a slight neck flexion while brief tone bursts (500 Hz, 125 dB SPL) were presented to elicit the VEMP responses. The VEMP recordings included both the p13 and n23 peaks.

b. ACEP Recording:
Electroencephalography (EEG) electrodes were positioned on the scalp according to the international 10-20 system. Participants were presented with click stimuli (1000 Hz, 80 dB SPL) to evoke the ACEP responses. The ACEP recordings captured the N1 and P2 peaks.

c.Noise Stimulation:
The noise stimuli were presented through circumaural headphones. Each testing session consisted of multiple trials, with each trial involving the simultaneous presentation of the noise stimulus and the respective evoked potential stimuli (tone bursts for VEMP and click stimuli for ACEP).

Data Analysis:
VEMP and ACEP waveforms were segmented and averaged across multiple trials to enhance the signal-to-noise ratio. The peak amplitudes and latencies of the VEMP and ACEP components were measured and analyzed using appropriate statistical techniques, such as repeated measures ANOVA.

a. Preprocessing: The VEMP and ACEP signals were preprocessed to remove artifacts, filter out noise, and enhance signal quality. Standard preprocessing techniques, such as baseline correction, filtering, and artifact rejection, were employed to ensure data integrity.

b. Feature Extraction: Relevant features were extracted from the VEMP and ACEP data to quantify the neural responses associated with each sensory modality. These features may include peak amplitudes, latencies, or waveform characteristics, which were computed for further statistical analysis.

c. Statistical Analysis: Statistical tests, such as t-tests, ANOVA, or correlation analysis, were performed to examine the differences and associations between VEMP and ACEP responses. Comparisons were made between baseline conditions and noise stimulation conditions, as well as between different groups of participants (e.g., healthy individuals vs. those with sensory impairments).

d. Data Integration: The findings from VEMP and ACEP analyses were integrated to explore the cross modal plasticity mechanism between these sensory modalities. The relationship between VEMP and ACEP responses under different noise conditions was examined to identify any interactions, modulations, or correlations.

Results:

The present study aimed to investigate the cross-modal interaction between vestibular myogenic evoked potential (VEMP) and auditory cortical evoked potential (ACEP) in response to noise stimulation. A total of 30 healthy adult participants (15 males and 15 females) took part in the experiment. The participants were exposed to different types of noise stimuli, including white noise, narrowband noise, and speech-shaped noise. VEMP and ACEP responses were recorded and analyzed to assess the effects of noise stimulation on the two modalities.

The analysis of VEMP responses revealed significant cross-modal effects of noise stimulation. When exposed to white noise, participants exhibited significantly enhanced VEMP amplitudes compared to the baseline ($p < 0.05$). This finding suggests that white noise led to increased excitability of the vestibular system. In contrast, narrowband noise resulted in significantly reduced VEMP amplitudes compared to the baseline ($p < 0.05$), indicating a suppressive effect on the vestibular system.

Regarding ACEP responses, noise stimulation also exerted significant cross-modal effects. In the presence of white noise, participants exhibited significantly increased ACEP amplitudes compared to the baseline ($p < 0.05$). This finding suggests that white noise enhanced the cortical processing of auditory stimuli. Furthermore, the latencies of ACEP responses were significantly shorter when participants were exposed to white noise ($p < 0.05$), indicating a facilitatory effect on the auditory cortical processing.

In contrast, narrowband noise produced opposite effects on ACEP responses. Participants showed significantly reduced ACEP amplitudes compared to the baseline ($p < 0.05$), indicating a suppressive effect on auditory cortical processing. Additionally, the latencies of ACEP responses were significantly prolonged in the presence of narrowband noise ($p < 0.05$), suggesting a delay in the cortical processing of auditory stimuli.

Speech-shaped noise, being a more complex stimulus, elicited variable effects on both VEMP and ACEP responses. The amplitude and latency changes observed in response to speech-shaped noise were inconsistent across participants, suggesting a more intricate cross-modal interaction between the vestibular and auditory systems.

Overall, the results indicate a clear cross-modal interaction between VEMP and ACEP in response to noise stimulation. The type of noise stimulus had differential effects on VEMP and ACEP responses, modulating the excitability and cortical processing of the vestibular and auditory systems. These findings contribute to our understanding of the complex interplay between sensory modalities and have implications for clinical applications, such as the development of diagnostic tools and interventions for individuals with vestibular and auditory impairments. Further research is necessary to elucidate the underlying mechanisms and optimize the use of noise stimulation in clinical settings.

Conclusions

This experiment demonstrated a clear cross-modal interaction between VEMP and ACEP in response to noise stimulation. The findings indicate that different types of noise stimuli can modulate the excitability and processing of both the vestibular and auditory systems. White noise enhanced both VEMP and ACEP responses, while narrowband noise suppressed them. These results highlight the intricate relationship between the two sensory modalities and provide insights into sensory processing mechanisms. Understanding the cross-modal interaction between VEMP and ACEP in noise stimulation has implications for clinical diagnostics and rehabilitation, aiding the development of targeted interventions for individuals with vestibular and auditory impairments. Further research is needed to explore the underlying mechanisms and optimize the use of noise stimulation in clinical settings.

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Study on protective effect of novel samll chemical compound against cisplatin-induced ototoxicity

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Cisplatin is an effective anti-cancer drug widely used in the treatment of solid cancer, but side effects such as neurotoxicity, nephrotoxicity, and ototoxicity have been reported. In particular, in the case of ototoxicity, an increase in hearing threshold of 20 dB or more has been reported in more than two-thirds of administered patients, and it adversely affected communication ability, causing a problem in the patient's quality of life after treatment. However, until now, a drug capable of treating or alleviating ototoxicity caused by cisplatin has not been developed, so the need to discover a protective or therapeutic drug is emerging. To investigate the possibility of alleviating ototoxicity by cisplatin, six new drug candidates were pre-treated to the House Ear Institute-Organ of Corti 1 cells, a mouse auditory organ-derived cell line for 1 h, and then 30 µM of cisplatin was treated for 30 h. As a result, I found Compound X with 30% protection. To investigate the protective mechanisms of Compound X in the apoptosis pathway, the expression of Bax, Bcl-2 and cleaved caspase-3, a key protein for apoptosis, was analyzed by western blot, this drug effetely protective form instinct apoptosis pathway. DNA fragmentation following the cleaved caspase-3 activity was also confirmed by the TUNEL (terminal deoxynucleotidyl transferase dUTP nick-end labeling assay), confirming that the pre-treatment group decreased. As a result of analyzing cells undergoing apoptosis with Annexin V-PI (propidium iodide) staining, it was found that Compound X had a protective effect against apoptosis by more than 15%. Previous studies have shown that cisplatin-induced ototoxicity is caused by oxidative stress that excessively accumulated reactive oxygen species (ROS) produced by dysfunctional mitochondria. To find out the protective mechanism of this drug, the ROS level of mitochondria, mitochondria membrane potential, intracellular ROS and interaction with the antioxidant system by glutathione were analyzed. As a result, it was confirmed that the mitochondrial ROS decreased by 15% or more in the pre-treatment group compared to the cisplatin-treated group, and it was inferred that Compound X plays a role related to the antioxidant system. Therefore, the level of oxidation/reduction status of glutathione, a representative antioxidant in cells, and the expression rates of Glutathione Reductase(GR), a protein involved in the reduction of glutathione, and Glutathione Peroxidase(GPx), involved in oxidation, were analyzed. Compared to the cisplatin group with a high ratio of oxidized glutathione, the pre-treated group showed the ratio of reduced state glutathione was the same as that of the control group, the expression of GR was not significantly different between the cisplatin and pre-treatment groups, but the expression of GPx was significantly increased in the pre-treatment group and the Compound X alone treatment group. Therefore, I found that Compound X acts as a powerful reducing agent for glutathione instead of GR and by increasing the ratio of reduced glutathione, helps other intra-cellular antioxidant system, neutralizing over-generated ROS of mitochondria and protecting it from apoptosis due to oxidative stress. The results of this study demonstrated that Compound X is an effective protective agent against ototoxicity caused by cisplatin, suggesting the possibility that it can be used as an effective therapeutic agent through additional research.

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Association between HbA1c and Hearing Loss

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Background: Diabetes mellitus (DM) is a common systemic metabolic disease with increasing worldwide prevalence. DM is associated with multiple microvascular complications, including the basilar membrane thickening and other neuropathic changes that could induce hearing loss. We investigated the correlation between HbA1c and hearing loss using a tertiary hospital data. Methods: We conducted a retrospective medical chart review of the patients diagnosed with sensorineural hearing loss and diabetes between 2006 and 2021 in Catholic Medical Center (CMC). The data were collected from the Catholic Medical Center clinical data warehouse (CMC-CDW). The mean pure-tone audiometry (PTA) thresholds for air conduction at 0.5, 1, 2, and 4 kHz were calculated. We used the HbA1c level as a diagnostic criterion for diabetes. The following criteria were used to define the HbA1c level: a normal HbA1c level is below 5.6%, a level between 5.6% and 6.4% suggests prediabetes and a 6.5% or more implies diabetes. Results: Among the 5,287 participants, 1,129 were normal, 2,119 were prediabetes and 2,039 were Diabetes. There was a significant increase in age in the diabetic group (p

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Role of microRNA-375-3p-mediated regulation in tinnitus development.

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Background: Changes in the dorsal cochlear nucleus (DCN) following exposure to noise play an important role in the development of tinnitus. As the development of several diseases is known to be associated with microRNAs (miRNAs/miRs), the aim of the present study was to identify the miRNAs that may be implicated in pathogenic changes in the DCN, resulting in tinnitus.

Methods: The study consisted of four stages, including identification of candidate miRNAs involved in tinnitus development using miRNA microarray analysis, validation of miRNA expression using reverse transcription-quantitative PcR (RT-qPcR), evaluation of the effects of candidate miRNA overexpression on tinnitus development through injection of a candidate miRNA mimic or mimic negative control, and target prediction of candidate miRNAs using mRNA microarray analysis and western blotting.

Results: The miRNA microarray and RT-qPcR analyses revealed that miR-375-3p expression was significantly reduced in the tinnitus group compared with that in the non-tinnitus group. Additionally, miR-375-3p overexpression via injection of miR-375-3p mimic reduced the proportion of animals with persistent tinnitus.

Conclusion: Based on mRNA microarray and western blot analyses, connective tissue growth factor (CTGF) was identified as a potential target for miR-375-3p. Thus, it was inferred that c TGF downregulation by miR-375-3p may weaken with the decrease in miRNA expression, and the increased pro-apoptotic activity of cTGF may result in more severe neuronal damage, contributing to tinnitus development. These findings are expected to contribute significantly to the development of a novel therapeutic approach to tinnitus, thereby bringing about a significant breakthrough in the treatment of this potentially debilitating condition.

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Cortical and behavioural discrimination in response to vowel-like spectral cues

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Keywords: frequency discrimination, electroencephalography, speech perception

Background: The use of behavioural methods to investigate sound discrimination and speech perception in hearing-impaired (HI) listeners can pose significant challenges, especially in young infants who cannot actively take part in such tasks. Intervention at an early age, however, has been proven to impact positively on the development of language and cognition skills in infants with hearing loss [1], [2]. Therefore, the development of objective measures to assess speech-like sound discrimination can provide clinically relevant feedback for hearing aid fitting evaluation, brain development over time, and intervention strategy selection [3]. While previous studies have made use of speech sounds to measure onset cortical activity from infants and adults, it remains unclear what is driving the response: the spectral cues, the underlying loudness cues, or a combination of the two. This study investigates a novel approach to evoke cortical responses to frequency discrimination using vowel-like sounds in which the loudness cue is minimised.

Methods: Electroencephalographic (EEG) recordings and behavioural responses were obtained from 9 normal hearing (NH) and 10 HI adults subjects. Stimuli consisted of a series of vowel-like sounds (i.e., fundamental frequency and three formants) where the second formant (F2) was periodically and continuously shifted up and down to evoke the acoustic change complex (ACC) response, a cortical response elicited by the frequency changes imposed to the stimuli. Two types of vowel-like stimuli (/u/ and /i/) were used, and stimuli were compensated in level to ensure frequency-specific audibility in HI listeners. The magnitude of the change applied to the second formant was determined from the behavioural frequency discrimination threshold (just noticeable difference-JND) [4], and it spanned between JND + 10 Hz to 10 x JND, with 2 intermediary steps. The loudness cue was minimised by imposing a slow (<10Hz) noise amplitude modulation to the stimuli. In addition, behavioural frequency discrimination thresholds to the second formant of each vowel were measured using a 3-alternative forced-choice (AFC) task.

Results: Cortical ACC responses were obtained from both hearing groups. ACC responses were larger for NH than HI listeners for both vowels, but the effect of frequency change was larger for the /u/ than the /i/ vowel. Behavioural frequency discrimination revealed larger thresholds for vowel type /i/ than /u/. The statistical analysis on the cortical responses revealed a significant interaction between hearing status (NH and HI), vowel type (/u/ and /i/) and frequency change magnitude. Investigations of the relationship between the objective and behavioural measurements are in progress.

Conclusion: Cortical ACC responses can be obtained from both hearing groups. As expected, the magnitude of the ACC response was affected by the magnitude of the frequency change. Despite stimuli being presented at an audible level, cortical responses are smaller in HI listeners.

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Using the McGurk effect to elicit audiovisual multisensory Event Related Potentials

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Keywords: Event Related Potentials (ERP), Audiovisual, Multisensory, McGurk Effect

Background: The "McGurk" effect is a well-known and robust phenomenon which occurs when a listener is presented with conflicting auditory and visual cues of a person speaking. The incongruent audiovisual information results in an illusionary auditory precept, one which matches with the visual information provided to the participant. This effect demonstrates the influence of vision on hearing in the perception of speech [see 1-3]. The purpose of this study was to assess how audiovisual (AV) multisensory stimuli are integrated in speech perception using behavioral and electrophysiological measures.

