ISH 2015

17th International Symposium on Hearing
15-19 June 2015, Groningen, Netherlands

Physiology, Psychoacoustics and Cognition in Normal and Impaired Hearing

university of groningen

umcg

Organisation committee

The organisers are members of the Department of Otorhinolaryngology of the University of Groningen / University Medical Center Groningen:

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Cris Lanting
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The University Medical Center Groningen
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The Groningen Congresbureau is providing logistics support. For more details please contact them at *http://www.groningencongresbureau.nl/en*

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Jellemieke Ekens - *jellemieke@gcb.nl*

Programme at a glance

Time	Sunday 14	Monday 15	Tuesday 16	Wednesday 17	Thursday 18	Friday 19
9:00		Opening				
		Talk 1	Talk 14	Talk 28		Talk 46
10:00		Talk 2	Talk 15	Talk 29	Talk 34	Talk 47
		Talk 3	Talk 16	Talk 30	Talk 35	Talk 48
		Break	Break	Break	Break	Break
11:00		Talk 4	Talk 17	Talk 31	Talk 36	Talk 49
		Talk 5	Talk 18	Talk 32	Talk 37	Talk 50
12:00		Talk 6	Talk 19	Talk 33	Talk 38	Talk 51
		Photo	Lunch	Lunch	Lunch	Closing
13:00		Lunch				Lunch
				Social		
14:00		Talk 7	Talk 20		Talk 39	
		Talk 8	Talk 21		Talk 40	
		Talk 9	Talk 22		Talk 41	
15:00		Talk 10	Talk 23		Talk 42	
		Break	Break		Break	
16:00		Talk 11	Talk 24		Talk 43	
		Talk 12	Talk 25		Talk 44	
		Talk 13	Talk 26		Talk 45	
17:00			Talk 27		Business meeting	
18:00						
	Reception Opening speech Prof.dr. S. Poppema President of the University of Groningen					
19:00		Dinner	Dinner	Gala dinner	Dinner	
20:00	Dinner					
21:00						
22:00						

General information

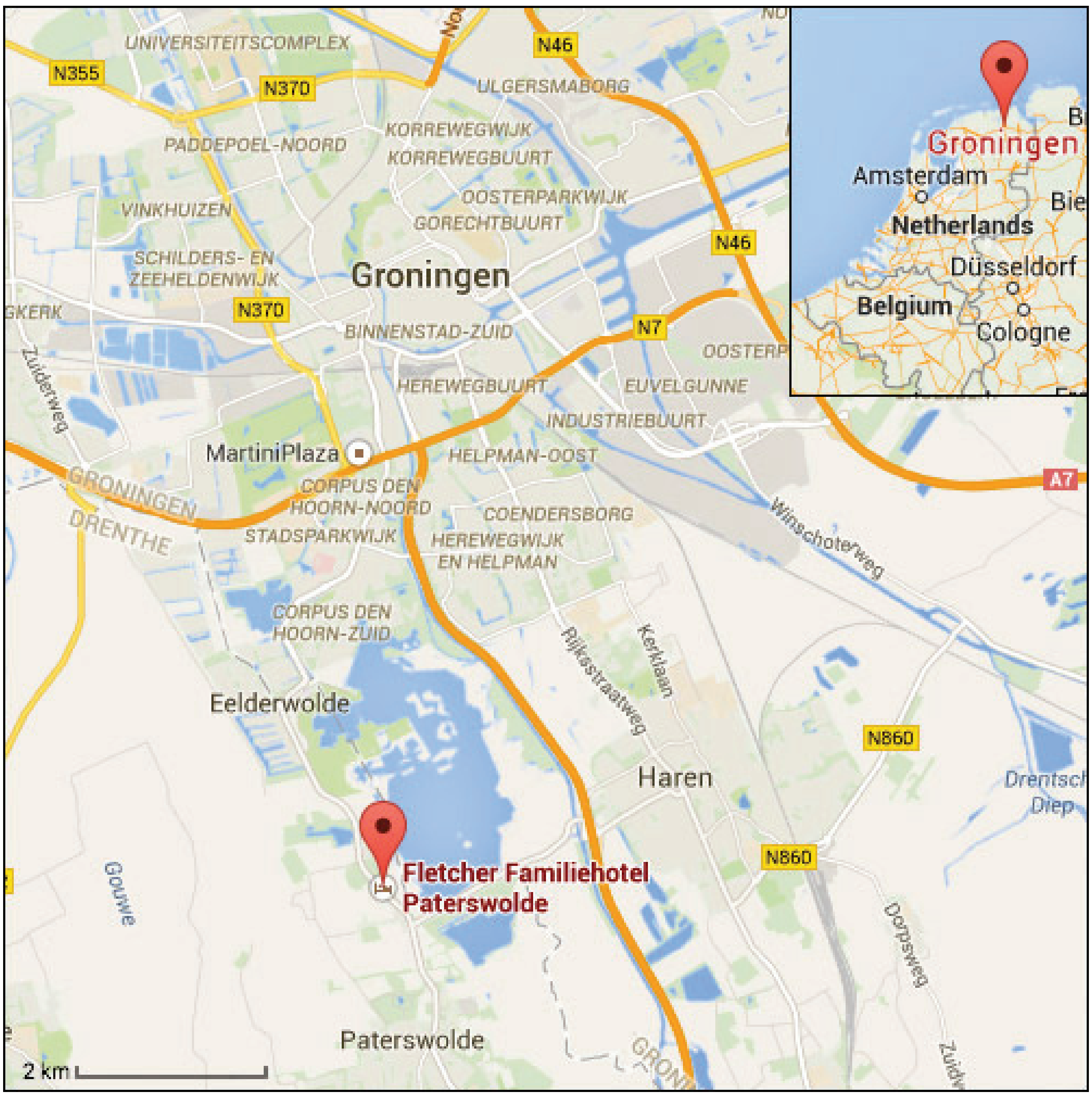
The 17th ISH will be held at the Familiehotel in Paterswolde, near Groningen, from the Monday 15 June to Friday 19 June 2015.

Coming to Groningen

There are direct flights from most big cities to Amsterdam Schiphol (AMS) airport. From there, direct trains to Groningen are available every hour, making the connection in about 2h. The train station in Schiphol is located in the airport itself. Tickets can be bought from machines or cashier in the airport (€26.20 one-way, 2nd class). Check the ns.nl for timetables.

Coming from London, it is also possible to fly directly to Groningen Aiport Eelde from London Southend airport. The company flybe is operating this connection. Eelde is located about 2 km South of Paterswolde.

Finally, it is also possible to fly to Bremen in Germany, and drive or take a coach from there. The ride takes under 2h.



Hotel

The symposium will take place at the Fletcher Familiehotel in Paterswolde. All meals will be served at the Familiehotel except the Gala dinner that will take place at the Prinsenhof. Bikes will be available from the Familiehotel, and going to the city center is a scenic 20 min bike ride along the lake.

Hotel costs are included in the conference fee and rooms can only be booked through the registration process.

From Groningen Central station, the hotel can be reached by taxi or by bus:

Taxi: the ride costs about €25. Taxis are located in front of the station, to the left. In case you have special needs or want to book your taxi, here are contact numbers of a few companies:

Taxi Groningen: +31 50 541 8452
Taxi Noord: +31 50 549 4940
Taxi VTG: +31 50 301 5222

Bus: bus stops are located to the right when exiting the station. Line 2 takes you directly to the hotel, in about 30 min. Tickets cost €2.00 and can be bought in the bus, but you need to have the exact change. Timetables and travelling details can be obtained from Google Maps or from 9292.nl.

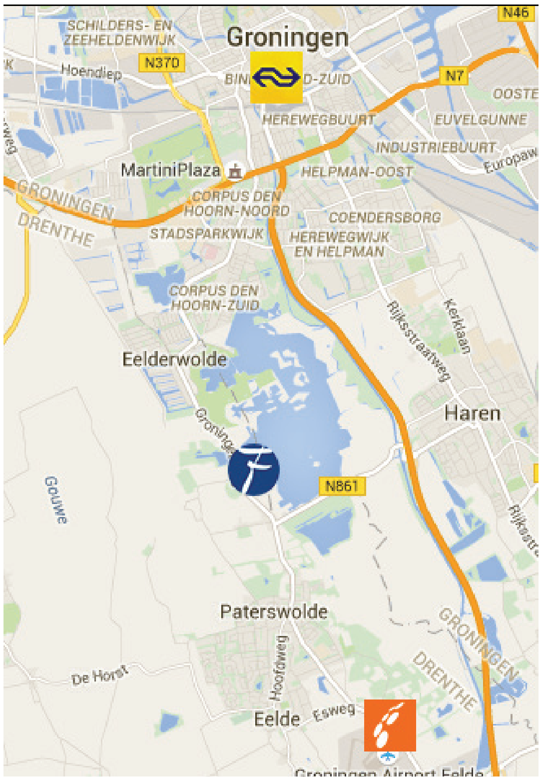
From Groningen Airport Eelde, the hotel can be reached either by taxi, or by bus (line 2).

Here are the addresses of the important locations:

Fletcher Familiehotel Paterswolde
Groningerweg 19
9765 TA Paterswolde

Station Groningen
Stationsplein 26
9726 AE Groningen

Groningen Airport Eelde
Machlaan 14a
9761 KT Eelde



Registration

When you arrive at the Fletcher Familiehotel, please register at the registration desk. There you will receive your name tag a printout of the conference booklet with abstracts and other conference materials.

The registration desk will be opened Sunday 14th, from 17:30h to 19:00h, and Monday 15th from 8:30h to 12:00h.

Linear programme

Session 1, Monday, 09:30 — **chair: Deniz Başkent & Andy Oxenham**

1. Effects of Age and Hearing Loss on the Processing of Auditory Temporal Fine Structure
   B. C. J. Moore

2. Aging Effects on Behavioural Estimates of Suppression with Short Suppressors
   E. Hegland, E. Strickland

3. Contributions of Coding Efficiency of Temporal-Structure and Level Information to the Lateralization Performance in Young and Early-Elderly Listeners
   A. Ochi, T. Yamasoba, S. Furukawa

Session 2, Monday, 11:10 — **chair: Deniz Başkent & Birger Kollmeier**

4. Investigating the Role of Working Memory in Speech-in-Noise Identification for Listeners with Normal Hearing
   C. Füllgrabe, S. Rosen

5. The Contribution of Auditory and Cognitive Factors to Intelligibility of Words and Sentences in Noise
   A. Heinrich, S. Knight

6. Do Hearing Aids Improve Affect Perception?
   J. Schmidt, D. Herzog, O. Scharenborg, E. Janse

Session 3, Monday, 14:00 — **chair: Emile de Kleine & Torsten Dau**

7. Suitability of the Binaural Interaction Component for Interaural Electrode Pairing of Bilateral Cochlear Implants
   H. Hu, M. Dietz, B. Kollmeier

8. Binaural Loudness Constancy
   J. Culling, H. Dare

9. Intelligibility for Binaural Speech with Discarded Low-SNR Speech Components
   E. Schoenmaker, S. van de Par

10. On the Contribution of Target Audibility to Performance in Spatialized Speech Mixtures
    V. Best, C. R. Mason, J. Swaminathan, G. Kidd, Jr., K. M. Jakien, S. D. Kampel, F. J. Gallun, J. M. Buchholz, H. Glyde

Session 4, Monday, 16:00 chair: Emile de Kleine & Olivier Macherey

11. Optimization of a Spectral Contrast Enhancement Algorithm for Cochlear Implants based on a Vowel Identification Model
    W. Nogueira Vazquez, T. Rode, A. Büchner

12. Roles of the Contralateral Efferent Reflex in Hearing Demonstrated with Cochlear Implants
    E. A. Lopez-Poveda, A. Eustaquio-Martin, J. S. Stohl, R. D. Wolford, R. Schatzer, B. S. Wilson

13. Deactivating Cochlear Implant Electrodes Based on Pitch Information for Users of the ACE Strategy
    D. Vickers, A. Degun, A. Canas, T. Stainsby, F. Vanpoucke

Session 5, Tuesday, 09:30 chair: Cris Lanting & Debi Vickers

14. Speech Masking and Masking Release in Normal, Impaired and Electric Hearing: Interactions Between Frequency Selectivity and Inherent Temporal Fluctuations in Noise
    A. J. Oxenham, H. A. Kreft

15. Effects of Pulse Shape and Polarity on Sensitivity to Cochlear Implant Stimulation: a Chronic Study in Guinea Pigs
    O. Macherey, Y. Cazals

16. Assessing the Firing Properties of the Electrically Stimulated Auditory Nerve using a Convolution Model
    S. B. Strahl, D. Ramekers, M. M. B. Nagelkerke, K. E. Schwarz, P. Spitzer, S. F. L. Klis, W. Grolman, H. Versnel

Session 6, Tuesday, 11:10 chair: Bert Maat & Brian Moore

17. Modeling the Individual Variability of Loudness Perception with a Multi-Category Psychometric Function
    A. C. Trevino, W. Jesteadt, S. T. Neely

18. Auditory fMRI of Sound Intensity and Loudness for Unilateral Stimulation
    O. Behler, S. Uppenkamp

19. Tinnitus-related Abnormalities in Brain Networks During Stimulated and Resting States
    C. Lanting, A. Woźniak, P. van Dijk, D. Langers

Session 7, Tuesday, 14:00 chair: Cris Lanting & Elizabeth Strickland

20. The Role of Conduction Delay in Creating Sensitivity to Interaural Time Differences
    C. E. Carr, G. Ashida, H. Wagner, T. McColgan, R. Kempter

21. Objective Measures of Neural Processing of Interaural Time Differences
D. McAlpine, N. Haywood, J. A. Undurraga, T. Marquardt

22. Minimum Audible Angles measured with Simulated Normally-Sized and Oversized Pinnas for Normal-Hearing and Hearing-Impaired Test Subjects
F. M. Rønne, S. Laugesen, N. S. Jensen, J. H. Pedersen

23. Moving Objects in the Barn Owl's Auditory World
U. Langemann, B. Krumm, K. Liebner, R. Beutelmann, G. M. Klump

Session 8, Tuesday, 16:00 chair: Diek Duifhuis & Catherine Carr

24. Change Detection in Auditory Textures
Y. Boubenec, J. Lawlor, S. Shamma, B. Englitz

25. The Relative Contributions of Temporal Envelope and Fine Structure in Mandarin Lexical Tone Perception in Auditory Neuropathy Spectrum Disorder
S. Wang, R. Dong, Y. Wang, D. Liu, L. Zhang, L. Xu

26. Interaction of Object Binding Cues in Binaural Masking Pattern Experiments
J. Verhey, B. Lübken, S. van de Par

27. Speech Intelligibility for Target and Masker with a Different Spectrum
T. Leclère, D. Thery, M. Lavandier, J. F. Culling

Session 9, Wednesday, 09:30 chair: Pim van Dijk & Glenis Long

28. Dynamics of Cochlear Nonlinearity
N. P. Cooper, M. van der Heijden

29. Responses of the Human Inner Ear to Low-Frequency Sound
M. Drexl, E. Krause, R. Gürkov, L. Wiegrebe

30. Suppression Measured from Chinchilla Auditory-Nerve-Fiber Responses Following Noise-Induced Hearing Loss: Adaptive-Tracking and Systems-Identification Approaches
M. Sayles, M. K. Walls, M. G. Heinz

Session 10, Wednesday, 11:10 chair: Etienne Gaudrain & Antje Heinrich

31. Does Signal Degradation Affect Top-Down Processing of Speech?
A. Wagner, C. Pals, C. de Blecourt, A. Sarampalis, D. Başkent

32. The Effect of Peripheral Compression on Syllable Perception Measured with a Hearing Impairment Simulator
T. Matsui, T. Irino, M. Nagae, H. Kawahara, R. D. Patterson

33. Towards Objective Measures of Functional Hearing Abilities
H. Innes-Brown, R. Tsongas, J. Marozeau, C. McKay

Session 11, Thursday, 09:50 **chair: Anita Wagner & Lars Riecke**

34. Connectivity in Language Areas of the Brain in Cochlear Implant Users as Revealed by fNIRS
    C. McKay, A. Shah, A. K. Seghouane, X. Zhou, L. Tate, W. Cross, R. Litovsky

35. Isolating Neural Indices of Continuous Speech Processing at the Phonetic Level
    G. Di Liberto, E. Lalor

Session 12, Thursday, 11:10 **chair: Etienne Gaudrain & Hedwig Gockel**

36. Brainstem Coding of Pitch – the Butte Hypothesis
    P. X. Joris

37. Can Temporal Fine Structure and Temporal Envelope be Considered Independently for Pitch Perception?
    N. Grimault

38. Locating Melody Processing Activity in Auditory Cortex with MEG
    R. D. Patterson, M. Andermann, S. Uppenkamp, A. Rupp

Session 13, Thursday, 14:00 **chair: Terrin Tamati & Enrique Lopez-Poveda**

39. Studying Effects of Transcranial Alternating Current Stimulation on Hearing and Auditory Scene Analysis
    L. Riecke

40. Functional Organization of the Ventral Auditory Pathway
    Y. E. Cohen, S. Bennur, K. L. Christison-Lagay, A. M. Gifford, J. Tsunada

41. Neural Segregation of Concurrent Speech: Effects of Background Noise and Reverberation on Auditory Scene Analysis in the Ventral Cochlear Nucleus
    M. Sayles, A. Stasiak, I. M. Winter

42. Audio Visual Integration with Competing Sources in the Framework of Audio Visual Speech Scene Analysis
    G. Attigodu Chandrashekara, F. Berthommier, J. L. Schwartz

Session 14, Thursday, 16:00 **chair: Anita Wagner & Roy Patterson**

43. Relative Pitch Perception and the Detection of Deviant Tone Patterns
    S. L. Denham, M. Coath, G. Háden, F. Murray, I. Winkler

44. Neural Correlates of Auditory-Tactile Integration in Musical Meter Perception
    J. Huang, T. Wu, S. Hsiao, X. Wang

45. Do Zwicker Tones Evoke a Musical Pitch?
    H. E. Gockel, R. P. Carlyon

Session 15, Friday, 09:30 — chair: Wiebe Horst & Julie Bierer

46. Speech Coding in the Midbrain: Effects of Sensorineural Hearing Loss
L. H. Carney, D. O. Kim, S. Kuwada

47. Sources of Variability in Consonant Perception and Implications for Speech Perception Modeling
J. Zaar, T. Dau

48. On Detectable and Meaningful Speech-Intelligibility Benefits
W. Whitmer, D. McShefferty, M. Akeroyd

Session 16, Friday, 11:10 — chair: Pim van Dijk & Laurel Carney

49. Individual Differences in Behavioral Decision Weights Related to Irregularities in Cochlear Mechanics
J. Lee, I. Heo, A. C. Chang, K. Bond, C. Stoelinga, R. Lutfi, G. R. Long

50. On the Interplay between Cochlear Gain Loss and Temporal Envelope Coding Deficits
S. Verhulst, P. Piktel, A. Jagadeesh, M. Mauermann

51. Frequency Tuning of the Human Efferent Effect on Cochlear Gain
V. Drga, C. J. Plack, I. Yasin

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Social Programme Wednesday June 17th

13:15 Social programme

13:15 Departure bus from hotel to main trainstation

14:00 *Group 1* : Boat tour with guide Claudia

Group 2 : City walk with guides Rens and Titus

15:15 *Group 1* : City walk with guides Rens and Titus

Group 2 : Boat tour with guide Claudia

16:15 Walk to the der Aa-kerk

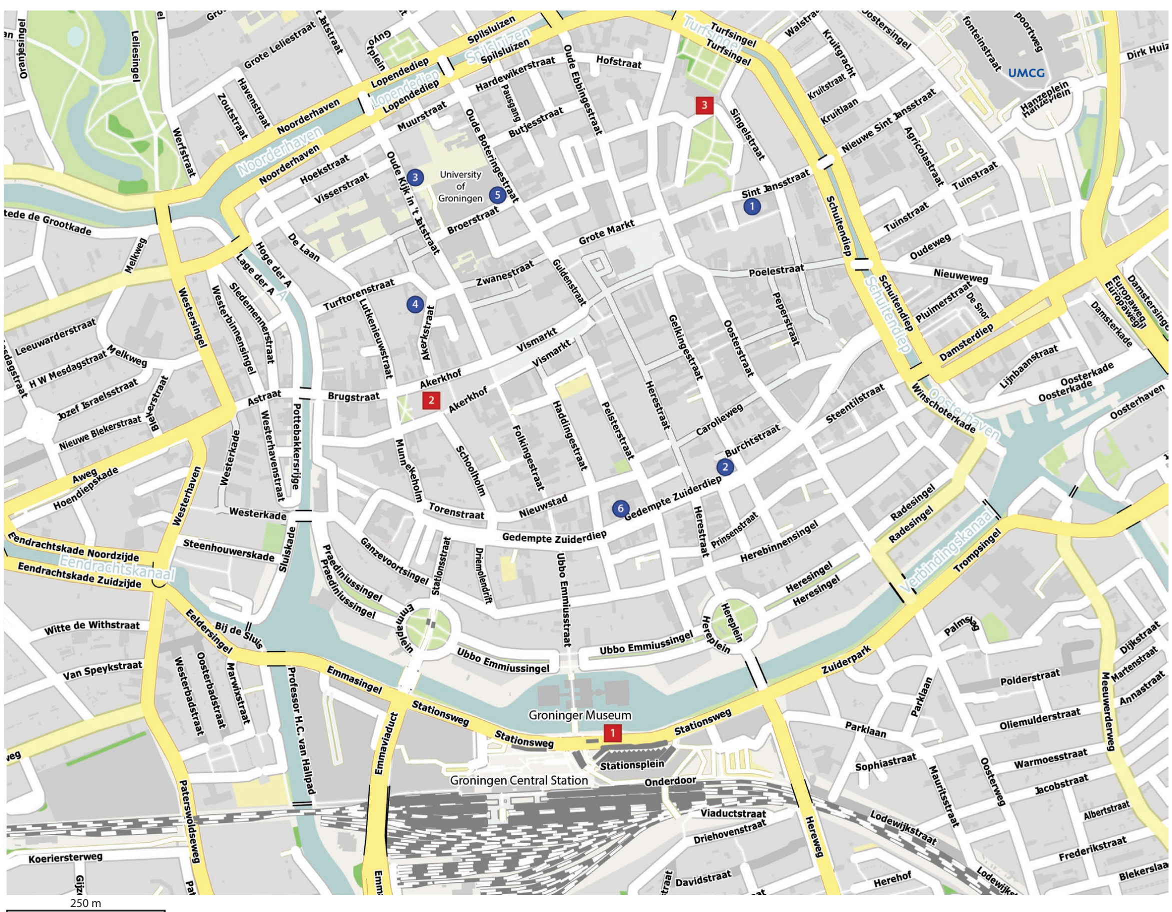
16:30 Departure bus from hotel to der Aa-kerk

17:00 Meet at the der Aa- kerk

17:15 Short introduction followed by an organ concert.