Methods: Participants were seated in a sound booth. Visual stimuli were presented on a television monitor situated in front of the participant. Auditory stimuli were presented using a pair insert earphones (Etymotic Research Corp, ER3C). Auditory stimuli consisted of one of two recorded speech tokens (/ba/ or /fa/) presented at 70 dB SPL. Visual stimuli consisted of one of two video files of a woman speaking the speech tokens /ba/ and /fa/ with no corresponding audio. Behavioral measures were conducted to determine which auditory token was perceived by the subjects in combination with the matching (congruous) or conflicting (incongruous) videos. Event related potentials (ERPs) evoked by the AV stimuli were recorded using the Duet acquisition platform and the SmartEP evoked potentials software (Intelligent Hearing Systems, Miami, Florida, USA). Data was collected using an "odd-ball paradigm" with common and odd stimuli selected randomly by the software, with an 80% to 20% ratio of odd to common stimuli at a presentation rate of 0.5/second. Stimuli were presented with three different paradigms: 1) Conventional audio only odd-ball paradigm (audio /ba/ as the common sand /fa/ as the odd stimulus). 2) Visual only odd-ball paradigm (video of woman speaking /ba/ as the common and /fa/ as the odd). 3) "McGurk" odd-ball paradigm (Congruent /ba/ speech and video as the common, and incongruent /ba/ speech with /fa/ video as the odd).

Results: Behavioral results indicated the McGurk effect was perceived by the subject population. As expected, the auditory and vision only stimulation generated corresponding ERPs to changes in common to odd presentations of each stimulus with P300 latencies of approximately 270 and 395 ms respectively. The McGurk incongruent presentation with the conflicting audio and video also generated a very robust ERP response with a latency of approximately 355 ms.

Conclusion: The results indicate that the illusionary auditory precept created by the McGurk stimulus does evoke a novelty response, albeit one which is different from standard auditory and visual odd-ball responses. The occurrence of the McGurk ERP at a latency in between the auditory and visual ERP responses suggests that there are additional mechanisms at play when integrating audio and visual information. Further investigation into this may help expand the understanding of how multisensory stimuli are weighted and integrated in speech perception and where this takes place along the AV pathway.

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Mismatch Negativity in children with phonological disorder

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Keywords: Mismatch Negativity. Auditory evoked potentials. Auditory processing. Phonological Disorder.

Background: Auditory discrimination represents a fundamental aspect for the correct production of speech sounds, as it is through the perception of acoustic characteristics that phonemes can be distinguished from each other, generating appropriate neural representations. Children with phonological disorders present disorganization of the sound system, with the presence of replacement and/or omission of phonemes, in an age range that is no longer expected. The etiology of this disorder is still unclear, however, the inability to auditory discriminate the characteristics of phonemes may be a causal or aggravating factor of this condition. Given the relationship between auditory skills and phonological disorders, the investigation of auditory processing in these children becomes extremely valuable. Thus, the objective assessment of auditory processing, through electrophysiological hearing tests, such as the Mismatch Negativity, assumes a relevant role in studies of this population. The present study aimed to compare the electrophysiological responses of the cortical auditory potential, focusing on mismatch negativity, in children with phonological disorders and with typical development.

Methods: Twenty children with phonological disorder, of both sexes and aged between four and seven years and eleven months, composed the study group (SG). They were paired with 20 children with typical language development, who composed the control group (CG). Children in both groups underwent a sample selection process and were submitted to otoscopy, immittance testing, pure tone audiometry, brainstem auditory evoked potential and ABFW Child Language Test. Finally, mismatch negativity was performed with natural speech stimuli /ta/, /ga/ and /da/ developed for the present study and combined in pairs /ta/-/da/ and /ga/-/da/, in order to correspond to the processes of deafening or stop sounds and fronting or backing for velars. The parameters of mismatch negativity latency, amplitude, area and duration, obtained by calculating the difference between the waves generated from the frequent and rare stimuli, were analyzed. The results were statistically analyzed using the Shapiro-Wilk, paired Student T and Wilcoxon tests.

Results: Mismatch negativity comparison between groups showed statistically significant differences in latency and amplitude between SG and CG, with the use of the /ga/-/da/ stimulus. In the SG intragroup comparison, the statistical analysis showed a difference in the mismatch negativity duration between the stimuli.

Conclusion: Children with phonological disorders present changes in Mismatch Negativity parameters related to preattentive auditory discrimination of acoustic contrasts. Thus, new studies related to these potentials may represent advances for the diagnosis and rehabilitation of this specific population.

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Musical training in teenagers with Type 1 Neurofibromatosis: effects on auditory perception and its electrophysiological correlates

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Background: Neurofibromatosis type 1 (NF1) often results in auditory processing disorders. We found that 70% of NF1 patients presented some deficit in music perception (amusia), especially in rhythm domain, associated with pre-attentional electrophysiological deficits detected by Mismatch Negativity (MMN) test.

Objectives: This preliminary study investigated if musical training may change auditory processing, music perception and MMN.

Methods: Nine volunteers teenagers diagnosed with NF1 aged between 12 and 16 years (5 female, 4 male) participated in a six-month musical training directed mainly to rhythmic learning. Test battery before and after training included: a short version of Montreal Battery of Evaluation of Amusia (MBEA) (music processing); Gaps in Noise (GIN) test (temporal auditory processing) and MMN (pre attentional auditory perception). A temporal paradigm was used to MMN recordings (20ms frequent and 80ms rare) .

Results: Three participants did not complete the study due to financial limitations (1), unavailable time for activities proposed (1) or lack of interest (1). The remaining six showed improvement in temporal auditory processing, with a reduction in mean values of GIN thresholds from 10,25 to 5,41 (Cohen D 2,03; p=0,035) (Table 1). All of them had detectable MMN post-training, whereas only 3 have presented detectable MMN in the pre-training test (Figure1). There was improvement in global and specific music perception (melody, rhythm and musical memory), although it was statistically significant only to global MBEA score (Cohen D=0,93; p=0,042) (Table1).

Conclusion: These preliminary results corroborate our hypothesis that music training may improve auditory functions, especially temporal auditory processing, and this may be present in the pre attentional level of auditory perception.

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Table 1: Comparison of music and auditory processing scores pre and after music training.

Figure 1: Long latency auditory evoked potential of a 17-year-old teenager before (03/14/2019) and after (07/26/2019) musical training program. MMN was detected only after music training and can be identified in this record as a negative wave peak at 181 millisecond latency.

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Influences of perceptual and cognitive deficiencies on complex speech processing: an electroencephalography (EEG) pilot study

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Background: Hearing-impaired listeners often display difficulties in understanding complex sentences. Reasons may lay in perceptual as well as cognitive deficiencies. This study evaluates the contribution of both factors to understanding sentences of differing complexity using electroencephalography (EEG) recordings. Event related potentials (ERP) such as the P600 and the left anterior negativity (LAN) indicate higher impact on working memory[1,2]. The early LAN (ELAN) is linked to syntactic integration difficulties[3] and could occur in hearing impaired subjects.

Methods: In a pilot study 5 hearing aid users and 5 normal hearing, age-matched (± 2 years) participants were tested. Audiometric and working memory tests were conducted. Sentences from the german Oldenburg corpus of Linguistically and Audiologically Controlled Sentences (OLACS) with subject- or object-initial structure that can lead to a temporal ambiguity of the acting role were presented. Simultaneously an EEG was recorded at multiple electrode sites (n=64). The participants had to choose the correct image out of two that were depicting scenarios with reversed acting roles to confirm their understanding of the sentences. First measurements with a cochlear implant (CI)-user and normal hearing participants were performed using embedded subject or object relative clause sentences additionally.

Results: In the pilot study, object initial sentences with feminine and neuter articles evoke a P600 potential at the POz electrode in both normal hearing and hearing aided listeners. The P600 latency is longer for the hearing-aid user group compared to the normal hearing group whereas the P600 amplitudes show no significant difference. Working memory tests exhibit no difference between the normal hearing and the hearing aided group. Initial results for EEG data resulting from presentation of embedded clause sentences in normal hearing subjects and a CI user are shown.

Conclusion: The EEG experiments are capable of showing differences in speech processing of sentences with varying complexity for hearing aid users and normal hearing participants. Longer P600 latencies point towards increased cognitive effort for processing complex sentences in hearing aided subjects compared to normal hearing participants.

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Event related potentials and brain network functional connectivity mechanisms in patients with noise induced hearing loss: a preliminary study

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Question：

Noise-induced hearing loss (NIHL) is a prevalent and debilitating condition that affects millions of individuals worldwide. Prolonged exposure to excessive noise levels can damage the delicate structures of the inner ear, leading to irreversible hearing impairment. While the primary pathology of NIHL is well understood, the impact of this condition on the central auditory system and associated cognitive processes remains an active area of research. In recent years, neurophysiological investigations utilizing event-related potentials (ERPs) and functional connectivity analysis have provided valuable insights into the neural mechanisms underlying NIHL.

Event-related potentials (ERPs) are electrical brain responses that are time-locked to specific sensory, cognitive, or motor events. These ERPs, captured using electroencephalography (EEG), offer a non-invasive means to examine the temporal dynamics of neural processing and have proven to be a powerful tool for investigating sensory and cognitive functions in both healthy individuals and those with various neurological disorders. By examining ERP components such as the auditory brainstem response (ABR), middle latency response (MLR), and late cortical potentials (e.g., N1, P2), researchers have gained valuable information regarding the integrity and efficiency of the auditory processing pathways in individuals with NIHL.

In addition to ERPs, the study of brain network functional connectivity has emerged as a promising approach to understanding the impact of NIHL on the broader neural networks underlying auditory perception and cognition. Functional connectivity refers to the temporal correlations between spatially distinct brain regions, indicating the degree of interaction and communication between these regions. Techniques such as resting-state functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) coherence analysis have been employed to investigate the alterations in functional connectivity patterns associated with NIHL. These studies have provided insights into how NIHL affects not only the local processing of auditory information but also the integration and coordination of neural activity across distributed brain regions.

The integration of ERP and functional connectivity measures in the study of NIHL has the potential to elucidate the complex interplay between sensory and cognitive processes in individuals with hearing loss. By combining high temporal resolution measures (ERPs) with assessments of large-scale brain network dynamics (functional connectivity), researchers can gain a more comprehensive understanding of the neural changes underlying NIHL. Furthermore, such investigations may contribute to the development of more targeted diagnostic and therapeutic interventions for individuals with NIHL.

In light of the significance of this topic, this research aims to explore the event-related potentials and brain network functional connectivity in patients with noise-induced hearing loss. The findings from this study will help uncover the neural mechanisms underlying the auditory deficits observed in NIHL and provide valuable insights into the functional reorganization of the central auditory system in individuals with hearing loss. Ultimately, this research may pave the way for the development of novel interventions and rehabilitation strategies to improve the quality of life for patients with NIHL.

Designs and Methods:

This study aimed to investigate event-related potentials (ERPs) and brain network functional connectivity in patients with noise-induced hearing loss (NIHL) compared to young subjects without hearing impairment. The research methodology involved the inclusion of 30 young subjects and 30 individuals with NIHL. Data collection encompassed a 4-hour electroencephalography (EEG) session to capture ERPs, specifically focusing on the P300 and mismatch negativity (MMN) components. Additionally, an 8-minute resting-state functional near-infrared spectroscopy (fNIRS) session was conducted to assess functional connectivity based on concentrations of oxygenated hemoglobin (HbO2) and deoxyhemoglobin (HbR) in the time series.

The study employed a between-group design, comparing the data obtained from the young subjects and individuals with NIHL. The EEG recordings allowed for the examination of ERPs, including the P300 and MMN, which are well-established markers of cognitive and sensory processing, respectively. These ERPs were elicited using specific paradigms designed to target the auditory processing pathways. The collected data were analyzed using SPSS 19.0 statistical software, employing one-way analysis of variance (ANOVA) and correlation analysis. Statistical significance was defined as $p < 0.05$, indicating a significant difference between the groups.

Furthermore, resting-state functional connectivity analysis was performed using fNIRS data collected during an 8-minute resting-state session. fNIRS is a non-invasive neuroimaging technique that measures changes in cerebral blood oxygenation to infer neural activity. The concentrations of HbO2 and HbR in the time series were utilized to calculate the resting-state functional connectivity strength between different brain regions. The analysis focused on several brain networks, including the sensory motor network (SEN), dorsal attention network (DAN), ventral attention network (VAN), default mode network (DMN), frontal parietal network (FPN), and visual network (VIS). By comparing the differences in functional connectivity between the two groups, the study aimed to identify alterations in network-level interactions associated with NIHL.

The statistical analysis of the ERP data involved one-way ANOVA to determine group differences in the P300 and MMN components. Additionally, correlation analysis was performed to explore potential relationships between ERPs and clinical characteristics of the participants with NIHL. The functional connectivity analysis was focused on quantifying the connectivity strength within and between the identified brain networks. Statistical comparisons were made to assess differences in connectivity strength between the young subjects and individuals with NIHL.

By employing these comprehensive methods, this study aimed to provide a detailed understanding of the neural alterations associated with NIHL. The combination of ERPs and functional connectivity analysis offered a holistic view of both the temporal dynamics and large-scale network interactions in individuals with hearing loss. The findings from this research have the potential to shed light on the neural mechanisms underlying auditory deficits in NIHL, ultimately contributing to the development of targeted diagnostic and therapeutic strategies for individuals with hearing impairments.

Results:

The analysis of event-related potentials (ERPs), specifically the P300 and mismatch negativity (MMN) components, revealed significant differences between patients with noise-induced hearing loss (NIHL) and individuals with normal hearing. In patients with NIHL, the P300 amplitude was found to decrease, indicating impaired cognitive processing, while the latency of the P300 response extended, suggesting delayed neural processing. These findings indicate that NIHL is associated with alterations in the neural responses underlying cognitive and sensory processing.