19:00 Gala Dinner at Prinsenhof

22:15/22.30 Departure bus from Prinsenhof hotel to Familiehotel Paterswolde



ISH 2015

Wednesday Socials

1 Boat tour

2 A-Kerk

3 Prinsenhof

Restaurants

1 't Feithhuis http://restaurant-feithhuis.nl/

2 Thai Jasmine http://www.thaijasmine.nl/

3 Louis XV http://louisxv.nl/

4 Brussels Lof http://www.brusselslof.com/

5 Mr. Mofongo http://www.mofongo.nl/

6 Hanasato http://hanasato.nl/

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Vismarkt with de der Aa kerk
https://www.flickr.com/photos/13382424@N00/

Train station Groningen
https://www.flickr.com/photos/13382424@N00/

Paterswoldse meer

Abstracts

Talk 1: Monday, 09:30

Effects of Age and Hearing Loss on the Processing of Auditory Temporal Fine Structure

B. C. J. Moore
University of Cambridge, Cambridge, UK

Within the cochlea, broadband sounds are filtered into a series of narrowband signals, each of which has a relatively slowly varying envelope (ENV) imposed on a rapidly oscillating carrier (the temporal fine structure, TFS). Information about ENV and TFS is conveyed in the timing and short-term rate of nerve spikes in the auditory nerve. This paper summarises evidence from studies that allow some separation of the effects of hearing loss and age on the processing of TFS and ENV information. The monaural processing of TFS information seems to be adversely affected by both hearing loss and increasing age. The monaural processing of ENV information is hardly affected by hearing loss or by increasing age. The binaural processing of TFS information is also adversely affected by both hearing loss and increasing age, but here the latter seems more important. The binaural processing of ENV information deteriorates somewhat with increasing age but is not markedly affected by hearing loss. The reduced TFS processing abilities found for older/hearing-impaired subjects may partially account for the difficulties that such subjects experience in complex listening situations.

Talk 2: Monday, 09:50

Aging Effects on Behavioural Estimates of Suppression with Short Suppressors

E. Hegland, E. Strickland
Purdue University, West Lafayette, IN, USA

Auditory two-tone suppression is a nearly instantaneous reduction in the response of the basilar membrane to a tone or noise when a second tone or noise is presented simultaneously. Previous behavioural studies provide conflicting evidence on whether suppression changes with increasing age, and aging effects may depend on whether a suppressor above (high-side) or below (low-side) the signal frequency is used. Most previous studies have measured suppression using stimuli long enough to elicit the medial olivocochlear reflex (MOCR), a sound-elicited reflex that reduces cochlear amplification or gain. It has a “sluggish” onset of approximately 25 ms. There is physiological evidence that suppression may be reduced or altered by elicitation of the MOCR. In the present study, suppression was measured behaviourally in younger adults and older adults using a forward-masking paradigm with 20-ms and 70-ms maskers and suppressors. In experiment 1, gain was estimated by comparing on-frequency (2 kHz) and off-frequency (1.2 kHz) masker thresholds for a short, fixed-level 2-kHz signal. In experiment 2, the fixed-level signal was preceded by an off-frequency suppressor (1.2 or 2.4 kHz) presented simultaneously with the on-frequency masker. A suppressor level was chosen that did not produce any forward masking of the signal. Suppression was measured as the difference in on-frequency masker threshold with and without the suppressor present. The effects of age on gain and suppression estimates will be discussed.

Talk 3: Monday, 10:10

Contributions of Coding Efficiency of Temporal-Structure and Level Information to the Lateralization Performance in Young and Early-Elderly Listeners

A. Ochi, T. Yamasoba
University of Tokyo, Tokyo, Japan

S. Furukawa
NTT Communication Science Labs, Atsugi, Japan

The performance of lateralization task based on interaural time or level difference (ITD or ILD) often varies among listeners. This study examined the extent to which this inter-listener variation could be accounted for by the coding efficiency of temporal-structure or level information below the stage of interaural interaction. Young listeners (20s to 30s) and early-elderly (60s) listeners with or without mild hearing loss were tested. The ITD, ILD, TIME, and LEVEL tasks were intended to measure sensitivities to ITD, ILD, the temporal structure of the stimulus encoded by the neural phase locking, and stimulus level, respectively. The performances of the ITD and ILD tasks were not significantly different between the age groups, while the elderly listeners exhibited significantly poorer performance in the TIME task (and in the LEVEL with high frequency stimulus only) than the young listeners. Significant correlations were found between thresholds for the ILD and LEVEL tasks with low- and high-frequency stimuli and for the ITD and TIME tasks for the high-frequency stimulus, implying peripheral coding efficiency as a major factor that determines lateralization performance. However, we failed to find a correlation between the ITD and TIME tasks for the low-frequency stimulus, despite a large range of threshold values of the TIME task. This implies that in a low frequency region, the peripheral coding efficiency of stimulus temporal structure is a relatively minor factor for the ITD-based lateralization performance.

Talk 4: Monday, 11:10

Investigating the Role of Working Memory in Speech-in-Noise Identification for Listeners with Normal Hearing

C. Füllgrabe
MRC Institute of Hearing Research, Nottingham, UK

S. Rosen
University College London, London, UK

With the advent of cognitive hearing science, increased attention has been given to individual differences in cognitive functioning and their explanatory power in accounting for inter-listener variability in understanding speech in noise (SiN). The psychological construct that has received most interest is working memory (WM), representing the ability to simultaneously store and process information. Common lore and theoretical models assume that WM-based processes subtend speech processing in adverse perceptual conditions, such as those associated with hearing loss or background noise. Empirical evidence confirms the association between WM capacity (WMC) and SiN identification in older hearing-impaired listeners. To assess whether WMC also plays a role when listeners without hearing loss process speech in acoustically adverse conditions, we surveyed published and unpublished studies in which the Reading-Span test (a widely used measure of WMC) was administered in conjunction with a measure of SiN identification. The survey revealed little or no evidence for an association between WMC and SiN performance. We also analysed new data from 132 normal-hearing participants sampled from across the adult lifespan (18 to 91 years), for a relationship between Reading-Span scores and identification of matrix sentences in noise. Performance on both tasks declined with age, and correlated weakly even after controlling for the effects of age and audibility ($r = 0.39$, $p \leq 0.001$, one-tailed). However, separate analyses for different age groups revealed that the correlation was only significant for middle-aged and older groups but not for the young (< 40 years) participants.

Talk 5: Monday, 11:30

The Contribution of Auditory and Cognitive Factors to Intelligibility of Words and Sentences in Noise

A. Heinrich, S. Knight

MRC Institute of Hearing Research, Nottingham, UK

Understanding the causes for speech-in-noise (SiN) perception difficulties is complex, and is made even more difficult by the fact that listening situations can vary widely in target and background sounds. While there is general agreement that both auditory and cognitive factors are important, their exact relationship to SiN perception across various listening situations remains unclear. This study manipulated the characteristics of the listening situation in two ways: first, target stimuli were either isolated words, or words heard in the context of low- (LP) and high-predictability (HP) sentences; second, the background sound, speech-modulated noise, was presented at two signal-to-noise ratios. Speech intelligibility was measured for 30 older listeners (aged 62–84) with age-normal hearing and related to individual differences in cognition (working memory, inhibition and linguistic skills) and hearing (PTA0.25-8kHz and temporal processing). The results showed that while the effect of hearing thresholds on intelligibility was rather uniform, the influence of cognitive abilities was more specific to a certain listening situation. By revealing a complex picture of relationships between intelligibility and cognition, these results may help us understand some of the inconsistencies in the literature as regards cognitive contributions to speech perception.

Talk 6: Monday, 11:50

Do Hearing Aids Improve Affect Perception?

J. Schmidt

Radboud University Nijmegen, Netherlands

D. Herzog

Phonak AG, Stäfa, Switzerland

O. Scharenborg, E. Janse

Radboud University Nijmegen, Netherlands

Normal-hearing listeners use acoustic cues in speech in order to interpret the speaker's emotional state. This study investigates how hearing loss affects the perception of the emotion dimensions arousal (aroused vs. calm) and valence (positive/negative attitude) in older adults using hearing aids. Affect ratings by 23 hearing aid users are compared for aided and unaided listening and are also compared to ratings by an age-matched group of 24 participants with age-normal hearing. More specifically, we investigate whether wearing a hearing aid improves the correlation between affect ratings and affect-related acoustic parameters.The rating results for the evaluation of arousal show that the hearing aid users rated utterances as generally more aroused in the aided compared to the unaided condition. Both listening condition and hearing loss severity differences among hearing aid users changed the use of certain acoustic parameters. Compared to the reference group, hearing aid users showed minor differences in the use of intensity for arousal rating. For valence, hearing loss severity did not influence ratings, and neither did listening condition (aided vs. unaided). For both emotion dimensions, ratings of hearing aid users in the aided condition did not generally differ from those of the participants with age-normal hearing. Hearing impairment and the use of hearing aids thus matter particularly for the interpretation of arousal. Therefore, future studies on affect perception in hearing aid users should treat perception of arousal and valence separately.

Talk 7: Monday, 14:00

Suitability of the Binaural Interaction Component for Interaural Electrode Pairing of Bilateral Cochlear Implants

H. Hu, M. Dietz, B. Kollmeier

Carl von Ossietzky University Oldenburg, Oldenburg, Germany

Although bilateral cochlear implants (BiCIs) have succeeded in improving the spatial hearing performance of bilateral CI users, the overall performance is still not comparable with normal hearing listeners. Limited success can be partially caused by an interaural mismatch of the place-of-stimulation in each cochlea. Pairing matched interaural CI electrodes and stimulating them with the same frequency band is expected to facilitate binaural functions such as binaural fusion, localization, or spatial release from masking. It has been shown in animal experiments that the magnitude of the binaural interaction component (BIC) derived from the wave-eV decreases for increasing interaural place of stimulation mismatch. This motivated the investigation of the suitability of an electroencephalography-based objective electrode-frequency fitting procedure based on the BIC for BiCI users. A 61 channel monaural and binaural electrically evoked auditory brainstem response (eABR) recording was performed in 7 MED-EL BiCI subjects so far. These BiCI subjects were directly stimulated at 60% dynamic range with 19.9 pulses per second via a research platform provided by the University of Innsbruck (RIB II). The BIC was derived for several interaural electrode pairs by subtracting the response from binaural stimulation from their summed monaural responses. The BIC based pairing results are compared with two psychoacoustic pairing methods: interaural pulse time difference sensitivity and interaural pitch matching. The results for all three methods analyzed as a function of probe electrode allow for determining a matched pair in more than half of the subjects, with a typical accuracy of ±1 electrode. This includes evidence for statistically significant tuning of the BIC as a function of probe electrode in human subjects. However, results across the three conditions were sometimes not consistent. These discrepancies will be discussed in the light of pitch plasticity versus less plastic brainstem processing.

Talk 8: Monday, 14:20

Binaural Loudness Constancy

J. Culling, H. Dare

Cardiff University, Cardiff, UK

In binaural loudness summation, diotic presentation of a sound usually produces approximately double the loudness of monotic presentation. However, experiments using loudspeaker presentation with and without earplugs find that magnitude estimates of loudness are little altered by the earplug, suggesting a form of loudness constancy. We explored the significance of controlling stimulation of the second ear using meatal occlusion as opposed to the deactivation of one earphone. We measured the point of subjective loudness equality (PSLE) for monaural vs. binaural presentation using an adaptive technique for both speech and noise. These stimuli were presented in a reverberant room over a loudspeaker to the right of the listener, or over lightweight headphones. Using the headphones, stimuli were either presented dry, or matched to those of the loudspeaker by convolution with impulse responses measured from the loudspeaker to the listener position, using an acoustic manikin. The headphone response was also compensated. Using the loudspeaker, monotic presentation was achieved by instructing the listener to block the left ear with their finger. Near perfect binaural loudness constancy was observed using loudspeaker presentation, while there was a summation effect of 3-6 dB for both headphone conditions. However, only partial constancy was observed when meatal occlusion was simulated. These results suggest that there may be contributions to binaural loudness constancy from residual low frequencies at the occluded ear as well as a cognitive element, which is activated by the knowledge that one ear is occluded.

Talk 9: Monday, 14:40

Intelligibility for Binaural Speech with Discarded Low-SNR Speech Components

E. Schoenmaker, S. van de Par
Carl von Ossietzky University of Oldenburg, Oldenburg, Germany

Speech intelligibility in multitalker settings improves when the target speaker is spatially separated from the interfering speakers. A factor that may contribute to this improvement is the improved detectability of target-speech components due to binaural interaction, in analogy to the Binaural Masking Level Difference (BMLD). This would allow listeners to hear target speech components within specific time-frequency intervals that have a negative SNR, similar to the improvement in the detectability of a tone in noise when these contain disparate interaural difference cues. To investigate whether these negative-SNR target-speech components indeed contribute to speech intelligibility a stimulus manipulation was performed where all target components were removed when local SNRs were smaller than a certain criterion value. It can be expected that for sufficiently high criterion values, target speech components will be removed that do contribute to speech intelligibility. For spatially separated speakers, assuming that a BMLD-like detection advantage contributes to intelligibility, degradation in intelligibility is expected already at criterion values below 0 dB SNR. However, for collocated speakers it is expected that higher criterion values can be applied without impairing speech intelligibility. Results show that degradation of intelligibility for separated speakers is only seen for criterion values of 0 dB and above, indicating a negligible contribution of BMLD-like processing in multitalker settings. These results show that the spatial benefit is related to a spatial separation of speech components at positive local SNRs rather than to a BMLD-like detection improvement for speech components at negative local SNRs.

Talk 10: Monday, 15:00

On the Contribution of Target Audibility to Performance in Spatialized Speech Mixtures

V. Best, C. R. Mason, J. Swaminathan, G. Kidd, Jr.
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Hearing loss has been shown to reduce speech understanding in spatialized multitalker listening situations, leading to the common belief that spatial processing is disrupted by hearing loss. This paper describes related studies from three laboratories that explored the contribution of reduced target audibility to this deficit. All studies used a stimulus configuration in which a speech target presented from the front was masked by speech maskers presented symmetrically from the sides. Together these studies highlight the importance of adequate stimulus audibility for optimal performance in spatialized speech mixtures and suggest that reduced access to target speech information might explain a substantial portion of the “spatial” deficit observed in listeners with hearing loss.

Talk 11: Monday, 16:00

Optimization of a Spectral Contrast Enhancement Algorithm for Cochlear Implants based on a Vowel Identification Model

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Speech intelligibility achieved with cochlear implants (CIs) shows large variability across different users. One reason that can explain this variability is the CI user's individual electrode nerve interface which can impact the spectral resolution they can achieve. Spectral resolution has been reported to be related to vowel and consonant recognition in CI listeners. One measure of spectral resolution is the spectral modulation threshold (SMT), which is defined as the smallest detectable spectral contrast in a stimulus. In this study we hypothesize that an algorithm that improves SMT may improve vowel identification, and consequently produce an improvement in speech understanding for CIs. With this purpose we implemented an algorithm, termed spectral contrast enhancement (SCE) that emphasizes peaks with respect to valleys in the audio spectrum. This algorithm can be configured with a single parameter: the amount of spectral contrast enhancement entitled "SCE factor". We would like to investigate whether the "SCE factor" can be individualized to each CI user. With this purpose we used a vowel identification model to predict the performance produced by the SCE algorithm with different "SCE factors" in a vowel identification task. In five CI users the new algorithm has been evaluated using a SMT task and a vowel identification task. The tasks were performed for SCE factors of 0 (no enhancement), 2 and 4. In general it seems that increasing the SCE factor produces a decrease in performance in both the SMT threshold and vowel identification.

Talk 12: Monday, 16:20

Roles of the Contralateral Efferent Reflex in Hearing Demonstrated with Cochlear Implants

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Our two ears do not function as fixed and independent sound receptors; their functioning is linked and dynamically adjusted via the contralateral medial olivocochlear efferent reflex (MOCR). The MOCR possibly facilitates speech recognition in noisy environments. Such a role, however, is yet to be demonstrated because selective deactivation of the reflex during natural acoustic listening has not been possible for human subjects up until now. Here, we propose that this and other roles of the MOCR may be elucidated using the unique stimulus controls provided by cochlear implants (CIs). Pairs of sound processors were constructed to mimic or not mimic the effects of the contralateral MOCR with CIs. For the non-mimicking condition (STD strategy), the two processors in a pair functioned independently of each other. When configured to mimic the effects of the MOCR (MOC strategy), however, the two processors communicated with each other and the amount of compression in a given frequency channel of each processor in the pair decreased with increases in the output energy from the contralateral pro-

cessor. The analysis of output signals from the STD and MOC strategies suggests that in natural binaural listening, the MOCR possibly causes a small reduction of audibility but enhances frequency-specific inter-aural level differences, and the segregation of spatially non-overlapping sound sources. The proposed MOC strategy could improve CI and hearing-aid performance.

Talk 13: Monday, 16:40

Deactivating Cochlear Implant Electrodes Based on Pitch Information for Users of the ACE Strategy

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There is a wide range in performance for cochlear implant (CI) users and there is some evidence to suggest that implant fitting can be modified to improve performance if electrodes that do not provide distinct pitch information are de-activated. However, improvements in performance may not be the same for users of all CI devices; in particular for those with Cochlear devices using n-of-m strategies (ACE or SPEAK). The goal of this research was to determine for users of Cochlear devices (CP810 implants with system 5 or 6 sound processors) if speech perception could be improved when indiscriminable electrodes were de-activated and this was also compared to when the same number of discriminable electrodes were de-activated. A cross-over study was conducted with thirteen adult CI users who received experimental maps with de-activated channels for a minimum of two months and these were compared to an optimised clinical programme. The findings showed that there were no significant benefits of electrode de-activation on speech perception and that there was a significant deterioration in spectro-temporal ripple perception when electrodes were switched off. There were no significant differences between de-activation of discriminable or indiscriminable electrodes. These findings suggest that electrode de-activation with n-of-m strategies may not be beneficial.

Talk 14: Tuesday, 09:30

Speech Masking and Masking Release in Normal, Impaired and Electric Hearing: Interactions Between Frequency Selectivity and Inherent Temporal Fluctuations in Noise

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Recent studies in normal-hearing listeners have used envelope-vocoded stimuli to show that the masking of speech by noise is dominated by the temporal-envelope fluctuations inherent in noise, rather than just the overall power of the noise. Because these studies were based on vocoding, it was expected that cochlear-implant (CI) users would demonstrate a similar sensitivity to inherent fluctuations. In contrast, we found that CI users showed no difference in speech intelligibility between maskers with inherent envelope fluctuations, and maskers with no fluctuations. Here, these initial findings in CI users were extended to listeners with cochlear hearing loss and the results were compared with those from normal-hearing listeners at either equal sensation level or equal sound pressure level. In CI users, the results support the predictions based of the hypothesis that poor spectral resolution leads to a summation of independently fluctuating temporal envelopes, which in turn leads to “smoother” effective noise temporal envelopes with less energy at modulation frequencies relevant for speech. In hearing-impaired listeners (and in normal-hearing listeners at high sound levels), the results are consistent with a reduction in low-frequency inherent noise fluctuations due to broader cochlear filtering. The reduced effect of inherent temporal fluctuations in noise, due to either current spread or broader cochlear filters, provides a new way to explain the loss of masking release experienced in CI users and hearing-impaired listeners when additional amplitude fluctuations are introduced in noise maskers.

Talk 15: Tuesday, 09:50

Effects of Pulse Shape and Polarity on Sensitivity to Cochlear Implant Stimulation: a Chronic Study in Guinea Pigs

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Most cochlear implants (CIs) stimulate the auditory nerve with trains of symmetric biphasic pulses consisting of two phases of opposite polarity. Animal and human studies have shown that both polarities can elicit neural responses. In human CI listeners, studies have shown that at suprathreshold levels, the anodic phase is more effective than the cathodic phase. In contrast, animal studies usually show the opposite trend. Although the reason for this discrepancy still remains unclear, computational modelling results have proposed that the degeneration of the peripheral processes of the neurons could lead to a higher efficiency of anodic stimulation. We tested this hypothesis in ten guinea pigs who were deafened with an injection of sysomycin and implanted with a single ball electrode inserted in the first turn of the cochlea. Animals were tested at regular intervals between 1 week after deafening and up to 1 year for some of them. Our hypothesis was that if the effect of polarity is determined by the presence or absence of peripheral processes, the difference in polarity efficiency should change over time because of a progressive neural degeneration. Stimuli consisted of charge-balanced symmetric and asymmetric pulses allowing us to observe the response to each polarity individually. For all stimuli, the inferior colliculus evoked potential was measured. Results show that the cathodic phase was more effective than the anodic phase and that this remained so even several months after deafening. This suggests that neural degeneration cannot entirely account for the higher efficiency of anodic stimulation observed in human CI listeners.

Talk 16: Tuesday, 10:10

Assessing the Firing Properties of the Electrically Stimulated Auditory Nerve using a Convolution Model

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The electrically evoked compound action potential (eCAP) is a routinely performed electrophysiological measure of the auditory nerve in cochlear implant users. Using a convolution model of the eCAP, additional information about the firing properties of the auditory nerve can be obtained. In this study, eCAPs for a monopolar biphasic pulse were analysed in two groups: acutely implanted normal-hearing and deafened guinea pigs, and human cochlear implant recipients. The estimated firing probability of the auditory nerve could be parameterised for most eCAPs by a bimodal probability distribution consisting of two Gaussian distributions with an average latency difference of 0.4-0.5 ms. The ratio of the late and early Gaussian distributions increased with neural degeneration in the guinea pig and this ratio decreased with stimulation intensity. This decrease with intensity was also observed in humans. The latency of the early Gaussian distribution decreased with neural degeneration in the guinea pig. Indirectly, this was observed in humans as well, assuming that the cochlear base exhibits more neural degeneration than the apex. Differences between guinea pigs and humans were observed, among other parameters, in the width of the early component: very robust in guinea pig, and dependent on stimulation intensity and cochlear region in humans. We conclude that the deconvolution of the eCAP is a valuable addition to existing eCAP analyses, in particular in revealing two separate firing components.