Furthermore, the investigation of functional connectivity using the concentrations of oxygenated hemoglobin (HbO2) revealed significant differences in connectivity patterns between the two groups. Within the sensory motor network (SEN), dorsal attention network (DAN), default mode network (DMN), frontal parietal network (FPN), and visual network (VIS), patients with NIHL exhibited a significant decrease in functional connectivity strength. This result suggests disrupted neural interactions within these networks, indicating compromised integration and coordination of neural activity in individuals with NIHL. Interestingly, no significant difference in functional connectivity strength was observed within the ventral attention network (VAN).

When exploring the connectivity between different brain networks, the analysis demonstrated a significant decrease in functional connectivity strength between other brain networks in the group with NIHL, except for SEN-VAN and SEN-DMN, which showed no significant difference. This result indicates that individuals with NIHL exhibit altered functional connectivity between brain networks, suggesting disrupted communication and integration of neural activity across distributed brain regions.

Additionally, the analysis of functional connectivity based on the concentrations of deoxyhemoglobin (HbR) revealed further insights into the neural alterations associated with NIHL. Patients with NIHL exhibited a significant reduction in functional connectivity strength within SEN, DAN, VAN, DMN, and FPN, indicating disrupted connectivity patterns within these networks. However, no significant difference in functional connectivity strength was observed within the visual network (VIS). These findings provide additional evidence for the widespread changes in functional connectivity associated with NIHL.

Collectively, the results of this study demonstrate that patients with noise-induced hearing loss exhibit significant alterations in both event-related potentials and brain network functional connectivity. The decrease in P300 amplitude and extended latency suggests impaired cognitive processing in individuals with NIHL. Moreover, the disrupted functional connectivity within specific brain networks, as well as the altered connectivity between different brain networks, indicates compromised neural integration and communication in patients with NIHL.

These findings contribute to our understanding of the neural mechanisms underlying NIHL and provide important insights into the functional reorganization of the central auditory system in individuals with hearing loss. The identified alterations in event-related potentials and functional connectivity may have implications for the development of targeted interventions and rehabilitation strategies aimed at improving the quality of life for patients with NIHL.

Conclusion:

In conclusion, the research investigating event-related potentials (ERPs) and brain network functional connectivity in patients with noise-induced hearing loss (NIHL) has yielded significant findings regarding the neural alterations associated with this condition.

The analysis of ERPs, specifically the P300 and mismatch negativity (MMN) components, revealed that patients with NIHL experience a decrease in P300 amplitude, indicating compromised cognitive processing. Additionally, the latency of the P300 response was found to extend, suggesting delayed neural processing in individuals with NIHL. These findings collectively indicate that NIHL has a detrimental impact on cognitive function, impairing the neural responses underlying cognitive and sensory processing.

Moreover, the investigation of brain network functional connectivity using functional near-infrared spectroscopy (fNIRS) data revealed notable differences between patients with NIHL and individuals with normal hearing. Within specific brain networks such as the sensory motor network (SEN), dorsal attention network (DAN), default mode network (DMN), frontal parietal network (FPN), and visual network (VIS), patients with NIHL exhibited a significant decrease in functional connectivity strength. These results indicate disrupted neural interactions within these networks, pointing to compromised integration and coordination of neural activity in individuals with NIHL. Importantly, no significant difference in functional connectivity strength was observed within the ventral attention network (VAN).

Additionally, the analysis of functional connectivity between different brain networks demonstrated that patients with NIHL experience a significant decrease in functional connectivity strength between various brain networks, except for specific pairs such as SEN-VAN and SEN-DMN, where no significant difference was observed. This finding suggests disrupted communication and integration of neural activity across distributed brain regions in individuals with NIHL.

Overall, the research concludes that patients with noise-induced hearing loss exhibit significant alterations in event-related potentials and brain network functional connectivity. The decrease in P300 amplitude, along with the extended latency, indicates impaired cognitive function in patients with NIHL. Furthermore, the reduced functional connectivity strength within specific brain networks and the disrupted connectivity between different brain networks highlight compromised neural integration and communication in individuals with NIHL.

These findings provide valuable insights into the neural mechanisms underlying NIHL and contribute to our understanding of the functional reorganization of the central auditory system in individuals with hearing loss. The observed alterations in event-related potentials and functional connectivity have implications for assessing cognitive function and developing targeted interventions and rehabilitation strategies to improve the quality of life for patients with NIHL. By better understanding the neural changes associated with NIHL, healthcare professionals can tailor interventions to address the specific cognitive and neural deficits experienced by individuals with noise-induced hearing loss.

Keywords: Event-related potentials, Brain network functional connectivity, Noisy deafness.

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LONG-LATENCY AUDITORY EVOKED POTENTIALS AND CORTICAL GAIN IN PATIENTS WITH TINNITUS DISORDER: PRELIMINARY STUDY

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Keywords: hearing, evoked potentials, long latency, tinnitus, cortical gain

Background: Previous research has pointed to evidence of changes in central auditory nervous system (CANS) in individuals with tinnitus disorder, reflected as an increase in central gain in the brainstem. The Long Latency Auditory Evoked Potential (LLAEP) plays an important role in the analysis of patients with tinnitus disorders; however, little is known about corresponding changes in the cortex. **Objective:** To measure in subjects with tinnitus disorder the amplitude of the LLAEP components, as well as the cortical gain, in terms of the ratio between the P2/P1 waves.

Method: This was an analytical, cross-sectional and quantitative study, approved by the Research Ethics Committee (nr 56038322.10000.5346). The sample comprised 20 individuals divided into two groups, which were homogeneous in terms of gender, age, and education. The first was a study group (SG): 7 women and 5 men aged 19–35 years (mean = 24 years); evaluations were done on 11 right ears (RE) and 12 left ears (LE); 10 individuals had bilateral tinnitus and 2 had unilateral tinnitus in the LE. The second was a control group (CG): 5 women and 3 men aged 19–35 years (mean = 25 years); 16 right ears (RE) and 16 left ears (LE) were evaluated. Inclusion criteria for both groups were: educated, right-handed, Brazilian Portuguese speakers, hearing thresholds within normal ranges, normal mobility of the tympanic–ossicular system, normal contralateral stapedial acoustic reflexes, integrity in cochlear functioning, and normal brainstem responses. Exclusion criteria were: pharmacological treatment for tinnitus, noise exposure, dizziness, objective tinnitus of a pulsatile type, and diagnosed or evident neurological, psychiatric, or cognitive impairment. **Testing:** All individuals were submitted to anamnesis, basic audiological evaluation, evaluation of transient otoacoustic emissions, click ABR, and LLAEP.

Results: Data analysis involved a Mann–Whitney *U*-test, adopting a p-value ≤ 0.05. Statistically significant differences between the groups were observed only for the amplitude of the P2 component ($p = 0.017$) in the left ear. **Conclusion:** These preliminary results corroborate the hypothesis that the presence of tinnitus can cause changes in the lower regions of the CANS, such as in the brainstem; however, in the cortex, there are few alterations and the LLAEP may not be a good predictor of central gain in such cases. Our studies need to be performed on a larger number of patients to confirm these initial findings.

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Comparative study of cognitive and hearing skills in functionally independent elderly

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Keywords: cognition, P300, hearing

Background: The study of the relationship between the P300 and cognitive skills can help in the assessment of elderly people with hearing complaints and in cognitive decline and thus subsidize discussions related to auditory and cognitive evaluation and rehabilitation in this population. As the P300 is influenced by aspects of cognitive function, it is extremely important to verify the cognitive domains associated with this long latency potential. In addition, knowledge of auditory and cognitive functions in healthy and frail elderly people can differentiate the elderly population from the perspective of health professionals and favor improvements in care for frail elderly people.

Methods: This was a cross-sectional, descriptive and comparative study conducted with 80 elderly people divided into two groups: the study group (composed of frail elderly and those at risk of frailty) and the comparative group (healthy elderly). All of them underwent hearing and cognitive evaluation, and the procedures are described as follows: Tone Threshold Audiometry, Speech perception test, Evoked Potential (P300) Test, HHIE Questionnaire (Hearing Handicap Inventory for the Elderly), MMSE (Mini-Mental State Examination), CDT (Clock Drawing Test), and CERAD (Consortium to Establish a Registry for Alzheimer"s Disease) battery.

Results: There were 40 elderly in each group. The study group (frail elderly) was composed of 75% women and 25% men and the comparative group (healthy elderly) had 82.50% women and 17.50% men. The frail elderly had a higher perception of the handicap when compared to the healthy elderly (p= 0,038). Hearing loss was present in 60% of healthy elderly and in 75% of elderly at risk of frailty/frail ones. There were more cases of altered P300 in the study group, and the language, executive function and memory skills and the MMSE result were associated with the P300 abnormal findings.

Conclusion: Hearing loss was highly prevalent in both groups, but the perception of the handicap was higher in frail elderly, as well as the change in the P300. The P300 was associated with language and executive function skills in healthy elderly. Executive function, MMSE and memory were associated with the P300 results in frail elderly. The comparison between frail elderly and healthy ones enriches the discussion about the impact of frailty on hearing and cognitive skills and differentiate the elderly population from the health professional"s perspective which may help improve elderly care.

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Preliminary Analysis of Auditory Brainstem and Cortical Responses Evoked by Running Speech in Preterm and Term Infants

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Question: Accurate, efficient auditory physiological processing from the brainstem to the cortex is essential for spoken language acquisition, as infants with hearing loss and neural-developmental conditions often have delayed or atypical language. The auditory brainstem response (ABR) and central auditory evoked potential (CAEP) are electrophysiological measures of the brainstem and cortex, respectively, that are recordable from infants at early ages and undergo numerous changes in early infanthood. Existing methods to measure CAEPs require different protocols than ABR measurements, and both measures are limited by the stimuli used to evoke them: repetitive trains of short, speech-like tokens. Polonenko and Maddox pioneered a paradigm, tested in normally hearing adults, that uses natural, running speech while simultaneously providing both a response with the canonical component waves of the ABR together with a response from the cortex. We hypothesize that using natural, running speech and measuring responses from brainstem through the cortex in infants will be informative for future language outcomes. The goals of this preliminary analysis are to (1) describe canonical ABR wave latency/morphology and CAEP morphology evoked by running speech and clicks; (2) compare ABR and CAEP latency and morphology between infants born preterm and at term.

Methods: The ABRs and CAEPs were analyzed in 10 preterm infants and 12 term infants. Five minutes of clicks generated through a Poisson process and 30 minutes of broadband peaky speech (speech made as click-like as possible while preserving its spectral-temporal properties) from an audiobook narrated by a male were presented to one ear of the infant through an ER-2 earphone. The ABRs and CAEPs were derived using cross-correlation for clicks and deconvolution for peaky speech. The input to the auditory system was the sequence of clicks for click stimuli, and the sequence of glottal pulses associated with the speech for the peaky speech stimuli, and the output was the EEG response recorded between electrodes placed at high forehead and mastoid of ipsilateral ear (ground at low forehead). The primary analysis was manual peak-picking by trained audiologists.

Results: Notable ABR peaks and troughs were observable across the post-stimulus time frame. CAEP waveforms had a characteristic negative-going wave around 20 ms and a broad, positive peak between 100-200 ms. CAEP and ABR waves evoked by speech had overall lower amplitudes than those evoked by clicks. The relationships between click and speech ABR latencies were similar for Wave I, but Wave V latency was longer for speech than clicks. Morphology of the ABR and CAEP waveforms differed between term and preterm infants.

Conclusion: The derived ABR and CAEPs evoked by clicks and running speech are measurable and present in preterm and term infants. The results suggest the possibility of exploring the contribution of subcortical and cortical speech processing to future language outcomes. [Research supported by 5R21DC019489 NIDCD/NIH]

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Loudness topography in the early deafness implanted patient

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Keywords: cochlear implant, loudness growth map, prelingual patient

Background: It has been suggested that prelingual implanted patient loudness perception varies with the electrical current magnitude, which in turn decreases as a function of distance from the electrodes.

Factors such as the position of the electrodes in the scala tympani, variation in the health condition along the implanted cochlea, growth of new tissue, and stimulation mode can affect length of current paths –impedance– between the electrodes and the auditory neurons. Relationship between electrical current (i) and voltage (v) is described by Ohm"s law as $v = Ri$. In an electrical hearing context i represents the current delivered by cochlear implant (CI) to an active electrode, R refers to the electrode impedance and v is a potential directly proportional to the current i flowing through R. In this work we show 3D loudness topography maps across electrode array generated by recording the scalp voltage v as the response to a variable intensity and frequency pip tone while patient is using the CI in real use conditions.

Methods: *Population.* Group of 15 prelingual implanted children with age in the range of 2 to 6 years old, without reliable sound field audiometry, initial electrode current levels based on Electrical Compound Action Potential (ECAP) threshold of some electrodes and CI fitting following a behavioral methodology. *Recording*. Patient asleep inside an audiometric test booth and using the CI in everyday mode. Four scalp EEG electrodes A1(-), A2(-), Cz(+) and Fpz (GND) for two recording channels. EEG amplifier wide band of 30 to 500 Hz with 0.1 to 300 Hz, LPF, 12 dB/Octave,12 bits A/D converter with a 20 kHz sampling rate. 50 ms EEG epochs were acquired, of which the average in groups of one hundred was used to obtain the corresponding electrode ECR for every test intensity. *Stimuli*. Random presentation of pips tone in sound field, 10 to 90 dBHL, and frequency corresponding to electrodes band pass filter central frequency [2].

Results: According to T and C levels setting and current dynamic range extension the 3D graphic representation of the RCE family curves of each electrode as a function of the input sound pressure level provides an integral view of loudness developing with the input sound pressure level across electrode array. We found that input sound pressure level for initial ECR detection is related to hearing threshold of the electrode under test and slope of the linear regression of the ECR peak amplitudes allows to identify overstimulation or under stimulation scenarios. Additionally, RCE waveshape of individual electrodes might be a measure of how well auditory neurons response follows the envelope of the input pip.