Talk 17: Tuesday, 11:10

Modeling the Individual Variability of Loudness Perception with a Multi-Category Psychometric Function

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Loudness is a measure of suprathreshold perception that provides insight into the status of the entire auditory pathway; cochlear damage manifests primarily as loudness recruitment, while central adaptations may affect the level at which listeners report discomfort. In addition to these broad effects, individuals with matched thresholds show significant individual variability in the details of their loudness perception. As a means to analyze and model listener variability, we introduce the multi-category psychometric function (MCPF), a novel representation for categorical data that fully describes the probabilistic relationship between stimulus level and categorical-loudness perception. We present results based on categorical loudness scaling (CLS) data for 15 normal-hearing (NH) adults and 22 adults with hearing loss (HL). A principle-component analysis of the parameterized listener data shows the major underlying factors that contribute to individual variability across listeners. We show how the MCPF can be used to improve CLS estimates, by combining listener models with maximum-likelihood estimation. The MCPF could be additionally used in an entropy-based stimulus-selection technique. These techniques utilize the probabilistic nature of categorical perception, a new dimension of loudness information, to improve the quality of loudness measurements.

Talk 18: Tuesday, 11:30

Auditory fMRI of Sound Intensity and Loudness for Unilateral Stimulation

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We report a systematic exploration of the interrelation of sound intensity, ear of entry, individual loudness judgments, and brain activity across hemispheres as well as a functional differentiation of regions within auditory cortices using auditory functional magnetic resonance imaging (fMRI). The stimuli employed were 4-kHz-bandpass filtered noise stimuli, presented monaurally to each ear at levels from 37 to 97 dB SPL. One diotic condition and a silence condition were included as control conditions. Normal hearing listeners completed a categorical loudness scaling procedure prior to listening to similar stimuli while auditory fMRI was performed. The relationship between brain activity, as inferred from blood oxygenation level dependent (BOLD) contrasts, and both sound intensity and loudness estimates were analyzed by means of functional activation maps and linear mixed effects models for various anatomically defined regions of interest in the ascending auditory pathway and in the cortex. The results indicate distinct functional differences between midbrain and cortical areas as well as between specific regions within auditory cortex, suggesting a systematic hierarchy in terms of lateralization and the representation of sensory stimulation and perception.

Talk 19: Tuesday, 11:50

Tinnitus-related Abnormalities in Brain Networks During Stimulated and Resting States

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D. Langers

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We investigated tinnitus-related differences in functional networks in adults with tinnitus in a functional connectivity study. Previously it was found that various networks show differences in connectivity in patients with tinnitus compared to controls. Whether this relates to patients' ongoing tinnitus and whether the ecological sensory environment modulates connectivity remains unknown. Twenty healthy controls and twenty patients suffering from chronic tinnitus

were enrolled in the study. Except for the presence of tinnitus in the patient group, all subjects were selected to have normal or near-normal hearing. fMRI data were obtained in two different functional states. In one session subjects freely viewed emotionally salient movie fragments ("fixed-state") while in the other they were not performing any task ("resting-state"). After data pre-processing, Principal Component Analysis was performed to obtain 25 components for all datasets. These were fed into an Independent Component Analysis (ICA), concatenating the data across both groups and both datasets, to obtain eleven group-level networks of neural origin, each consisting of spatial maps with their respective time-courses. Subject-specific maps and their time-course were obtained by back-projection (Dual Regression). For each of the components a mixed-effects linear model was composed with factors group (tinnitus vs. controls), task (fixed-state vs. resting state) and their interaction. The neural components comprised the visual, sensorimotor, auditory, and limbic systems, the default mode, dorsal attention, executive-control, and frontoparietal networks, and the cerebellum. Most notably, the default mode network (DMN) was less extensive and significantly less strongly active in tinnitus patients than in controls. This group difference existed in both paradigms. At the same time, the DMN was stronger during resting-state than during fixed-state in the controls but not the patients. We attribute this pattern to the unremitting engaging effect of the tinnitus percept.

Talk 20: Tuesday, 14:00

The Role of Conduction Delay in Creating Sensitivity to Interaural Time Differences

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Axons from the nucleus magnocellularis (NM) and their targets in nucleus laminaris (NL) form the circuit responsible for encoding interaural time difference (ITD). In barn owls, NL receives bilateral inputs from NM, such that axons from the ipsilateral NM enter NL dorsally, while contralateral axons enter from the ventral side. These afferents act as delay lines to create maps of ITD in NL. Because NL is tonotopically organized, these maps are technically maps of interaural phase difference; time difference is computed in the inferior colliculus after combining across frequency channels (Wagner, Takahashi, & Konishi, 1987). Since delay line inputs are characterized by a precise latency to auditory stimulation, but the postsynaptic coincidence detectors respond to ongoing phase difference, we asked whether the latencies of a local group of axons were identical, or varied by multiples of the inverse of the frequency they respond to, which is equivalent to multiples of 2π phase. Intracellular recordings from NM axons were used to measure delay-line latencies in NL. Systematic shifts in conduction delay within NL accounted for the maps of ITD, but recorded latencies of individual inputs at nearby locations varied by 2π or 4π Therefore microsecond precision is achieved through sensitivity to phase delays, rather than absolute latencies. We propose that the auditory system "coarsely" matches ipsilateral and contralateral latencies using physical delay lines, so that inputs arrive at NL at about the same time, and then "finely" matches latency modulo 2π to achieve microsecond ITD precision.

Talk 21: Tuesday, 14:20

Objective Measures of Neural Processing of Interaural Time Differences

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We developed an objective measure to assess neural sensitivity to interaural time differences (ITDs) conveyed in the temporal fine structure (TFS) of low-frequency sounds, and to distinguish it from neural sensitivity to ITDs conveyed in the temporal envelope of amplitude-modulated

(AM'ed) high-frequency sounds. Bilateral cochlear implant (CI) users can potentially access the latter cues, but are largely unable to process low-frequency ITD information. To this end, a measure of brain activity that distinguishes between neural pathways coding ITDs in the TFS and the stimulus envelope would be useful in developing stimulus strategies to improve spatial listening in CI users. Using electroencephalography (EEG), we recorded brain activity to sounds in which the interaural phase difference (IPD) of the TFS (or the modulated temporal envelope) was repeatedly switched between leading in one ear or the other. When the amplitude of the tones is modulated equally in the two ears at 41 Hz, the interaural phase modulation (IPM) generates an intracranial percept of a sound moving from one side to the other – and evokes an IPM following-response (IPM-FR) in the EEG signal. For low-frequency signals (520-Hz carrier), IPM-FRs were reliably obtained for a wide range of modulation rates and IPDs, and were largest for an IPM rate of 6.8 Hz and when IPD switches (around 0°) were in the range 45-90°. Increasing the modulation frequency increased the magnitude of IPM-FRs. IPDs conveyed in envelope of high-frequency tones (3-kHz tones AM'ed at 128 Hz, with a second-order modulation of 41 Hz) also generated a reliable pattern of IPM-FRs, but one in which response maxima occurred for IPDs switched between 0° and 180° IPD. The data are consistent with the interpretation that distinct binaural mechanisms generate the IPM-FR at low and high frequencies, and with the reported physiological responses of medial superior olive (MSO) and lateral superior olive (LSO) neurons in other mammals. Low-frequency binaural neurons in the MSO are considered maximally activated by IPDs in the range 45°-90°, consistent with their reception of excitatory inputs from both ears. High-frequency neurons in the LSO receive excitatory and inhibitory input from the two ears receptively – as such maximum activity occurs when the sounds at the two ears are presented out of phase.

Talk 22: Tuesday, 14:40

Minimum Audible Angles measured with Simulated Normally-Sized and Oversized Pinnas for Normal-Hearing and Hearing-Impaired Test Subjects

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The human pinna introduces spatial acoustic cues in terms of direction-dependent spectral patterns that shape the incoming sound. These cues are specifically useful for localization in the vertical dimension. Pinna cues exist at frequencies above approximately 5 kHz, a frequency range where people with hearing loss typically have their highest hearing thresholds. Since increased thresholds often are accompanied by reduced frequency resolution, there are good reasons to believe that many people with hearing loss are unable to discriminate these subtle spectral pinna-cue details, even if the relevant frequency region is amplified by hearing aids. One potential solution to this problem is to provide hearing-aid users with artificially enhanced pinna cues – as if they were listening through oversized pinnas. In the present study, it was tested whether test subjects were better at discriminating spectral patterns similar to enlarged-pinna cues. The enlarged-pinna patterns were created by transposing (T) generic normal-sized pinna cues (N) one octave down, or by using the approach (W) suggested by Naylor & Weinrich (2011). The experiment was cast as a determination of simulated minimum audible angle (MAA) in the median sagittal plane. 13 test subjects with sloping hearing loss and 11 normal-hearing test subjects participated. The normal-hearing test subjects showed similar discrimination performance with the T, W, and N-type simulated pinna cues, as expected. However, the results for the hearing-impaired test subjects showed only marginally lower MAAs with the W and T-cues compared to the N-cues, while the overall discrimination thresholds were much higher for the hearing-impaired compared to the normal-hearing test subjects.

Talk 23: Tuesday, 15:00

Moving Objects in the Barn Owl's Auditory World

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Barn owls are keen hunters of moving prey. They have evolved an auditory system with impressive anatomical and physiological specializations for localizing their prey. Here we present behavioural data on the owl's sensitivity for discriminating acoustic motion direction in azimuth that, for the first time, allow a direct comparison of neuronal and perceptual sensitivity for acoustic motion in the same model species. We trained two birds to report a change in motion direction within a series of repeating wideband noise stimuli. For any trial the starting point, motion direction, velocity (53-2400°/s), duration (30-225 ms) and angular range (12-72°) of the noise sweeps were randomized. Each test stimulus had a motion direction being opposite to that of the reference stimuli. Stimuli were presented in the frontal or the lateral auditory space. The angular extent of the motion had a large effect on the owl's discrimination sensitivity allowing a better discrimination for a larger angular range of the motion. In contrast, stimulus velocity or stimulus duration had a smaller, although significant effect. Overall there was no difference in the owls' behavioural performance between "inward" noise sweeps (moving from lateral to frontal) compared to "outward" noise sweeps (moving from frontal to lateral). The owls did, however, respond more often to stimuli with changing motion direction in the frontal compared to the lateral space. The results of the behavioural experiments are discussed in relation to the neuronal representation of motion cues in the barn owl auditory midbrain.

Talk 24: Tuesday, 16:00

Change Detection in Auditory Textures

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Many natural sounds have spectrotemporal signatures only on a statistical level, e.g. wind, fire or rain. While their local structure is highly variable, the spectrotemporal statistics of these auditory textures can be used for recognition. This suggests the existence of a neural representation of these statistics. To explore their encoding, we investigated the detectability of changes in the spectral statistics in relation to the properties of the change. To achieve precise parameter control, we designed a minimal sound texture — a modified cloud of tones — which retains the central property of auditory textures: solely statistical predictability. Listeners had to rapidly detect a change in the frequency marginal probability of the tone cloud occurring at a random time. The size of change as well as the time available to sample the original statistics were found to correlate positively with hit rate and negatively with reaction time, suggesting the accumulation of noisy evidence. In summary we quantified dynamic aspects of change detection in statistically defined contexts, and found evidence of integration of statistical information.

Talk 25: Tuesday, 16:20

The Relative Contributions of Temporal Envelope and Fine Structure in Mandarin Lexical Tone Perception in Auditory Neuropathy Spectrum Disorder

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Previous studies have demonstrated that temporal envelope (E) is sufficient for speech perception, while fine structure (FS) is important for pitch perception and lexical tone perception for normal-hearing (NH) listeners. Listeners with sensorineural hearing loss (SNHL) have an impaired ability to use FS in lexical tone perception due to the reduced frequency resolution. Listeners with auditory neuropathy spectrum disorder (ANSD) may have deficits in temporal resolution. Little is known about how such deficits may impact their ability to use E and FS to perceive lexical tone, and whether it is the deficit in temporal resolution or frequency resolution that may lead to more detrimental effects on FS processing in pitch perception. Three experiments were conducted in the present study to address the above-mentioned questions. Experiment I used the “auditory chimera” technique to investigate how listeners with SNHL and with ANSD would achieve lexical tone recognition using either the E or the FS cues. Experiment II tested the frequency resolution for the two groups of listeners as measured with the Q10 dB values of the psychophysical tuning curves (PTCs). Experiment III tested their temporal resolution as measured with the temporal gap detection (TGD) threshold. The results showed that the listeners with SNHL had reduced frequency selectivity, but intact temporal resolution ability, while the listeners with ANSD had degraded temporal resolution ability, but intact frequency selectivity. In comparison with the SNHL listeners, the ANSD listeners had severely degraded ability to process the FS cues and thus their ability to perceive lexical tone mainly depended on the ability to use the E cues. These results suggested that, in comparison with the detrimental impact of the reduced frequency selectivity, the impaired temporal resolution may lead to more degraded FS processing in pitch perception.

Talk 26: Tuesday, 16:40

Interaction of Object Binding Cues in Binaural Masking Pattern Experiments

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Object binding cues such as binaural and across-frequency modulation cues are likely to be used by the auditory system to separate sounds from different sources in complex auditory scenes. The present study investigates the interaction of these cues in a binaural masking pattern paradigm where a sinusoidal target is masked by a narrowband noise. It was hypothesized that beating between signal and masker may contribute to signal detection when signal and masker do not spectrally overlap but that this cue could not be used in combination with interaural cues. To test this hypothesis an additional sinusoidal interferer was added to the noise masker with a lower frequency than the noise whereas the target had a higher frequency than the noise. Thresholds increase when the interferer is added. This effect is largest when the spectral interferer-masker and masker-signal distances are equal. The result supports the hypothesis that modulation cues contribute to signal detection in the classical masking paradigm and that these are analysed with modulation bandpass filters. A monaural model including an across-frequency modulation process is presented that account for this effect. Interestingly, the interferer also affects dichotic thresholds indicating that modulation cues also play a role in binaural processing.

Talk 27: Tuesday, 17:00

Speech Intelligibility for Target and Masker with a Different Spectrum

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The speech intelligibility index (SII) calculation is based on the assumption that the effective range of signal-to-noise ratio (SNR) regarding speech intelligibility is [-15 dB; +15 dB] with an importance equally distributed over this interval. In a specific frequency band, speech intelligibility would no longer be influenced if the SNR is increased above +15 dB or decreased below -15 dB. These assumptions were tested in four experiments measuring speech reception thresholds (SRTs) with a speech target and speech-spectrum noise, while attenuating target or noise above or below 1400 Hz, with different levels of attenuation allowing the testing of different SNRs in the two bands. The results confirmed that SRT varied linearly with attenuation at low-attenuation levels and an asymptote was reached for high-attenuation levels. However, this asymptote was reached (intelligibility was not influenced by further attenuation) for different attenuation levels across conditions. The -15-dB SII limit was confirmed for high-pass filtered targets, whereas for low-pass filtered targets, intelligibility was further impaired by decreasing the SNR below -15 dB (until about -30 dB). For the high-pass and low-pass filtered noises, speech intelligibility kept improving when increasing the SNR beyond the +15 dB (up to about 40 dB). Before reaching the asymptote, a 10-dB increase of SNR obtained by filtering the noise had a larger impact on intelligibility than a corresponding 10-dB decrease of SNR obtained by filtering the target. These results question the use of the SNR range and the importance function adopted by the SII when considering sharply filtered signals.

Talk 28: Wednesday, 09:30

Dynamics of Cochlear Nonlinearity

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Dynamic aspects of cochlear mechanical compression were studied by recording basilar membrane (BM) vibrations evoked by tone pairs (“beat stimuli”) in the 11-19 kHz region of the gerbil cochlea. The frequencies of the stimulus components were varied to produce a range of “beat rates” at or near the characteristic frequency (CF) of the BM site under study, and the amplitudes of the components were balanced to produce near perfect periodic cancellations, visible as sharp notches in the envelope of the BM response. We found a compressive relation between instantaneous stimulus intensity and BM response magnitude that was strongest at low beat rates (e.g., 10 - 100 Hz). At higher beat rates, the amount of compression reduced progressively (i.e. the responses became linearized), and the rising and falling flanks of the response envelope showed increasing amounts of hysteresis; the rising flank becoming steeper than the falling flank. This hysteresis indicates that cochlear mechanical compression is not instantaneous, and is suggestive of a gain control mechanism having finite attack and release times. In gain control terms, the linearization that occurs at higher beat rates occurs because the instantaneous gain becomes smoothened, or low-pass filtered, with respect to the magnitude fluctuations in the stimulus. In terms of peripheral processing, the linearization corresponds to an enhanced coding, or decompresssion, of rapid amplitude modulations. These findings are relevant both to those who wish to understand the underlying mechanisms and those who need a realistic model of nonlinear processing by the auditory periphery.

Talk 29: Wednesday, 09:50

Responses of the Human Inner Ear to Low-Frequency Sound

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The perceptual insensitivity to low frequency (LF) sound in humans has led to an underestimation of the physiological impact of LF exposure on the inner ear. It is known, however, that intense, LF sound causes cyclic changes of indicators of inner ear function after LF stimulus offset, for which the term “Bounce” phenomenon has been coined. Here, we show that the mechanical amplification of hair cells (OHCs) is significantly affected after the presentation of LF sound. First, we show the Bounce phenomenon in slow level changes of quadratic, but not cubic, distortion product otoacoustic emissions (DPOAEs). Second, Bouncing in response to LF sound is seen in slow, oscillating frequency and correlated level changes of spontaneous otoacoustic emissions (SOAEs). Surprisingly, LF sound can induce new SOAEs which can persist for tens of seconds. Further, we show that the Bounce persists under free-field conditions, i.e. without an in-ear probe occluding the auditory meatus. Finally, we show that the Bounce is affected by contralateral acoustic stimulation synchronized to the ipsilateral LF sound. These findings clearly demonstrate that the origin of the Bounce lies in the modulation of cochlear amplifier gain. We conclude that activity changes of OHCs are the source of the Bounce, most likely caused by a temporary disturbance of OHC calcium homeostasis. In the light of these findings, the effects of long-duration, anthropogenic LF sound on the human inner ear require further research.

Talk 30: Wednesday, 10:10

Suppression Measured from Chinchilla Auditory-Nerve-Fiber Responses Following Noise-Induced Hearing Loss: Adaptive-Tracking and Systems-Identification Approaches

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The compressive nonlinearity of cochlear signal transduction, reflecting outer-hair-cell function, manifests as suppressive spectral interactions; e.g., two-tone suppression. Moreover, for broadband sounds, there are multiple interactions between frequency components. These frequency-dependent nonlinearities are important for neural coding of complex sounds, such as speech. Acoustic-trauma-induced outer-hair-cell damage is associated with loss of nonlinearity, which auditory prostheses attempt to restore with, e.g., “multi-channel dynamic compression” algorithms. Neurophysiological data on suppression in hearing-impaired (HI) mammals are limited. We present data on firing-rate suppression measured in auditory-nerve-fiber responses in a chinchilla model of noise-induced hearing loss, and in normal-hearing (NH) controls at equal sensation level. Hearing-impaired (HI) animals had elevated single-fiber excitatory thresholds (by ~20-40 dB), broadened frequency tuning, and reduced-magnitude distortion-product otoacoustic emissions; consistent with mixed inner- and outer-hair-cell pathology. We characterized suppression using two approaches: adaptive tracking of two-tone-suppression threshold (62 NH, and 35 HI fibers), and Wiener-kernel analyses of responses to broadband noise (91 NH, and 148 HI fibers). Suppression-threshold tuning curves showed sensitive low-side suppression for NH and HI animals. High-side suppression thresholds were elevated in HI animals, to the same extent as excitatory thresholds. We factored second-order Wiener-kernels into excitatory and suppressive sub-kernels to quantify the relative strength of suppression. We found a small decrease in suppression in HI fibers, which correlated with broadened tuning. These data will help guide novel amplification strategies, particularly for complex listening situations (e.g., speech in noise), in which current hearing aids struggle to restore intelligibility.

Talk 31: Wednesday, 11:10

Does Signal Degradation Affect Top-Down Processing of Speech?

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Speech perception is formed based on both the acoustic signal and listeners' knowledge of the world and semantic context. Access to semantic information can facilitate interpretation of degraded speech, such as speech in background noise or the speech signal transmitted via cochlear implants (CIs). This paper focuses on the latter, and investigates the time course of understanding words, and how sentential context reduces listeners' dependency on the acoustic signal for natural and degraded speech via an acoustic CI simulation. In an eye-tracking experiment we combined recordings of listeners' gaze fixations with pupillometry, to capture effects of semantic information on both the time course and effort of speech processing. Normal-hearing listeners were presented with sentences with or without a semantically constraining verb (e.g., crawl) preceding the target (baby), and their ocular responses were recorded to four pictures, including the target, a phonological (bay) competitor and a semantic (worm) and an unrelated distractor. The results show that in natural speech, listeners' gazes reflect their uptake of acoustic information, and integration of preceding semantic context. Degradation of the signal leads to a later disambiguation of phonologically similar words, and to a delay in integration of semantic information. Complementary to this, the pupil dilation data show that early semantic integration reduces the effort in disambiguating phonologically similar words. Processing degraded speech comes with increased effort due to the impoverished nature of the signal. Delayed integration of semantic information further constrains listeners' ability to compensate for inaudible signals.

Talk 32: Wednesday, 11:30

The Effect of Peripheral Compression on Syllable Perception Measured with a Hearing Impairment Simulator

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Hearing impaired (HI) people often have difficulty understanding speech in multi-speaker or noisy environments. With HI listeners, however, it is often difficult to specify which stage, or stages, of auditory processing are responsible for the deficit. There might also be cognitive problems associated with age. In this paper, a HI simulator, based on the dynamic, compressive gammachirp (dcGC) filterbank, was used to measure the effect of a loss of compression on syllable recognition. The HI simulator can counteract the cochlear compression in normal hearing (NH) listeners and, thereby, isolate the deficit associated with a loss of compression in speech perception. Listeners were required to identify the second syllable in a three-syllable "nonsense word", and between trials, the relative level of the second syllable was varied, or the level of the entire sequence was varied. The difference between the Speech Reception Threshold (SRT) in these two conditions reveals the effect of compression on speech perception. The HI simulator adjusted a NH listener's compression to that of the "average 80-year old" with either normal compression or complete loss of compression. A reference condition was included where the HI simulator applied a simple 30-dB reduction in stimulus level. The results show that the loss of compression has its largest effect on recognition when the second syllable is attenuated relative to the first and third syllables. This is probably because the internal level of

the second syllable is attenuated proportionately more when there is a loss of compression.