Conclusion: Up to now relationship we observed between 3D loudness profile and patient hearing behavior make us be optimistic about its potential clinical use, especially for non-cooperative implanted young children. Finally, this approach to electric hearing may be a new tool that allow us to make an objective judgment about quality of the hearing provided by CI.

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Illuminating regularity violations: optical imaging in an auditory oddball paradigm

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Background: Auditory stimuli that deviate from regular patterns elicit distinct neural responses, which are crucial for source identification in complex acoustic scenes. The oddball paradigm has been employed extensively in EEG, MEG, and fMRI studies to induce such regularity deviations. These investigations have generated various hypotheses explaining the differences observed between standard and deviant stimuli, ranging from neuronal adaptation to predictive coding. However, functional near infra-red spectroscopy (fNIRS) signals have not yet been utilized to evaluate these hypotheses.

Methods: Our sample consisted of 5 normal hearing adults who performed an auditory oddball task involving two spectral ripples differing in their occurrence probabilities: a high-probability standard (p=0.92) and a low-probability deviant (p=0.08). Utilizing functional near infra-red spectroscopy, we examined the hemodynamic responses of participants during the auditory oddball paradigm with optodes monitoring the pre-frontal cortex.

Results: Our findings showed a consistent hemodynamic pattern, with deviant stimuli eliciting significant increases in oxygenated haemoglobin levels coupled with decreases in deoxygenated haemoglobin levels, when compared to the standard stimuli.

Conclusion: We present preliminary data demonstrating the potential of relative changes in oxy- and deoxy-haemoglobin to serve as neural markers for capturing oddball responses. Our current results provide evidence for the viability of fNIRS as a tool for capturing neural responses to regularity violations in the auditory domain. We discuss our findings in the context of current hypotheses for deviance detection derived from previous electrophysiological investigations. Future embodiments will extend this research to cochlear implant recipients, who may benefit from the reduced susceptibility to artifacts in optical imaging.

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What is known about functional connectivity assessed with electroencephalography in children with mild traumatic brain injury

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Background: Mild traumatic brain injury (mTBI) is a physiological disruption of the brain when the head is subject to significant force. Every year, more than 3 million children could be affected by mTBI [1]. Up to a third of these children suffer from persistent symptoms. Full recovery can happen within the first month, but it may take longer for some children. Therefore, it is of interest to investigate the processes involved in the persistence of symptoms. Functional connectivity, the temporal relationship between brain regions, has been shown to help understand normal and abnormal neural processes. It could be measured at rest or during auditory tasks by electroencephalography (EEG). Such a method could help to understand better the neural mechanisms affected by mTBI. The present study consists of a comprehensive review of the literature on functional connectivity assessed with EEG in children with mTBI in order to define the prevailing methodologies and results.

Methods: Following a systematic search strategy executed across multiple online databases to identify relevant studies, ten articles met the inclusion criteria for analysis. The inclusion criteria encompassed the pediatric population (2 to 18 years old), mTBI and concussion, functional connectivity and EEG or qEEG. Only articles published in English or French were included in the current review.

Results: All studies use a prospective design, with most using a comparison cohort design. Brain Network Analysis (BNA) was used in 7 out of 10 studies, making it the primary type of functional connectivity analysis recorded. Seven studies used auditory tasks in their test paradigm. In terms of results, five studies reported significant differences between the mTBI and group and normal controls. Only two of these five studies used BNA, whereas the other three used alternative analysis methods. Secondary to group differences, six studies also reported significant differences between measures over time within the mTBI group, all of which used BNA.

Conclusions: Functional connectivity assessment based on EEG can identify some differences in children with mTBI. Most articles reporting significant differences relied on assessment techniques other than BNA. Although BNA was not particularly sensitive to group differences, it was more useful in following changes over time. The results of this review indicate the need for further studies on this subject among children with mTBI.

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P54

Auditory Event-related potentials for word stimuli in the Kannada language among native Kannada speakers with Dementia

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Question: Can word stimuli be used to generate ERP in patients with dementia ?

Keywords: Evoked potentials, Minimal pairs, P300, cognitive functions, auditory perception, Dementia, odd-ball paradigm

Background: P300 is a type of event-related potential (ERP) that occurs as a positive waveform that approximately 300 milliseconds after the onset of the oddball stimuli. Tone and monosyllabic stimuli have been widely used in P300 research, providing valuable insights into auditory perception, phoneme discrimination, language processing, and other cognitive processes. (Cass & Polich,1997; Katayama and Polich, 2003; Massa et al, 2011; Kalaiah & Shastri, 2016; Perez et al 2016: Ramteke and Mesharam, 2020). The effect of stimulus complexity on P300 can also depend on individual factors, such as cognitive abilities and experience with the stimuli. Minimal pairs are pairs of words that differ by only one phoneme (sound). Bi-syllabic minimal pairs are pairs of words that differ by only one phoneme. Bi-syllabic minimal pairs may be more challenging for some individuals because they require processing and discrimination of more complex phonemic structures. Bi-syllabic minimal pairs may be more relevant for assessing certain types of speech and language disorders, such as apraxia of speech, which can affect the production of multisyllabic words. The aim of the study was to elicit and analyze the auditory event-related potentials for word stimuli in the Kannada language among individuals with Dementia.

Method: The prospective study was planned on ten native Kannada language speakers (5 male; 5 female) who were diagnosed with Dementia; aged 55 -70 years (Mean 64 ± 2 years); with hearing ranging from normal hearing to moderate high frequency sloping sensory neural hearing loss with no history of otological and/or neuro-otological pathologies and normal otoscopic view and immittance audiometry were the participants of the study. MMSE (Mini-Mental State Examination) and ACE III-K (Addenbrooke"s Cognitive Examination III in Kannada) was administered to all the participants to determine the diagnosis of cognitive impairment.

For obtaining the latency and amplitude of evoked potential using the meaningful word (speech) stimuli, IHS Smart EP version 3.54 was used. Voluntary written consent for participation was taken from each participant. The naturally produced and recorded CVCV tokens (/ko:ti/ and /ko:thi/ pair; /a:me/ and /a:ne pair) in Kannada were used in the auditory oddball paradigm. The sequence was presented binaurally to each participant at a comfortable loudness level (intensity -70% in the system equivalent to 65 dB SPL) using the headset with IR -3A earphones connected to the computer with compatible software. The participant was instructed to be awake, be alert to hear the stimulus yet not respond to it.

Results: The prominent peak for word (PPW) stimuli with clear morphology were used to obtain the latency and amplitude. The latency of this prominent peak was measured from the time of onset of the stimulus (in msec) to the appearance of the peak as displayed on the time window (Polich, 2007). For the amplitude, the peak-to-peak (like N2-P3) amplitude, in microvolt (µV), was obtained. Mean and SD values for the latency of the PP were 545 msec ± 38 msec and the amplitude was 2.5 ± 1.5 µV.

Conclusion: Literature suggests differences in latency and amplitude values as stimulus changes from tone to mono-syllabic speech stimulus. Perez, Zillaoto & Pereira (2016), reported that pure tone had more reliable results than speech, though no statistical significance. Ramteke and Mesharam (2020) showed that the non-speech stimuli had lower latencies than speech stimuli though the values did not show the effect of gender or ear tested.

As we go higher up in the central auditory system, the identification of pathology is possible with complex stimuli. The minimal pairs which are bi-syllabic meaningful utterances would help us identify the pathology at cortical levels, especially in conditions like Dementia, Schizophrenia, ADHD, Parkinson"s disease, and traumatic brain injury. Hence it is important to use more complex stimuli during the oddball paradigm for the detection of cortical lesions.

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P55

ANSD case study: More for good measure?

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A single case study will be presented of a ten month old baby boy born at 35 weeks gestation age. The infant was diagnosed with intrauterine viral infection suspected which caused calcification of the placenta. He presented with athetoid cerebral palsy, choreoathetosis, bilateral nystagmus, ? visual impairment and profound central hypotonia. The ENT identified persistent otitis media that didn"t respond to treatment and proceeded to schedule theatre for myringotomy and grommet insertion. Auditory evoked potential (AEP) testing was performed under general anaesthetic which indicated (initially) typical ANSD: ie pronounced cochlear microphonics with no neural component to the neurological auditory brainstem response (ABR) testing and response to 500 Hz narrowband CE chirp at 100 dB HL bilaterally only. Auditory steady state response testing (ASSR), however, was in stark contrast to the ABR results, indicating a mild hearing loss at 0.5 to 4 kHz in the left ear and a rising severe to mild hearing loss in the right ear. A significant air bone gap could be measured using ASSR at 0.5 and 1 kHz suggesting the low and mid frequency hearing loss was purely conductive in nature in the right ear. Follow up diagnostic indicated OAEs were present. Speech and language assessment results from a year after this assessment will be presented, along with postulation regarding the possible reason for the contradictory ABR and ASSR results.

P56

A preliminary study of the effect of various contralateral auditory attention tasks on efferent pathway among patient with schizophrenia.

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Keywords: Efferent pathways, Otoacoustic, Suppression, Attention, Neuroscience

Background:

Selective auditory attention leads to the activation of primary and secondary auditory cortex areas in normal-healthy individuals. Meanwhile, auditory cortices auto-activate due to dysconnectivity between brain regions associated with auditory hallucinations (AH) in schizophrenia patients. In turn, these activities affect the micromechanics of cochlear outer hair cells through the efferent auditory pathways. An interesting finding is that the physiological activities of the efferent auditory pathways can be indirectly and objectively measured by using a rapid and non-invasive test known as contralateral suppression of otoacoustic emissions (CSOAE). Thus, this allows further investigation of the efferent pathways and the relationship between auditory attention and auditory hallucinations in schizophrenia patients.

Methods:

This study included 36 healthy controls (HC) and 8 schizophrenia patients. Out of 8, 3 are active and 5 are passive AH patients. Atypical antipsychotic medications are being prescribed to the patients. Schizophrenia with active AH (SAc) was defined as experiencing voices within two weeks including the date of evaluation. In contrast, passive AH (SPa) was defined as not experiencing voices for at least 2 weeks including the date of evaluation. Participants underwent bilateral otoscopic examinations, acoustic immittance tests, pure tone audiometry, and routine Transient Evoked Otoacoustic Emissions (TEOAE) tests to ensure that their auditory systems were intact and bilateral hearing was normal. The participants did not report any difficulties understanding speech in quiet or noise, tinnitus, or long-term exposure to noise. To test for suppression, we used a 1-channel TEOAE instrument on the tested ear to measure the linear TEOAE amplitude in quiet at 60 dB SPL. Afterwards, the TEOAE amplitude of all subjects was measured with four types of randomly delivered contralateral suppressors: S1 (White Noise), S2 (White Noise + Attention Task I), S3 (White Noise + Attention Task II), and S4 (White Noise + Attention Task III). At 65 dB SPL, these contralateral suppressors were simultaneously delivered to the contralateral ear as the TEOAE amplitude was measured in the tested ear. CSOAE values represent the difference between TEOAE amplitudes with and without suppressors. One-way ANOVA was carried out to measure the suppression difference between HC, SAc, and SPa while repeated measures ANOVA was carried out to measure the difference in suppression of TEOAEs between different stimuli for all groups.

Results:

A comparison of the suppression values between the left and right ear in each group did not identify a significant difference between the suppressors, allowing the data from both ears to be combined. As a result, the auditory attention tasks presented to the participants in S2, S3, and S4 affected suppression, with S2 showing the highest TEOAE suppression value among them. Among all the suppressors, only S4 showed a significant greater suppression in SAc than in HC. In spite of this, there were no significant differences between the suppressors across the groups of participants.

Conclusion:

This study suggestions are three-folds. First, more challenging auditory attention tasks are required to identify schizophrenia patients with active hallucinations. Secondly, schizophrenia patients who have active hallucinations are likely to have hyperactivity of the efferent auditory pathways due to these hallucinations. As a third point, a larger sample size is needed in order to make comparisons between schizophrenia patients with active and passive hallucinations.

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Student presentations

S1

Auditory steady-state responses: multiplexed amplitude modulation frequencies to reduce recording time

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Background: This study compared two auditory steady-state response (ASSR) stimuli types. The first type, the single ASSR stimulus, is considered a standard method to elicit an ASSR. The single ASSR stimulus comprises a single carrier wave that is amplitude-modulated (AM) at a specific frequency. The second type, the multiplexed AM stimulus, is a novel method in which a single carrier wave is modulated simultaneously at multiple frequencies. The goal of the multiplexed AM stimulus is to efficiently obtain information from different neural generators across the auditory pathway. Various neural generators are targeted by selecting the AM frequencies from a broad range (< 10 Hz to > 100 Hz). Responses to slow AM frequencies originate primarily from cortical areas, while responses to faster AM frequencies originate primarily from subcortical areas such as the brainstem. This approach differs from "multiple ASSRs," where multiple carrier frequencies are used simultaneously. The advantage of using the multiplexed AM stimulus is that it can reduce recording time.

Methods: Twenty-two bilaterally normal-hearing subjects participated; each was placed in a soundproof booth and listened to four ASSR stimuli presented at 80 dBA via insert earphones. Three out of four stimuli (i.e., single ASSR stimuli) were created by amplitude-modulating speech-shaped noise at either 3 Hz, 40 Hz, or 102 Hz. The fourth stimulus was a multiplexed AM stimulus, where the speech-shaped noise was amplitude-modulated with the three frequencies simultaneously. Each stimulus lasted for eight minutes. We investigated the effect of the type of stimulus (single vs. multiplexed) on the signal-to-noise ratio (SNR) and the required stimulus duration to reach a significant SNR for each type of stimulus. We varied the stimulus duration from 1 to 8 minutes in 1-minute intervals. The SNR was calculated using Hostelling's T2 square statistic and was based on the recordings from two electrodes, namely P9 and P10.

Results: Across participants, the median SNR for single and multiplexed ASSR types was above the significance threshold. We found no significant difference in SNR for multiplexed vs. single AM stimuli. However, when considering stimulus duration, we found a significant difference of 0.55 SNR dB in favor of the single ASSR stimuli. Despite the slightly better performance of sequentially presented single AM stimuli, it takes a minimum of 14 minutes of recording time to achieve a significant SNR for each AM frequency. In contrast, the multiplexed ASSR only requires 9 minutes to reach a significant SNR.

Conclusion: Our study revealed that the multiplexed ASSR effectively generates synchronized brain activity across multiple AM frequencies and simultaneously targets multiple neural generators. Consequently, the multiplexed AM stimulus offers a promising approach to reduce recording time, being 1.56 times faster compared to the sequential approach. This result makes it a more practical choice for all subjects, reducing the potential for fatigue, insufficient attention, or diminished arousal during the recording process.

S2

New objective measurement for assessing high-frequency ototoxic damage

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Question: For children receiving ototoxic medication, measuring in the high frequency (HF) range (8-20 kHz) can provide an early warning sign for ototoxic damage. For older children (i.e. over 3-4 years old) it is possible to measure hearing thresholds in this frequency range with behavioural audiometry. However, there are no reports for measuring this with auditory brainstem response (ABR) in younger or uncooperating children. Reponses to current HF-ABR-stimuli are hard to find and no norm values for these stimuli are available. In this study, we developed new stimuli and measured norm-values to enable HF-ABR.

Methods: Two chirp stimuli were made, one 8kHz-octave band stimulus and one 8-20 kHz band pass stimulus. These stimuli were presented to normal-hearing young adults (age 18-25 years) on the Duet ABR system (Intelligent Hearing Systems). Sensation levels were determined and stimuli were presented from approximately 50dBSL downwards. For comparison a 8kHz tone-burst and a combined 8-14 kHz tone-burst (based on [1]) were measured as well. ABR-peaks were marked (I, III, V and VI) and average latency, average amplitude and detectability of the peaks was calculated.

Results: Analysis of the first 12 subjects showed that the 8 kHz chirp gave well detectable peaks. Compared to 8 kHz tone-burst, the amplitudes of the 8 kHz chirp were larger (0.24 vs. 0.18 uV for peak V at 90 dBpeSPL / ~50 dBSL). Detection percentage at higher intensities were similar, but the 8 kHz chirp gave a better detection percentage near the threshold (90% vs. 50% for peak V at 60 dBpeSPL / ~20 dBSL). The 8-20 kHz chirp gave also well detectable peaks (>80% detection of peak V at 70 dBpeSPL / ~20 dBSL), with an amplitude of 0.22 uV for peak V at 100 dBpeSPL (~50 dBSL). The difference with the combined 8-14 kHz tone-burst was small. Interestingly, in the responses of the extended high frequency chirp stimulus, peak VI could be clearly identified.

Conclusions: Both 8 kHz and 8-20 kHz chirp stimuli can be used for high frequency ABR and are promising for early detection of ototoxicity. Further research is necessary to determine the frequency selectivity of the stimuli and to determine latency-norm-values in young children.

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S3

Frequency-Following Responses in Sensorineural Hearing Loss: A Systematic Review

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Introduction
Scalp-recorded frequency-following responses (FFRs) are a family of auditory evoked potentials representing the periodicity of acoustic stimuli and can be used to reveal the integrity of sound processing. They are believed to be generated predominantly in the auditory midbrain. Both the envelope (F0) and temporal fine structure (TFS) component of sound are represented in FFRs and are, therefore, appropriate for studying the mechanisms underlying sound processing and speech recognition. The present systematic review aims to assess whether hearing loss has an impact on different FFR parameters.

Methods
A systematic review was performed and reported according to PRISMA guidelines. The online databases PubMed, Web of Science, and Scopus were searched up to January 2023. Studies evaluating FFRs in patients with hearing loss and normal-hearing controls were included. No restriction on age or severity of hearing loss was implemented. Two independent reviewers performed study selection, data extraction, and risk of bias assessment.

Results
Eleven case-control studies met our inclusion criteria. Acquisition parameters differed widely across studies. Six of the studies used the speech stimulus /da/, however, with varying stimulus duration, intensity and presentation rate. In the time domain, there seemed to be a tendency towards prolonged latencies in patients with hearing loss. The specific waves that were prolonged differed across studies. There was no consensus across studies regarding the wave amplitude in the time domain. In the frequency domain, when focusing on studies that elicited FFRs with stimuli of 170 ms or longer, there seemed to be a consensus towards a significantly smaller fundamental frequency (F0) in participants with SNHL. Results regarding changes in the temporal fine structure (TFS) were variable.

Discussion
Patients with sensorineural hearing loss may require a longer time for processing (speech) stimuli, reflected in the prolonged latencies. It is however not clear if this delay occurs in the onset, transition, steady-state or offset of the response. Additionally, when presenting longer stimuli of at least 170 ms, participants with SNHL show difficulties in tracking the fundamental frequency (F0) of (speech) stimuli. No definite conclusions could be drawn on the influence of hearing loss on wave amplitude in the time domain and the TFS in the frequency domain. Participant characteristics, acquisition parameters, and FFR outcome parameters differed greatly across studies. Since stimuli with a duration of around 40 ms are too short to allow proper neural phase- locking analyses, we strongly recommend future studies to elicit FFRs using longer stimuli of at least 170 ms. It is also notable that most studies used the same stimulus intensity for hearing loss participants as for controls. Moreover, ages of the subject groups differed greatly in several studies, which possibly also affected results of individual studies. Future studies should be performed in larger subject groups, with longer stimuli presented at maximum loudness level in participants with hearing loss.

S4

Exploring objective measures of auditory temporal resolution

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Keywords: temporal resolution, auditory brainstem response, forward and backward masking, two clicks paradigm, suprathreshold hearing

Background: Auditory temporal resolution is an important aspect of suprathreshold hearing, especially for speech comprehension and it is typically defined as the ability to detect temporal changes in a signal. Several methods have been proposed for the objective measurement of temporal resolution, although these approaches have not generally been compared in the same subjects. The present study aims to develop a reliable objective method to measure temporal resolution thresholds based on Auditory Brainstem Responses (ABR) combined with sensitive statistical signal detection methods.

Methods: This study included 23 subjects (ages 20-35 years) with normal hearing. To determine the objective temporal resolution thresholds, two approaches have been explored: 1. ABRs to temporal notched noise with clicks inserted in the middle of a variable duration gap 2. Two clicks with a variable gap between them. Bootstrap, Fsp, Hotelling's T2, and peak-to-peak amplitude estimation methods were used to detect the presence of ABR responses. A psychometric Gaps in Noise test was used to find corresponding behavioural subject thresholds for comparison.

Results: Most of the participants showed an ABR response for 4-ms and above gap durations. At a group level, the amplitude of the responses and the number of ABRs detected decreased as gap durations approached the threshold levels. At an individual level, response detection shows considerable variability as the gap duration decreased. Behavioural tests using the temporal notched noise showed lower gap-duration thresholds than were obtained with the ABR.

Conclusions: Both experimental paradigms with objective detection methods look promising to estimate temporal resolution at a group level, with similar performance as gap durations increase. Individual objective temporal resolution threshold determination appears more challenging.

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S5

Optimization of the acoustic change complex recording procedure to accurately predict speech perception

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Background: The acoustic change complex (ACC) is a brain potential evoked by a change in an ongoing sound recorded by means of an electroencephalogram (EEG). A previous study by our group investigated ACCs in 24 normal-hearing and 13 hearing-impaired subjects and found a remarkably high correlation between speech perception scores as expressed by speech reception threshold (SRT) and ACC outcome measures. Thus, the ACC may be used as an objective measure to assess hearingperformance in patients who cannot reliably perform speech perception tests, in particular because of insufficient language proficiency and/or cognitive abilities. The sound stimuli used in our previous study were quite long (i.e. 3.3 s). If shorter stimuli yield a similar outcome, the ACC recording can be shortened, which would make the test more attractive to implement for clinical diagnosis of hearing impairment.

Methods: A total of 20 normal-hearing participants will be included in this observational study. ACC recordings will be performed according to the three frequency ACC recording protocol which has been used in our previous study (1000, 2000 and 4000 Hz). The recording protocol will be repeated at the same three base frequencies, but with shorter stimulus durations of 2300 ms (2000 ms + 300 ms), 1800 ms (1500 ms + 300 ms), and 1300 ms (1000 ms + 300 ms) with 300 ms referring to the duration of the frequency change. Stimuli will be presented in random order to minimize the influence of adaptation on waveform amplitude and latency. Prior to the ACC recordings, standard pure-tone audiometry and speech-in-noise thresholds will be determined for each participant. The primary objective is to examine whether acoustic change stimuli with a shorter duration than 3.3 s yield similar ACCs (response amplitudes and latencies) as ACCs evoked with the 3.3-s stimulus. The secondary objective is to examine the agreement between predicted speech-in-noise thresholds for the shorter stimuli and those for the 3.3-s stimuli and compare those to measured speech-in-noise thresholds.

Results: This observational study is foreseen to start in June. By September, (preliminary) results will be obtained.

Conclusions: A long stimulus duration results in a longer duration to complete the ACC protocol required for the speech perception prediction model developed by our group. It is yet unknown if a shorter stimulus duration yields similar ACC latencies and amplitudes to the 3300 ms stimulus. If this optimization study proves that the ACC recording can be shortened, it would make the test more attractive to implement for clinical diagnosis of hearing impairment and hearing screening.

S6

Psychoacoustic and electroencephalographic measures of amplitude modulation depth and frequency and their relation to speech recognition in cochlear implant users

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Background: Cochlear implant (CI) users rely on low-frequency temporal envelope modulations (TEMs) to understand speech, and differences in their ability to encode these modulations may explain some of the outcome variability among CI users. To address this, the acoustic change complex (ACC), an electrophysiological measure of change detection at cortical level, can be used to assess the encoding of TEMs. This could provide a more objective measure of speech understanding than traditional speech tests that can also be linked to CI fitting, to pave the way towards closed-loop CIs.

Methods: In this study [1], we assessed amplitude modulation detection (AMD) and amplitude modulation frequency discrimination (AMFD) using the ACC with direct electrical stimulation at single basal and apical electrodes, and at different modulation frequencies. We also performed psychoacoustic tasks to assess AMFD thresholds. Our novel 3-stimulus electroencephalography (EEG) paradigm allowed us to simultaneously record onset/offset cortical auditory evoked potentials (CAEPs), ACCs, and auditory steady-state responses (ASSRs). We then correlated our electrophysiological and behavioral results with speech-in-noise understanding scores.

Results: Apical stimulation led to significantly higher EEG responses than basal stimulation, and there was no significant difference across modulation frequencies. However, the signal-to-noise ratio (SNR) of AMFD-ACC was low, and N1 amplitudes did not correlate with speech-in-noise performance. We found a significant correlation between behavioral AMFD thresholds and speech-in-noise scores, as well as between AMD-ACC N1 amplitude and speech-in-noise scores.

Conclusion: Our study highlights the potential of using ACC to assess TEM encoding and predict speech recognition in a more objective manner, even in patients who are unable to provide active feedback. AMD-ACC and AMFD-ACC hold potential as clinically applicable measures, although the SNR of AMFD-ACC needs to be improved through more repetitions, better EEG amplifiers or invasive EEG electrodes.

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S7

Measuring listening effort using the P300 auditory evoked potential within young and older adults

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Question: Speech understanding is an auditory-cognitive process. In adverse listening conditions, more demands are placed on these cognitive functions. This expended cognitive effort has been defined as listening effort (LE). To physiologically determine LE, event-related potentials are of major interest due to a great temporal resolution [1]. Given limited research, this study aimed to investigate differences in P300 amplitudes, P300 latencies, and N1-P300 interpeak intervals between different listening conditions in young and older adults, as potential physiological measures of LE.

Methods: Thirteen young adults (mean age: 25.15 years, range: 19-29 years) and 13 older adults (mean age: 58.69 years, range: 51-80 years) with age-appropriate hearing were included. The P300 was recorded at Fz, Cz, and Pz, referenced to the tip of the nose, using an auditory two-stimulus oddball paradigm with the numbers 'three' and 'one' as standard and deviant stimuli, respectively. The P300 was conducted in two quiet (65 dB SPL and 69 dB SPL) and two noisy (SNR 0 dB SPL and SNR +4 dB SPL) listening conditions. N1 amplitude and latency of the standard and deviant waveforms served as measures of detection ability, whereas P300 amplitude, P300 latency, and the N1-P300 interpeak interval of the deviant waveform served as potential physiological measures of LE. Based on normal distribution, parametric analyses were used for P300 amplitudes, while non-parametric analyses were used for P300 latencies and N1-P300 interpeak intervals. To assess the effects of the different listening conditions on the outcome variables, a Repeated Measures ANOVA and Friedman Test were conducted. Effects of age group on each of these variables were investigated using a One-Way ANOVA and Kruskal-Wallis test.

Results: Visual inspection of the standard and deviant waveforms showed reliable N1 and P300 responses. A significant increase in P300 amplitude and latency, as well as in N1-P300 interpeak interval was found between the two quiet listening conditions on the one hand, and the noisy listening conditions on the other hand. A group effect was found in all listening conditions, showing significantly smaller amplitudes, prolonged P300 latencies, and prolonged N1-P300 interpeak intervals for the older adults.

Conclusions: Results revealed a statistically significant increase in P300 amplitude, P300 latency, and N1-P300 interpeak interval as the listening condition became more taxing. Moreover, a significant group effect was found for all outcome measures, favoring young adults. Based on these results, the P300 was considered a potential physiological measure of LE. Given the influence of advancing age on both hearing status and cognitive functioning [2], our research group is conducting more research in normal-hearing and hearing-impaired adults.