Talk 33: Wednesday, 11:50

Towards Objective Measures of Functional Hearing Abilities

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Aims: People with impaired hearing often have difficulties in hearing sounds in a noisy background. This ability relies partly on the capacity of the auditory system to process temporal information in the sound signal. In this study we examined the relationships between perceptual sensitivity to temporal fine-structure cues, brainstem encoding of complex harmonic and amplitude-modulated sounds, and the ability to understand speech in noise. Understanding these links will allow the development of an objective measure that could be used to detect changes in functional hearing before the onset of permanent threshold shifts. Methods: We measured TFS sensitivity and speech in noise performance (QuickSIN) behaviourally in 34 normally-hearing adults with ages ranging from 18 to 34 years. We recorded brainstem responses to complex harmonic sounds and a 4000 Hz carrier signal modulated at 110 Hz. We performed cross-correlations between the stimulus waveforms and scalp-recorded brainstem responses to generate a simple measure of stimulus encoding accuracy, and correlated these measures with age, TFS sensitivity and speech-in-noise performance. Results: Speech-in-noise performance was negatively correlated with TFS sensitivity and age. TFS sensitivity was also positively correlated with stimulus encoding accuracy for the complex harmonic stimulus, while increasing age was associated with lower stimulus encoding accuracy for the modulated tone stimulus. Conclusions: The results show that even in a group of people with normal hearing, increasing age was associated with reduced speech understanding, reduced TFS sensitivity, and reduced stimulus encoding accuracy (for the modulated tone stimulus). People with good TFS sensitivity also generally had more faithful brainstem encoding of a complex harmonic tone.

Talk 34: Thursday, 09:50

Connectivity in Language Areas of the Brain in Cochlear Implant Users as Revealed by fNIRS

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Many studies, using a variety of imaging techniques, have shown that deafness induces functional plasticity in the brain of adults with late-onset deafness, and in children changes the way the auditory brain develops. Cross modal plasticity refers to evidence that stimuli of one modality (e.g. vision) activate neural regions devoted to a different modality (e.g. hearing) that are

not normally activated by those stimuli. Other studies have shown that multimodal brain networks (such as those involved in language comprehension, and the default mode network) are altered by deafness, as evidenced by changes in patterns of activation or connectivity within the networks. In this paper, we summarise what is already known about brain plasticity due to deafness and propose that functional near-infra-red spectroscopy (fNIRS) is an imaging method that has potential to provide prognostic and diagnostic information for cochlear implant users. Currently, patient history factors account for only 10% of the variation in post-implantation speech understanding, and very few post-implantation behavioural measures of hearing ability correlate with speech understanding. As a non-invasive, inexpensive and user-friendly imaging method, fNIRS provides an opportunity to study both pre- and post-implantation brain function. Here, we explain the principle of fNIRS measurements and illustrate its use in studying brain network connectivity and function with example data.

Talk 35: Thursday, 10:10

Isolating Neural Indices of Continuous Speech Processing at the Phonetic Level

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The human ability to understand speech across an enormous range of listening conditions is underpinned by a hierarchical auditory processing system whose successive stages process increasingly complex attributes of the acoustic input. In order to produce a categorical perception of words and phonemes, it has been suggested that, while earlier areas of the auditory system undoubtedly respond to acoustic differences in speech tokens, later areas must exhibit consistent neural responses to those tokens. Neural indices of such hierarchical processing in the context of continuous speech have been identified using low-frequency scalp-recorded electroencephalography (EEG) data. The relationship between continuous speech and its associated neural responses has been shown to be best described when that speech is represented using both its low-level spectrotemporal information and also the categorical labelling of its phonetic features (Di Liberto et al., submitted). While the phonetic features have been proven to carry extra-information not captured by the speech spectrotemporal representation, the causes of this EEG activity remain unclear. This study aims to demonstrate a framework for examining speech-specific processing and for disentangling high-level neural activity related to intelligibility from low-level activity in response to spectrotemporal fluctuations of speech. Preliminary results suggest that neural measure of processing at the phonetic level can be isolated.

Talk 36: Thursday, 11:10

Brainstem Coding of Pitch – the Butte Hypothesis

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Pitch has been described as "the heart of hearing theory" (Plomp 2002), but its physiological underpinnings are unclear and have been much debated in preceding ISH meetings. I propose a new view in which a brainstem property plays a key role in the coding of periodicity. I refer to this property as "entracking", a contraction of entrained phase-locking. A robust code for pitch exists in the auditory nerve in the form of a pooled interspike interval (ISI) distribution (Cariani and Delgutte 1996), which resembles the stimulus autocorrelation function. An unsolved question is how such a representation could be grounded in physiology, as its computation seems to require a combination of coincidence detectors and a range of delays extending over many milliseconds. I propose a scalar rather than vector code of periodicity by virtue of coincidence detectors that code the dominant ISI directly into spike rate through entracking. Perfect entracking means that a neuron fires one spike per repetition period, so that the firing rate equals the repetition frequency. Key properties of entracking are that it improves with increasing SPL and that the number of entracking neurons increases with SPL. The main limitation in this code is the upper limit of firing (usually near 500 Hz). It is proposed that entracking provides a periodicity tag which is superimposed on a tonotopic analysis. At low SPLs and fundamental frequencies > 500 Hz, a spectral or place mechanism codes for pitch. With increasing SPL the place code degrades but entracking improves and first occurs in the neurons with the lowest thresholds for the spectral components present. The prediction is that populations of neurons extended across CF form plateaus ("buttes") of firing equaling the fundamental frequency. The core idea is that entracking brings a stratification to firing rate tied to periodicity.

Talk 37: Thursday, 11:30

Can Temporal Fine Structure and Temporal Envelope be Considered Independently for Pitch Perception?

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In psychoacoustics, works on pitch perception attempt to distinguish between envelope and fine structure cues that are generally viewed as independent and separated using a Hilbert transform. To empirically distinguish between envelope and fine structure cues in pitch perception experiments, a dedicated signal has been proposed. This signal is an unresolved harmonic complex tones with all harmonics shifted by the same amount of Hz. As the frequency distance between adjacent components is regular and identical than in the original harmonic complex tone, such a signal has the same envelope but a different fine structure. So, any perceptual difference between these signals is interpreted as a fine structure based percept. Here, as illustrated by very basic simulations, I suggest that this orthogonal point of view that is generally admitted could be a conceptual error. In fact, neither the fine structure nor the envelope is required to be fully encoded to explain pitch perception. Sufficient information is conveyed by the peaks in the fine structure that are located nearby a maximum of the envelope. Envelope and fine structure could then be in perpetual interaction and the pitch would be conveyed by "the fine structure under envelope". Moreover, as the temporal delay between peaks of interest is rather longer than the delay between two adjacent peaks of the fine structure, such a mechanism would be much less constrained by the phase locking limitation of the auditory system. Several data from the literature are discussed from this new conceptual point of view.

Talk 38: Thursday, 11:50

Locating Melody Processing Activity in Auditory Cortex with MEG

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This paper describes a technique for isolating the brain activity associated with melodic pitch processing. The magnetoencephalograhic (MEG) response to a four note, diatonic melody built of French horn notes, is contrasted with the response to a control sequence containing four identical, "tonic" notes. The transient response (TR) to the first note of each bar is dominated by energy-onset activity; the melody processing is observed by contrasting the TRs to the remaining melodic and tonic notes of the bar (2-4). They have uniform shape within a tonic or melodic sequence which makes it possible to fit a 4-dipole model and show that there are two sources in each hemisphere – a melody source in the anterior part of Heschl's gyrus (HG) and an onset source about 10 mm posterior to it, in anterior planum temporale (PT). The N1m to the initial

note has a short latency and the same magnitude for the tonic and the melodic sequences. The melody activity is distinguished by the relative sizes of the N1m and P2m components of the TRs to notes 2-4. In the anterior source a given note elicits a much larger N1m-P2m complex with a shorter latency when it is part of a melodic sequence. The TRs are accompanied by a sustained field (SF) originating from a source in HG near the melody source. However, the SF magnitude is of comparable size for the tonic and melodic bars. This study shows that melodies evoke activation in a separate, anterior part of auditory cortex.

Talk 39: Thursday, 14:00

Studying Effects of Transcranial Alternating Current Stimulation on Hearing and Auditory Scene Analysis

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Recent studies have shown that perceptual detection of near-threshold auditory events may depend on the timing of the event, relative to the phase of ongoing brain oscillations (i.e., periodic fluctuations in neural excitability). It has been further shown that transcranial alternating current stimulation (tACS), a non-invasive and silent brain stimulation technique, can entrain ongoing cortical alpha oscillations and thereby offer some experimental control over the phase of these oscillations. Based on these and related alpha-tACS findings, the present study investigates the potential of delta/theta-tACS to modulate hearing and auditory scene analysis in normally-hearing listeners. Detection performance is measured in silence or in a multi-tone background for near-threshold auditory stimuli that are modulated at 4Hz and presented at various moments (phase lags) during ongoing oscillatory electric stimulation (two synchronous 4-Hz alternating currents applied transcranially and simultaneously to the two cerebral hemispheres). Preliminary results indicate that performance fluctuates as a function of phase lag, and these fluctuations can be explained best by a sinusoid whose frequency matches that of the tACS. This suggests that tACS may amplify/attenuate sounds that are temporally coherent/anticoherent with it and thereby enhance/reduce their audibility.

Talk 40: Thursday, 14:20

Functional Organization of the Ventral Auditory Pathway

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The fundamental problem in audition is determining the mechanisms required by the brain to transform an unlabelled mixture of auditory stimuli into coherent perceptual representations. This process is called auditory-scene analysis. The perceptual representations that result from auditory-scene analysis are formed through a complex interaction of perceptual grouping, attention, categorization and decision-making. Despite a great deal of scientific energy devoted to understanding these aspects of hearing, we still do not understand (1) how sound perception arises from neural activity and (2) the causal relationship between neural activity and sound perception. Here, we review the role of the “ventral” auditory pathway in sound perception. We hypothesize that, in the early parts of the auditory cortex, neural activity reflects the auditory properties of a stimulus. However, in latter parts of the auditory cortex, neurons encode the sensory evidence that forms an auditory decision and are causally involved in the decision process. Finally, in the prefrontal cortex, which receives input from the auditory cortex, neural activity reflects the actual perceptual decision. Together, these studies indicate that the ventral pathway contains hierarchical circuits that are specialized for auditory perception and scene analysis.

Talk 41: Thursday, 14:40

Neural Segregation of Concurrent Speech: Effects of Background Noise and Reverberation on Auditory Scene Analysis in the Ventral Cochlear Nucleus

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Concurrent complex sounds (e.g., two voices speaking at once) are perceptually disentangled into separate "auditory objects". This neural processing often occurs in the presence of acoustic-signal distortions from noise and reverberation (e.g., in a busy restaurant). A difference in periodicity between sounds is a strong segregation cue under quiet, anechoic conditions. However, noise and reverberation exert differential effects on speech intelligibility under "cocktail-party" listening conditions. Previous neurophysiological studies have concentrated on understanding auditory scene analysis under ideal listening conditions. Here, we examine the effects of noise and reverberation on periodicity-based neural segregation of concurrent vowels /a/ and /i/, in the responses of single units in the guinea-pig ventral cochlear nucleus (VCN): the first processing station of the auditory brain stem. In line with human psychoacoustic data, we find reverberation significantly impairs segregation when vowels have an intonated pitch contour, but not when they are spoken on a monotone. In contrast, noise impairs segregation independent of intonation pattern. These results are informative for models of speech processing under ecologically valid listening conditions, where noise and reverberation abound.