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S8

Effects of Mouth Movements on Speech Intelligibility in Naturalistic Audiovisual Environment

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Keywords: audiovisual, electroencephalography, eeg, temporal response functions, trf, virtual environment

Background: Current methods of measuring speech intelligibility do not adequately address real-life scenarios. To address this, we propose a more realistic approach by combining two recently published methods. The first method is the Objective Measure of Speech Intelligibility (OMSI), which utilizes electroencephalography (EEG) to record brain responses to speech [1]. The OMSI can be described as a measurement of neural tracking to speech. The second method is the Audiovisual True-to-life Assessment of Auditory Rehabilitation (AVATAR), which employs virtual reality to immerse individuals in realistic environments while behaviorally assessing their speech intelligibility [2]. We have coined the combination of these two methods as the Audiovisual Realistic and Objective Measurement for the Intelligibility of Speech (ARTOMIS). In this study, our aim was to objectively evaluate the impact of mouth movements on speech intelligibility using ARTOMIS.

Methods: In this study, we recruited 20 native Dutch-speaking participants. We conducted an experiment where the participants listened to a set of standardized Dutch sentences while their brain activity was recorded using EEG (electroencephalography). The sentences were presented at different levels of background noise, resulting in five different signal-to-noise ratios (SNRs) ranging from complete silence to -9 dB. We employed two experimental conditions: audio-only (AO) and audiovisual (AV). In the AO condition, the sentences were presented without any accompanying mouth movements from the virtual avatar. In the AV condition, the virtual avatar displayed synchronized mouth movements with the sentences. To analyze the collected EEG data, we utilized a linear model known as the Temporal Response Function (TRF). This model allowed us to examine the linear relationship between the recorded brain activity and a specific feature of the speech that was heard by the participants.

Results: We compared the temporal response functions (TRFs) between the auditory-only (AO) and audiovisual (AV) conditions and observed a higher level of neural tracking for AV stimuli compared to AO stimuli. Additionally, we found that as the signal-to-noise ratio (SNR) level decreased, neural tracking decreased as well. However, the rate of decrease was less pronounced for the AV condition compared to the AO condition.

Conclusion: The goal of this study was to investigate the effects of mouth movements on speech intelligibility within a realistic, audiovisual environment. We found that the presence of mouth movements improves speech intelligibility, as evident in both behavioral assessments and objective measurements using EEG. For our future research, we aim to explore the feasibility of integrating ARTOMIS into clinical settings to improve the evaluation of speech intelligibility through objective measures.

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S9

Platinum- induced ototoxicity: potential bio-markers of cochlear synaptopathy

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Background: For a number of solid malignancies, platinum-derivates are the backbone of treatment. Although cisplatin is a highly effective anti-cancer drug, adverse effects such as ototoxicity or neurotoxicity can sometimes limit its use. The incidence of cisplatin-induced ototoxicity has been estimated to range between 40 and 80%, resulting in bilateral permanent or sometimes progressive sensorineural hearing loss (SNHL) and tinnitus [1]. Carboplatin has long been considered less ototoxic than cisplatin. Reports on the incidence of carboplatin-induced hearing loss range from 7% to 15% when evaluated with pure-tone audiometry. However, recent animal-research studies have shown that carboplatin induces selective damage to the inner hair cells (IHCs) and auditory nerve fibers (ANFs), i.e., cochlear synaptopathy or hidden hearing loss [2]. Patients report tinnitus and a decreased ability to understand speech in a noisy environment. Despite the recent progress in diagnostic CS markers, the presence of CS after ototoxic cancer treatments has not yet been thoroughly investigated. The aim of this study is to evaluate the impact of chemotherapy (cis- and/or carboplatin) on audiological tests including auditory evoked potential (AEP) markers of CS.

Methods: Twenty-five patients (mean age 57,37 years ± 11,35 standard deviation, 34-74 years) treated with cis- and/or carboplatin were tested at the University Hospital Ghent. Patients were divided into three groups: fourteen patients received cisplatin (Cis), seven patients received carboplatin (Carbo) and four patients received a combination of cis- and carboplatin (Cis+Carbo). Patients underwent a baseline measurement (before starting chemotherapy) and a follow-up measurement after the first cycle of chemotherapy. This first cycle is patient specific and can consequently contain a different dose (mg/m^2) of chemo.The test battery included pure-tone audiometry (PTA) at conventional and extended high frequencies (EHFs), distortion product otoacoustic emissions (DPOAE), speech-in- noise tests (Flemish Matrix Test) and supra- threshold AEPs, i.e. auditory brainstem response (ABRs) and envelope following responses (EFRs). EFRs were recorded to a rectangularly amplitude modulated (RAM) pure tone with a carrier frequency of 4 kHz.

Results: Linear mixed models across all patients showed a significant difference ($p<0.05$) between baseline and follow-up for the pure-tone audiometric thresholds at 8 kHz and 12.5 kHz. No significant differences were found for the speech reception threshold (SRT) of the broadband filtered speech-in-noise. The DPOAE amplitude or EFR magnitude showed no significant differences between baseline and follow-up. For none of the audiological variables, a significant difference between baseline and follow-up was found when the three groups were analysed separately. Visual representations suggest higher pure-tone thresholds, worse SRTs, lower DPOAE amplitude responses and smaller EFR magnitude at the follow-up measurement, and this is given by that some subjects had greater effects than others. We are further investigating whether the individual damage relates to the baseline hearing status and/or cumulative dose.

Conclusion: We evaluated changes in audiological variables between baseline and follow-up measurements for patients treated with cis- and/or carboplatin. Our test battery included a non-invasive marker to evaluate the impact of chemotherapy on the synapse between the IHCs and the ANFs. The group analysis (Cis, Carbo, Cis+Carbo) did not confirm that carboplatin only affects the IHC/ANF structures, as was priorly concluded in animal research. Our human data showed individual differences in both audiological thresholds and EFR magnitude after treatment. Our study is important with respect to ototoxicity monitoring during chemotherapy, and can help to diagnose and mitigate potential adverse effects of chemotherapy on hearing.

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S10

Music festivals: The effect of recreational noise exposure on young adults hearing

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Keywords: Recreational noise exposure, dosimeters, young adults, electroencephalography, Auditory synaptopathy

Background: Noise exposure in young adults mainly takes place during leisure time activities, of which concerts and festivals have been reported as the loudest. A possible result of excessive noise exposure is a temporary threshold shift or "TTS". While TTSs caused by noise exposure were previously believed to be innocuous, animal studies revealed that TTSs can produce a permanent loss of up to 50% of synapses between cochlear inner hair cells and auditory nerve fibers, without widespread hair cell loss. This synapse loss has been named cochlear synaptopathy, and potentially contributes to the origin of tinnitus and hyperacusis. Suprathreshold auditory evoked potentials are promising measurements to diagnose cochlear synaptopathy in humans, as high-threshold auditory nerve fibers have been shown to be most vulnerable to noise damage. The objective of the current study was to evaluate the effects of recreational noise exposure on young adults hearing, by evaluating the subjects hearing status before and after attending a music festival.

Methods: A group of 42 young adults with normal audiometric thresholds, attended a music festival in summer 2022. Personal exposure was objectively monitored by the use of dosimeters, and auditory status was evaluated before going to the music venue and again at one, and three days after the event. In case of persisting damage, an additional test session was conducted two weeks post-exposure. Every session, the subjects completed a questionnaire and a test battery of (extended high frequency) audiometry, distortion product otoacoustic emissions (DPOAEs), and auditory evoked potentials, comprising auditory brainstem responses (ABR) and envelope following responses (EFR).

Results: Exposure on the festivals reached equivalent continuous sound pressure levels (LAeq) and peak sound pressure levels (LCPeak) up to 104.8 dBA and 143.5 dBC, respectively. The mean exposure duration was nine hours and 31 minutes. Although a TTS, as defined by OSHA-standards, was found in only one subject, deteriorations of 10 dB or more at other frequencies were found in several subjects. Preliminary data analyses, based on 95% confidence intervals taking into account the mean and standard deviation of each individual measurement, showed a significant deterioration in EFR-strength in 20% and 27% of the subjects on the frequencies 4 and 6 kHz, respectively. Extensive data analysis in which objective sound level measures, in addition to all test parameters of extended high frequency audiometry, DPOAEs and ABR are evaluated before and after attending a music festival both on individual and group level, will be presented at the congress.

Conclusion: This study makes a valuable contribution at both collective and individual preventative level. Firstly, these results contribute to the formulation of exposure guidelines, as well as the clinical application of EFRs, as an early indicator of hearing damage. Secondly, this study provides important contributions on the individual level where one should continue to sensitize the festival attendee about the possible consequences of noise exposure at such events, in addition to the correct use of hearing protection.

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S11

Comparison of newborn hearing screening program results in different periods

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Objectives: To evaluate the results of the newborn hearing screening program in consecutive three periods (from 2004 to 2009, 2010 to 2014, and 2015 to 2020) using automated auditory brainstem response (AABR) with a confirmation method using click auditory brainstem response (ABR) at a single tertiary care medical center.

Methods: A retrospective chart review was conducted to evaluate the AABR results of healthy newborns born at our facility over a period of time, identify "refer" instances, and validate the ABR test and follow-up test results. Infants were deemed to have impaired hearing if their ABR thresholds during the diagnostic tests were higher than 30 dB nHL. It was examined how much had changed between the initial diagnostic and follow-up tests based on the graded hearing level. According to the ear with greater hearing, the severity of the bilateral hearing loss was evaluated.

Results: Within the three time periods, there were 12,193, 11,383, and 12,239 healthy births, respectively. 10,879 (89.22%), 10,529 (92.50%), and 11,181 (91.36%) individuals underwent AABR. They included 148 (1.36%), 75 (0.71%), and 121 (1.08%) patients who displayed the "refer" results. In each period, diagnostic ABR was carried out in 117 (79.05%), 66 (88%), and 81 (66.12%). 45 (38.46%), 32 (48.48%), and 39 (48.15%) of the participants who were classified as "refer" in the AABR were found to have an abnormal hearing in the diagnostic ABR, respectively. The frequencies of abnormal hearing were estimated to be 3 to 4 per 1000 healthy live births and were 0.41%, 0.30%, and 0.35% of all healthy newborns. Follow-up tests were performed on 34 (75.6%), 26 (81.3%), and 25 (64.1%) of the individuals who had impaired hearing at the diagnostic ABR, and 11 (32.4%), 4 (15.4%), and 8 (32%) were later found to have bilateral normal hearing.

The screening rate for AABR over three periods was 91.17%, while the referral rate for AABR was 1.06%. 76.74% of them had diagnostic ABR testing, and 43.94% of them displayed abnormal hearing. At follow-up examinations, 27% of those with diagnostic ABR-impaired hearing were found to have bilateral normal hearing.

Conclusions: Three periods were used to examine the 17 years of newborn auditory screening experience. It was proven that the referral rate was constant over all time periods. There is a need to check and address the underlying causes in the future to prevent follow-up loss since the diagnostic ABR rate and follow-up test rate in the most recent period were lower than in prior periods.

Keywords: newborn hearing screening program, auditory brainstem response (ABR)

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Student Poster

SP1

Evaluation of binaural interaction in SSD CI users based on the calculated binaural interaction component of auditory brainstem responses

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Keywords: electric/ acoustic evoked auditory brainstem response, binaural interaction component, SSD CI

Background: In single sided deaf cochlear implant (SSD CI) users a relatively large interaural mismatch between intracochlear positions for electrical and acoustic stimulation was identified and reducing this mismatch was suggest to improve binaural processing [1]. The auditory brainstem response (ABR) and the electrically evoked ABR (eABR) can be used to objectify neural processing in the auditory brainstem of acoustic hearing subjects and bilateral CI users, respectively.

Methods: In research, the binaural interaction component (BIC) is often used to investigate existing binaural processing. It is calculated by the subtraction of the sum of the unilaterally acoustically or electrically evoked ABRs (left and right) by the binaurally evoked (e)ABR. The BIC is difficult to derive reproducibly in normal-hearing subjects [2]. In contrast, Hu and Dietz (2015) showed that in bilateral CI users BIC can be derived more robustly. In the current study, we recorded both ABR and eABR to calculate BIC in SSD CI users. To find electrode/frequency pairs allowing for place-matched stimulation, intracochlear electrode locations were analyzed based on Digital Volume Tomography (DVT) scans. Further, amplitude and stimulation timing [4] were balanced for recordings.

Results: Results showed reproducible BICs in three out of seven SSD CI users. In those subjects with identifiable BIC, (e)ABRs were also recorded for stimulation on intracochlear electrodes adjacent to the anatomically matched one revealing a decrease in BIC in most cases.

Conclusion: These recordings reveal an alteration of BIC the larger the intracochlear distance and thus the larger the interaural place-of-stimulation mismatch gets. Concluding, BIC can be an objective biomarker for binaural processing in a subset of SSD CI users.

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SP2

Investigating Latency Differences between ASSRs of Adults and Children with Normal Hearing

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Keywords: phase delay, electroencephalography, auditory-steady-state responses, maturation

Question: Speech is a highly dynamic signal, and it is characterized by the temporal envelope (TE) and temporal fine structure (TFS) cues [1]. Temporal envelope modulations are important for speech perception and the neural synchronization to these modulations can be tested using auditory-steady-state responses (ASSRs) [2]. ASSRs are auditory evoked potentials elicited with modulated sounds [3]. The latencies of ASSRs refer to the time between the presentation of the auditory stimulus to the generation of the steady-state response. ASSRs vary in latency based on modulation frequency [4] and age [5]. In our study, we chose the 40-and-80 Hz modulation frequencies because the locations of neural generators are potentially different. Adult data show that latencies derived for these two modulation frequencies yield cortical and brainstem neural generators, respectively [6]. However, age-related changes in latencies for these two modulation frequencies have not been determined for school-aged children. This study aims to investigate ASSRs' latencies in adults and children with normal hearing to determine potential maturational changes related to different modulation frequencies.

Methods: The study is being conducted on participants with normal hearing aged 18-25 and children aged 6-14 years. The white noise, centered around 1 kHz, is presented at varying modulated frequencies (37-40-43 Hz and 77-80-83 Hz) with 64-channel electroencephalography (EEG). The purpose is to determine the latencies from the phase delays. Each participant is presented with 300 epochs for each stimulus separately and bilaterally while watching a silent subtitled movie. This is repeated for 18 different scenarios (6 modulation frequencies x 3 sides of stimulation). The total testing time is 2 hours.

Results: Measurements are still ongoing and the data will be presented at the symposium.

Conclusions: It is not possible to draw solid conclusions until more data has been collected.

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SP3

Reduced Auditory Nerve Phase-locking in Healthy Older Listeners Measured with Electrocochleography

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Question

The frequency following response (FFR) is an electrophysiological potential that reflects synchronized neural activity, phase-locked to the fine structure of auditory stimuli. Amplitudes of brainstem FFRs have been shown to reduce with advancing age, even in cases where hearing thresholds remain clinically normal. This reduction has been attributed to desynchronized neural activity at the brainstem's "central" processing stages. Nevertheless, recent computational modeling work suggests that early degeneration at the level of the auditory nerve (AN) could explain the reduction observed in the central FFR. If the age-related reduction of AN fibers is driving reductions in brainstem FFRs, it would present the possibility of using the FFR as a diagnostic tool for quantifying AN degeneration. However, it is first necessary to compare responses to the same acoustic stimuli simultaneously recorded from the auditory nerve (i.e., AN neurophonics, ANN) and the brainstem (i.e., FFR) in both younger and older participants.

Methods

We recorded electroencephalographic potentials from 28 participants, including 14 young and 14 older individuals with near-normal hearing thresholds. Peripheral potentials were measured using a tympanic membrane (TM) electrode, while traditional brainstem responses were recorded simultaneously. We derived auditory brainstem responses (ABRs) and compound action potentials (CAPs) from 100-µs clicks at 115.5 dB ppeSPL. Additionally, we obtained FFRs and ANNs from 10-ms pure tone bursts at 0.5, 1, and 3 kHz and 250-ms tone bursts at 0.5 and 1 kHz presented at 100 dB peSPL and 85 dB SPL, respectively. The stimuli were presented with alternating polarity at 12/s and 2/s presentation rates, for the clicks and short tones, and longer tones, respectively.

Results

Age-related reductions were observed in FFRs to the 250-ms tone bursts in both recording montages, with a similar decrease in isolated peripheral responses and scalp-recorded FFRs. CAP amplitudes were reduced in older participants, while no age-related effects were found in ABR wave-V amplitudes. The ANN response (TM-to-mastoid montage) to 10-ms tone bursts exhibited significant reductions at 1032 and 3096 Hz. Peripheral responses to 3096-Hz tones, which mainly reflect hair cell activity (cochlear microphonic, CM), were over 10 dB smaller compared to responses at 516 and 1032 Hz, suggesting minimal contamination of ANN responses (516 and 1032 Hz) by the CM.

Conclusions

We observed reduced ANN and CAP amplitudes in older normal-hearing participants with TM electrode recordings. FFRs recorded using a classical brainstem montage were similarly reduced, but not ABR wave V. We suggest that the reduction in scalp brainstem FFRs is driven, at least in part, by age-related degeneration of the level of the AN, deeming the FFR as a potential biomarker of AN damage.

SP4

Electrocochleographic Patterns and Hearing Preservation During the Initial Year of Cochlear Implant Use

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Question: Intracochlear electrocochleography (ECochG) responses in cochlear implant (CI) users with residual hearing can provide valuable information regarding the hair cell and neural health surrounding the recording electrodes at different regions in the cochlea [1]. When a low-frequency acoustic stimulus is used, the highest ECochG amplitudes are expected at the most apical electrodes, due to the close proximity of these electrodes to the tonotopical region of the characteristic frequency. However, patterns with maximal amplitudes in the more basal regions of the cochlea have been reported [2]. Assumptions were made that due to contact between the basilar membrane (BM) and the electrode array, acoustic energy is focused close to this fixation [3]. We hypothesize that the contact between the BM and the electrode array could set off an inflammatory process within the cochlea and affect the cochlear health. The aim of this study is to investigate how different ECochG patterns correlate with residual hearing changes in the initial year following CI surgery.

Methods: Adult subjects with residual acoustic hearing undergoing CI surgery at the University Hospital of Zurich were included in this study. ECochG responses to 500 Hz tone bursts were recorded with different electrodes of the electrode array at three different time-points: intraoperatively after full CI electrode array insertion, between four and twelve weeks postoperatively, and after one year of CI activation. Pure Tone Audiometry (PTA) was performed preoperatively, approximately six weeks post-surgery, and after one year of CI activation.

Results: Preliminary results show that intraoperative atypical ECochG peak patterns, with a maximum in the more basal region, remain stable after six weeks and one year after implantation. Residual hearing was reduced six weeks after implantation but no further reduction was measured after one year in patients with a more basal peak pattern.

Conclusions: More basal ECochG peak patterns can indicate a possible fixation of the BM, and can lead to a reduction in residual hearing within first 6 weeks following cochlear implantation. However, it does not necessarily lead to changes of cochlear health or further deterioration of acoustic hearing thresholds after one year of CI use.

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SP5

Cortical Auditory Potentials Evoked by Changes in Interaural Phase Difference

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Background: Binaural hearing plays a crucial role in improving speech understanding in complex listening scenarios. Understanding its functional principles and neural correlates not only contributes to fundamental auditory research but also has practical implications for the development of clinical diagnostic tools. The Acoustic Change Complex (ACC) (e. g. [1]) can be used to assess binaural hearing. It is a cortical P1-N1-P2 complex elicited by changes that occur during an ongoing acoustic stimulus. Ross et al. (2008) used dynamic changes in the interaural phase difference (IPD) and reported a decreasing ACC when increasing carrier frequency from 500 to 1000 Hz and above in young individuals with normal hearing. However, the frequency region between 500 and 1000 Hz, which is associated with minimum interaural time difference thresholds [2], has not been investigated using this or similar paradigms. It remains unclear if the ACC is indeed monotonically decreasing or if a maximum exists between 500 and 1000 Hz. Additionally, Ross (2008) reported an asymmetry in responses between IPD changes from an IPD of 0° to 180° and vice versa. However, the underlying mechanisms of this asymmetry have not been investigated yet and will be addressed in this study.

Methods: Thirteen young normal hearing subjects participated in the study. Sinusoidally amplitude modulated tones with a starting IPD of 0° and carrier frequencies of 250, 500, 750, 1000, and 1250 Hz were used. The amplitude modulation frequency was 40 Hz for all stimuli. The stimuli contained eight IPD changes from 0° to 180° and vice versa every 400 ms, starting 800 ms after stimulus onset. To evaluate the dependence of the change responses on the relative order of IPD changes, an additional measurement was conducted with a 500-Hz tone, where the stimuli had an IPD of 180° at onset. Subsequently, the IPD changes in the modulated segment of the stimulus were in reverse order relative to the conditions where stimuli were diotic at onset.

Results: ACCs were observed for frequencies up to 1000 Hz and showed an inverse U-shaped frequency dependence. A consistent response asymmetry manifesting as larger responses to changes from an IPD of 0° to 180° than vice versa was observed for all frequencies at which change responses could be measured. This asymmetry persisted even when the contributions of the first IPD changes in each trial were excluded from the averaged waveforms. The asymmetry in change responses was also observed in the condition where the initial IPD was 180°. Similarly, stimuli that had an initial IPD of 180° evoked a larger N1 magnitude at sound onset than stimuli that were diotic at sound onset.

Conclusion: The frequency dependence of the ACC was found to be in line with expectations based on the binaural dominance region [2]. The observed change response asymmetry cannot be attributed solely to the fact that the magnitude of the change responses to the initial IPD change tends to be larger than the responses to subsequent IPD changes. Instead, they are consistent with previous studies that show increased response magnitudes for changes from point-like spatial percepts along the auditory midline to spatially diffuse percepts than vice versa [3].

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SP6

An electrophysiological version of the Audible Contrast Threshold (ACT™) test: Correlation to HINT and behavioural ACT as well as test-retest differences

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Keywords: acoustic change complex, spectro temporally modulated stimuli, audible contrast threshold test; auditory evoked responses.

Background: The Audible Contract Threshold (ACT) is a suprathreshold psychophysical diagnostic test that measures the discrimination threshold of speech-like spectro-temporal modulations using a band-limited noise carrier on which a temporal modulation of 4 Hz and a spectral modulation of 2 cycles/octave are imposed. The ACT test requires active participation from the patient; thus, it is not possible to test young children or the hard-to-test populations. This would, however, be possible with an electrophysiological version of the ACT test.

Methods: Here, we propose an electrophysiological version of the ACT test using a paradigm based on the Acoustic Change Complex (ACC), which is a cortical response elicited by a change in an ongoing sound. ACC responses to ACT-like stimuli were obtained from adult listeners where audibility was ensured by ear-and-frequency-specific compensation.

The E-ACT threshold was estimated by means of a seeking procedure; ACC recordings were first obtained at the easiest level at 16 dB nCL (full modulation) and after a response the contrast level was halved to 8 dB nCL. After each successive response, the contrast level was again halved, while in cases of no response the contrast level was increased by the same step-size. A test run came to an end when either a step-size of 1 dB or the time constrain was reached. The detection of a response was performed online, and it compromised artefact rejection (epochs with amplitudes exceeding 50 µV were rejected), bandpass filtering, and the statistical analysis used to decide if a significant response was present. Two separate threshold-defining-runs were carried out to allow for an investigation of test-retest differences. Following data collection, a final offline analysis including eyeblink removal was carried out.

Furthermore, a prediction of speech-in-noise abilities measured with the behavioural ACT test will be measured together with speech-in-noise abilities assessed directly with a modified, more ecologically valid version of the Danish Hearing in Noise Test (HINT) where two competing talkers are presented from separate loudspeakers at +/- 135° with low-level speech-shaped noise mixed in.

Results: Test-retest difference of E-ACT is presented together with a correlation to the behavioural ACT test as well as a correlation to HINT.

Conclusion: Results will clarify the applicability of the E-ACT test and reveal potential further needs for research.

SP7

Longitudinal EEG potentials (VEP) evoked by visual pattern reversal as an outcome prediction marker for cochlear implant users

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Background: Cross-modal plasticity occurs in the deaf population due to deprived sense of hearing. The issue of either adaptive or maladaptive effects of the cross-modal plasticity on cochlear implant (CI) recipients is still on debate, highlighting the need of closer look at long-term modal-specific changes in CI users. Vision, for instance, might have been enhanced as a compensation of lost hearing. In the current study, we hypothesized that greater dependence on vision would impede auditory processing and slow down the improvement in speech intelligibility.

Methods: We compared EEG visual potentials evoked by pattern-pattern reversals (VEP) in two CI recipients longitudinally (before implantation, at 3, 6, 12 and 18 months after CI) focusing on the latency of N1 and the absolute amplitude of the N1-P2 complex along with speech intelligibility. The study prospectively included 2 adult CI recipients who received Cochlear (Lane Cove, Australia) CI622 implants. Scalp EEG were recorded longitudinally up until 18 months at 5 time points using CURRY 7 software and a SynAmps2 amplifier (Compumedics, Neuroscan, Charlotte, NC, USA) from whole brain 64 Ag/Cl electrodes. A pattern-pattern reversal VEP was elicited using two different achromatic black-white checkerboards with an inter-trial-intervals of 600 msec, totaling 400 trials. Artefacts associated with CI electrical stimulation and eye-movement were minimized using an independent component analysis and thresholds on amplitude and slope.

Results: All the patients (mean age 32.5 years) revealed gradual enhancement in speech intelligibility and gradual decrease in VEP amplitude and latency. However, the good performer revealed faster entrance to the phase of decrease both in latency and amplitude unlike the poor performer. Furthermore, the correlation analysis revealed that the speech score was negatively correlated with VEP amplitude (r = -0.971, p < .001) and with VEP latency (r = -0.780, p=0.008).

Conclusion: Based on the results of this study, we speculate that the enhancement of speech intelligibility in CI recipients are strongly related with their vision processing patterns, as evidenced in our correlation results. Efficient use of vision is suggested to contribute to enhanced speech processing decreasing the visual dependence. Our results offer new perspectives on cross-modal plasticity in deaf population and contribute to the development of prognosis and rehabilitation for CI recipients.

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SP8

The impact of speech rate and target word intensity on speech processing and listening effort in background noise in older listeners

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Keywords: P3, N4, listening effort, speech in noise

Background: Older listeners often have difficulty with speech perception, particularly in background noise This difficulty may be driven by numerous variables, including age-related hearing loss, and a decline in higher-level cognitive processing. This difficulty with speech perception leads to the need for listeners to use a great deal of effort when listening to speech. The overall aim was to examine the effects of speech rate and target word intensity on speech perception (measured behaviorally), speech processing (measured using event-related potentials), and listening effort (measured using subjective questionnaires as well as a dual-task paradigm) in older adults and older adults with hearing loss.

Methods: This study is ongoing. To date, 10 younger adults (mean age: 28.60 years, SD: 3.84) and 18 older adults (mean age: 67.28 years, SD: 4.92) have participated. The younger participants had normal hearing sensitivity between 250 and 8000 Hz. The older participants had normal hearing sensitivity through 1000 Hz and had up to mild to moderate hearing loss in higher frequencies. All older participants passed the MMSE cognitive screening test. Conversations focused on three different topics (food, animals, locations) were presented in a background of restaurant noise at 0 SNR. Each conversation contained target words with high or low expectancy. A slow condition was created using 50% time expansion. An intensity-enhanced condition was created by increasing the intensity of target words by 6 dB SPL. A dual-task paradigm was used to measure listening effort and perceived effort was evaluated using the NASA Task Load Index. Event-related potentials were recorded simultaneously with the dual-task paradigm and P3 and N4 were obtained.

Results: For the target word identification task, reaction times (RT) in the intensity-enhanced condition were shorter compared to the unprocessed condition, but more so for younger adults. RTs increased in the slow condition, but for low expectancy targets, the slowing was much greater for older adults. Percent correct target identification was relatively unchanged as a function of condition in younger adults; however, in older adults, percent correct performance increased in the intensity-enhanced condition for both high and low expectancy targets. For the NASA task load index, listening effort dropped in the intensity-enhanced condition for both groups but increased in the slow condition. Frustration ratings decreased only for the younger group. For ERP data, in the intensity-enhanced condition, P3 and N4 amplitude increased and latency decreased relative to the unprocessed condition for younger adults; however, for older adults, N4 (but not P3) amplitude increased and latency decreased. In the slow condition, P3 and N4 were shorter in latency, but smaller in amplitude compared to the unprocessed condition.

Conclusion: These preliminary results suggest that increasing target word intensity aids in the perception and processing of speech, particularly for low expectancy targets; however, slowing the rate of speech does not, at least for the stimuli used in this study. These objective findings were accompanied by perceived drops in listening effort. Although we have not yet examined the impact of hearing loss separately from age, from inspection of the data, we anticipate that the combination of age and HL on processing and perception will be greater than either factor alone.

SP9

The impact of hearing loss on attention network tests among older individuals: An event related potential study

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Keywords: attention networks, ERPs, hearing loss, executive attention, older individuals.

Background: Hearing loss is one of the most common non-communicable conditions affecting millions worldwide. Research has shown the interference of hearing loss on a person"s quality of life and cognitive functioning. Attention is one such core cognitive domain crucial in facilitating day-to-day life. Using an attention network test (ANT) along with event-related potentials (ERPs) in older individuals with hearing loss would provide excellent information about the impact of hearing loss on attentional processes. Thus, the current study aims to understand attentional deficits and their cortical dynamics in older individuals with and without hearing loss.

Methods: A total of 392 older individuals aged 60 to 80 years were screened, resulting in the recruitment of 40 potential participants for the study. The current study had two groups, group 1 had 20 individuals with mild to moderate sensorineural hearing loss, and Group 2 had 20 age and education-matched controls with normal or near-normal hearing sensitivity. All the participants underwent cognitive tests with simultaneous 32-channel EEG Recording. The testing was done in a dimly lit, sound-treated room with comfortable participant seating.

Results: Electrophysiological measures revealed significant main effects of group and cue condition on N100 amplitude, reflecting the differences in alerting and orienting effects. on P300 amplitude, results showed significant main effects of group and flanker conditions suggesting differences in executive attention network among groups. In behavioral measures, results revealed longer reaction time in individuals with hearing loss compared to their normal hearing counterparts. In attentional network scores, the hearing-impaired group showed poorer scores in executive control networks only. In addition, correlation analysis showed significant associations between PTA, SNR loss, and executive attention scores.

Conclusion: Our study provides compelling evidence of impaired executive attention in older individuals with hearing loss. In addition, subtle dysfunction in alerting and orienting networks is also reported in older individuals with hearing loss. The outcomes indicate compromised cognitive processes due to hearing loss. Additionally, our study highlights the crucial role of hearing sensitivity measures in executive function impairments in older individuals. The study suggests that hearing loss could independently lead to attention deficits in older individuals despite their age and education.

SP10

Auditory cognitive and sensory load modulate neuronal oscillatory activity before and after the behavioral response

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Background: Most communication in everyday life takes place in adverse listening conditions. The impact of sensory-perceptual load (i.e., sensory) (e.g., background noise, competing talkers) and auditory-cognitive (i.e., cognitive) load (i.e., task demands related to cognitive functions, such as working memory and attention) on the underlying neural processes during complex listening is not yet clear. The objective was to identify neuronal biomarkers related to both sensory and cognitive loads.

Methods: Electroencephalographic recordings (64 channels) have been obtained from young normal hearing adult listeners (n = 20). Two auditory tasks, a vowel identification task and an auditory Stroop task, were presented in two listening conditions, quiet and noise. Time-frequency representations using wavelet analysis were derived and both evoked and induced responses were analyzed. The time frequency representation of the vowel identification task was compared to the Stroop task (congruent stimuli) to identify the cognitive load effect, while a comparison between the vowel identification task in quiet and in noise, revealed the sensory load effect. Source localization via beamforming was performed on the time-frequency activity of interest to identify the anatomical sources.

Results: Both vowel identification and Stroop tasks evoked responses were observed in the delta-theta band immediately following the onset of the stimulus. Alpha desynchronization and theta and beta synchronizations were observed in the induced power, indicating extensive post-response processing seconds after the behavioral response. Higher sensory load (noise vs. quiet) decreased the evoked theta power, increased the induced activations in alpha-beta frequency band, and further increased the induced theta power after the response. Higher cognitive load (Stroop task vs. vowel identification task) resulted in an increased, long-lasting theta activity.

Conclusion: The present methodology revealed biomarkers of high-level auditory processing during adverse listening conditions in time-frequency domain. The observed activities in time-frequency domain and their brain sources differed between sensory and cognitive loads, suggesting distinct underlying neural processes. The early evoked theta activity was reduced in higher sensory load condition, while in higher cognitive load it was increased. In addition to this finding, the time frequency representation in both loads showed neural activities in the entire observation time, including seconds after the behavioral responds, indicating the ongoing neural processes even when the behavioral response already ended.

*Brilliant and Yaar Soffer contributed equally to the study

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SP11

Comparing Vestibular Evoked Myogenic Potential (VEMP) frequency tuning curves between B71 and minishaker transducers

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Keywords: ocular and saccular frequency tuning curves, bone conduction, minishaker, VEMP, cVEMP, oVEMP

Background: Vestibular Evoked Myogenic Potentials (VEMPs) are used to evaluate the function of the vestibular system through the assessment of otolith organs (1). Frequency tuning is the process of identifying the optimal frequency to produce the strongest response in VEMP tests (2-4). It involves adjusting the stimulus frequency to elicit the largest VEMP. Different simulation methods can be used to obtain the VEMP responses (1). For vibrational stimulation, it is challenging to determine what kind of transducer to use for excitation and which frequency would be most efficient to obtain a VEMP response with a given transducer. The primary aim of this research is to compare the effects of frequency, stimulus polarity, and eye position on VEMPs elicited with B71 and minishaker transducers, to gain insights into similarities or differences in the underlying mechanisms governing these physiological responses.

Methods: The study included 10 participants (5 female/5 male) aged 23-40 with normal hearing, no back/neck problems and no balance complaints. The analyses were made using two stimulation methods (B71 and mini shaker) at four different frequencies (125, 250, 500, and 750 Hz). The effect of changing the stimulus phase was examined. Also, oVEMP responses were evaluated in upward gaze and straight gaze. The analyses include the use of objective measures of response quality using Fsp and Bootstrap methods.

Results: Non-parametric tests (Friedman) tests were used to analyse data. Paired significance was examined with Wilcoxon Signed Rank tests. In addition, Bonferroni correction was applied when making paired comparisons within the group. cVEMP and oVEMP tests using the Bone 71 transducer showed the greatest response amplitude at 500 Hz ($p<.05$), while the minishaker showed the greatest response amplitude at 125 Hz ($p<.05$). The minishaker was affected by the polarity changes at low frequencies such as 125 and 250 Hz. ($p<0.05$). The minishaker and B71 were affected by the gaze position at 125 Hz with maximum output ($p<0.05$).

Conclusion: The present study found that low-frequency mini-shaker elicited oVEMPs exhibit distinct properties compared to high-frequency c- or o-VEMPs. Specifically, low-frequency responses were highly sensitive to changes in stimulus polarity, whereas high-frequency responses were not. This sensitivity was demonstrated by the fact that low-frequency responses were very small with alternating polarity stimuli but were enhanced with single polarity stimulation with minishaker. These results suggest that low-frequency responses mirror the properties of the stimulus in a way that high-frequency oVEMPs do not, and this difference may reflect differences in underlying response mechanisms. Upward gaze position during oVEMP evaluation was found to increase response amplitude, consistent with a physiological response. During the calibration of the stimuli with the B71 and the mini shaker, more output was obtained with the minishaker at low frequencies (125 Hz), but at higher frequencies (500 Hz), the transducers had similar outputs). Indeed the spectral output of the B71 to 125 Hz excitation showed little energy at 125 Hz, so the B71 is not able to stimulate low frequencies in the way that the minishaker can.

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SP12

Use of an electromagnetic actuator as an implantable microphone - first results

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Introduction

Conventional cochlear implants (CI) use external microphones as there is still no optimal solution for a fully implantable microphone. In everyday life, this can have disadvantages in certain situations, for example when the processor has to be removed at night, when swimming, or when wearing a helmet. Systems that can be fully implanted and do not require an external processor could eliminate these disadvantages. Several approaches to implantable microphones have already been investigated, but they still don't reach the performance of external microphone solutions. The actuator (FMT, Floating-Mass-Transducer) of the active middle ear implant Vibrant Soundbridge (VSB; MED-EL, Austria) consists of a mass that oscillates in an electromagnetic field in the core of a coil. Due to this design, it thus has the potential to be used vice versa as a microphone. The aim of this study was to perform initial measurements on the use of the actuator as a microphone.

Material and Methods

Frequency responses were recorded using different types of FMTs (different size and number of coil layers) as a microphone. Based on these results a model was developed for creating a standard German speech understanding test (Freiburger Sprachtest). The test was generated for speech presentation levels of 60 down to 35 dB SPL.

Results

The frequency responses differed slightly across the FMTs and ranged approximately from 300 Hz to 6000 Hz. The optimal sensitivity was obtained between 450 Hz – 1.8 kHz and decreased at lower and higher frequencies. Recordings of two syllables speech-signals were comprehensible for normal hearing subjects down to 40 dB SPL speech level.

Discussion

The FMT as a middle ear microphone is an interesting new potential application. Initial measurements using the FMT as a microphone show a sufficient dynamic and frequency range. The recorded speech signals will be extended to monosyllables and used for speech understanding tests with CI patients to determine the speech intelligibility.

SP13

Patterns of Device Failure among Different Types of Hearing Aids

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Background: Hearing aids are one of the most important and effective auditory rehabilitation methods for patients with hearing loss by amplifying the sound. Currently more than 6.12% of the global population (466 million) suffers from disabling hearing loss, and use of hearing aids are also increasing. The purpose of this study is to investigate the proportion of device failure of hearing aids, especially within one year of use, and differentiate the patterns of device failure among different types of hearing aids.

Methods: We retrospectively reviewed medical data of patients with hearing loss from January 2019 to December 2021 who experienced device failure within one year of hearing aids use. Patients were divided according to the types of hearing aids (Receiver in Canal; RIC, Completely in Canal; CIC, Behind the Ear; BTE), onset of device failure (<6months, ≥6months), and reasons for device failure. Data were statistically analyzed using Pearson's Chi square test and Fisher"s exact test in SPSS.

Results: A total of 2157 patients prescribed with hearing aids (1899 RIC, 161 CIC, 97 BTE) were enrolled in this study. Of these patients, 167 patients (7.7%) experienced device failure within one year (113 RIC, 33 CIC, 21 BTE) and required warranty service. The incidence of device failure within one year differed significantly between RIC and CIC (6.0% vs 20.5%; p<0.001), RIC and BTE (6.0% vs 21.6%; p<0.001). Within 6 months, failure rate of RIC and CIC, RIC and BTE still remained statistically different (2.4% vs 14.9%, 2.4% vs 9.3%; both p<0.001), while between 6 months and 1 year, only RIC and BTE differed significantly (3.7% vs 13.6%; p<0.001). Regarding reasons for device failure, patient negligence significantly accounted for a larger portion of malfunction in CIC type compared to RIC (62.5% vs 35.6%, p=0.04) during the first 6 months, while BTE type overwhelmed CIC in the latter 6 months (66.7% vs 36.8%, p=0.02).

Conclusion: RIC type hearing aids had the least proportion of warranty service requirement compared to the other two types, especially within the first 6 months. As there was higher overall device failure rate due to patient negligence in BTE and CIC compared to RIC, patient education may hold an important role in sustaining device integrity in these types and patient's fine motor skills should also be considered in prescribing hearing aids.

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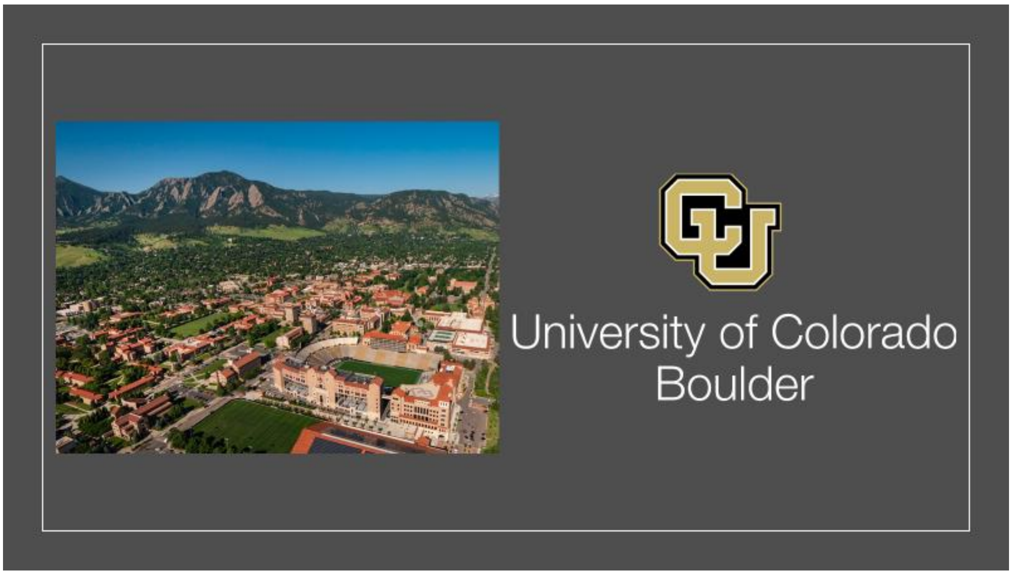
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