Talk 42: Thursday, 15:00

Audio Visual Integration with Competing Sources in the Framework of Audio Visual Speech Scene Analysis

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We introduce "Audio-Visual Speech Scene Analysis" (AVSSA) as an extension of the two-stage Auditory Scene Analysis model towards audiovisual scenes made of mixtures of speakers. AVSSA assumes that a coherence index between the auditory and the visual input is computed prior to audiovisual fusion, enabling to determine whether the sensory inputs should be bound together. Previous experiments on the modulation of the McGurk effect by audiovisual coherent vs. incoherent contexts presented before the McGurk target have provided experimental evidence supporting AVSSA. Indeed, incoherent contexts appear to decrease the McGurk effect, suggesting that they produce lower audiovisual coherence hence less audiovisual fusion. The present experiments extend the AVSSA paradigm by creating contexts made of competing audiovisual sources and measuring their effect on McGurk targets. The competing audiovisual sources have respectively a high and a low audiovisual coherence (that is, large vs. small audiovisual comodulations in time). The first experiment involves contexts made of two auditory sources and one video source associated to either the first or the second audio source. It appears that the McGurk effect is smaller after the context made of the visual source associated to the auditory source with less audiovisual coherence. In the second experiment with the same stimuli, the participants are asked to attend to either one or the other source. The data show that the modulation of fusion depends on the attentional focus. Altogether, these two experiments shed light on audiovisual binding, the AVSSA process and the role of attention.

Talk 43: Thursday, 16:00

Relative Pitch Perception and the Detection of Deviant Tone Patterns

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Most people are able to recognise familiar tunes even when played in a different key. It is assumed that this depends on a general capacity for relative pitch perception; the ability to recognise the pattern of inter-note intervals that characterises the tune. However, when healthy adults are required to detect rare deviant melodic patterns in a sequence of randomly transposed standard patterns they perform close to chance. Musically experienced participants perform better than naïve participants, but even they find the task difficult, despite the fact that musical education includes training in interval recognition. To understand the source of this difficulty we designed an experiment to explore the relative influence of the size of within-pattern intervals and between-pattern transpositions on detecting deviant melodic patterns. We found that task difficulty increases when patterns contain large intervals (5-7 semitones) rather than small intervals (1-3 semitones). While task difficulty increases substantially when transpositions are introduced, the effect of transposition size (large vs small) is weaker. Increasing the range of permissible intervals to be used also makes the task more difficult. Furthermore, providing an initial exact repetition followed by subsequent transpositions does not improve performance. Although musical training correlates with task performance, we find no evidence that violations to musical intervals important in Western music (i.e. the perfect fifth or fourth) are more easily detected. In summary, relative pitch perception does not appear to be conducive to simple explanations based exclusively on invariant physical ratios.

Talk 44: Thursday, 16:20

Neural Correlates of Auditory-Tactile Integration in Musical Meter Perception

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Previously we reported that auditory and tactile inputs are seamlessly integrated to form the percept of meter in human subjects (Huang, et al. 2012). In this study, we examined the neural correlates of auditory and tactile integration in meter perception. Event Related Potentials (ERP) was recorded from 15 human subjects while they were presented with unimodal auditory, unimodal tactile or bimodal sequences. We report that the ERP signals corresponding to missing notes are similar to those induced by both the metrically important and unimportant auditory or tactile notes depending on the testing conditions. The results demonstrate that ERP can be induced without actual sensory input (either auditory or tactile) as long as the “virtual” notes are embedded in a sequence with a valid meter structure. Furthermore, the ERP components corresponding to bimodal sequences are determined by the modality of the metrically important notes, but not the physical sensory properties of the notes. The shape of ERP induced by tactile notes in a sequence could be auditory ERP as long as the metrical important notes were auditory stimulation, and vice versa. These results demonstrate neural correlates of auditory

and tactile integration of meter perception. Our findings further suggest that either auditory or tactile modality can play a dominant role in the processing of meter information.

Talk 45: Thursday, 16:40

Do Zwicker Tones Evoke a Musical Pitch?

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It has been argued that musical pitch, i.e. pitch in its strictest sense, requires phase locking at the level of the auditory nerve. The aim of the present study was to assess whether a musical pitch can be heard in the absence of peripheral phase locking, using Zwicker tones (ZTs). A ZT is a faint, decaying tonal percept that arises after listening to a band-stop (notched) broadband noise. The pitch is within the frequency range of the notch. Several findings indicate that ZTs are unlikely to be produced mechanically at the level of the cochlea and, therefore, there is unlikely to be phase locking to ZTs in the auditory periphery. In stage I of the experiment, musically trained subjects adjusted the frequency, level, and decay time of an exponentially decaying sinusoid so that it sounded similar to the ZT they perceived following a broadband noise, for various notch positions. In stage II, subjects adjusted the frequency of a sinusoid so that its pitch was a specified musical interval below that of either a preceding ZT or a preceding sinusoid (as determined in stage I). Subjects selected appropriate frequency ratios for ZTs, although the standard deviations of the adjustments were larger for the ZTs than for the equally salient sinusoids by a factor of 1.1-2.2. The results suggest that a musical pitch may exist in the absence of peripheral phase locking.

Talk 46: Friday, 09:30

Speech Coding in the Midbrain: Effects of Sensorineural Hearing Loss

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In response to voiced speech sounds, auditory-nerve (AN) fibres phase-lock to both harmonics near best frequency (BF) and to the fundamental frequency (F0) of voiced sounds. Due to nonlinearities in the healthy ear, phase-locking in each frequency channel tends to be dominated either by a single harmonic, for channels tuned near formants, or by F0, for channels between formants. The alternating dominance of these factors sets up a robust pattern in the F0-synchronized rate across best frequency (BF). This profile of a temporally coded measure is transformed into a mean rate profile at the level of the midbrain (inferior colliculus, IC), where neurons are sensitive to low-frequency fluctuations. In the impaired ear, the F0-synchronized rate profile is affected by several factors: Reduced synchrony capture decreases the dominance of a single harmonic near BF on the response, resulting in more widespread F0-synchrony. Elevated thresholds also reduce the effect of rate saturation, resulting in increased F0-synchrony. Wider peripheral tuning results in a wider-band envelope with reduced F0 amplitude. In general, sensorineural hearing loss reduces the contrast in AN F0-synchronized rates across BF. Here, we use computational models for AN and IC neurons to illustrate the F0-synchronized rate profiles set up in response to voiced speech sounds. The IC models include those for neurons with band-enhanced, band-suppressed, and hybrid modulation transfer functions. These models provide an illustration of the effects of peripheral hearing loss on central representations of voiced speech sounds.

Talk 47: Friday, 09:50

Sources of Variability in Consonant Perception and Implications for Speech Perception Modeling

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The present study investigated the influence of various sources of response variability in consonant perception. A distinction was made between source-induced variability and receiver-related variability. The former refers to perceptual differences induced by differences in the speech tokens and/or the masking noise tokens; the latter describes perceptual differences caused by within- and across-listener uncertainty. Consonant-vowel combinations (CVs) were presented to normal-hearing listeners in white noise at six different signal-to-noise ratios. The obtained responses were analyzed with respect to the considered sources of variability using a measure of the perceptual distance between responses. The largest effect was found across different CVs. For stimuli of the same phonetic identity, the speech-induced variability across and within talkers and the across-listener variability were substantial and of similar magnitude. Even time-shifts in the waveforms of white masking noise produced a significant effect, which was well above the within-listener variability (the smallest effect). Two auditory-inspired models in combination with a template-matching back end were considered to predict the perceptual data. In particular, an energy-based and a modulation-based approach were compared. The suitability of the two models was evaluated with respect to the source-induced perceptual distance and in terms of consonant recognition rates and consonant confusions. Both models captured the source-induced perceptual distance remarkably well. However, the modulation-based approach showed a better agreement with the data in terms of consonant recognition and confusions. The results indicate that low-frequency modulations up to 16 Hz play a crucial role in consonant perception.

Talk 48: Friday, 10:10

On Detectable and Meaningful Speech-Intelligibility Benefits

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The most important parameter that affects the ability to hear and understand speech in the presence of background noise is the signal-to-noise ratio (SNR). Despite decades of research in speech intelligibility, it is not currently known how much improvement in SNR is needed to provide a meaningful benefit to someone. We propose that the underlying psychophysical basis to a meaningful benefit should be the just noticeable difference (JND) for SNR. The SNR JND was measured in a series of experiments using both adaptive and fixed-level procedures across participants of varying hearing ability. The results showed an average SNR JND of approximately 3 dB for sentences in same-spectrum noise. The role of the stimulus and link to intelligibility was examined by measuring speech-intelligibility psychometric functions and comparing the intelligibility JND estimated from those functions with measured SNR JNDs. Several experiments were then conducted to establish a just meaningful difference (JMD) for SNR. SNR changes that could induce intervention-seeking behaviour for an individual were measured with subjective scaling and report, using the same stimuli as the SNR JND experiment as pre- and post-benefit examples. The results across different rating and willingness-to-change tasks showed that the mean ratings increased near linearly with a change in SNR, but a change of at least 6 dB was necessary to reliably motivate participants to seek intervention. The magnitude of the JNDs and JMDs for speech-intelligibility benefits measured here suggest a gap between what is achievable and what is meaningful.

Talk 49: Friday, 11:10

Individual Differences in Behavioral Decision Weights Related to Irregularities in Cochlear Mechanics

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An unexpected finding of previous psychophysical studies is that listeners show highly replicable, individualistic patterns of decision weights on frequencies affecting their performance in spectral discrimination tasks – what has been referred to as individual listening styles (Doherty and Lutfi, 1996; Lutfi and Liu, 2007; Jesteadt et al., 2014). We, like many other researchers, have attributed these listening styles to peculiarities in how listeners attend to sounds, but we now believe they partially reflect irregularities in cochlear micromechanics affecting what listeners hear. The most striking evidence for cochlear irregularities is the presence of low-level spontaneous otoacoustic emissions (SOAEs) measured in the ear canal and the systematic variation in stimulus frequency otoacoustic emissions (SFOAEs), both of which result from back-propagation of waves in the cochlea. SOAEs and SFOAEs vary greatly across individual ears and have been shown to affect behavioural thresholds, behavioural frequency selectivity and judged loudness for tones (Long and Tubis, 1988, Baiduc, Lee and Dhar, 2012, Mauermann, Long and Kollmeier, 2004). The present paper reports pilot data providing evidence that SOAEs and SFOAEs are also predictive of the relative decision weight listeners give to a pair of tones in a level discrimination task. In one condition the frequency of one tone was selected to be near that of an SOAE and the frequency of the other was selected to be in a frequency region for which there was no detectable SOAE. In a second condition the frequency of one tone was selected to correspond to an SFOAE maxima, the frequency of the other tone, an SFOAE minima. In both conditions a statistically significant correlation was found between the average relative decision weight on the two tones and the difference in OAE level.

Talk 50: Friday, 11:30

On the Interplay between Cochlear Gain Loss and Temporal Envelope Coding Deficits

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Hearing impairment is characterized by two components: (i) cochlear gain loss that yields wider auditory filters and elevated hearing thresholds, and (ii) cochlear neuropathy, a noise induced aspect of hearing loss that may impact temporal coding fidelity of supra-threshold sound. This study uses a psychoacoustic amplitude modulation (AM) detection task in quiet and multiple noise backgrounds to test whether these aspects of hearing loss can be isolated in listeners with normal to mildly impaired hearing ability. Psychoacoustic results were correlated to hearing threshold, categorical loudness scaling, distortion product otoacoustic emission (DPOAE) thresholds and envelope-following response (EFR) measures. AM thresholds to noise carriers (4 kHz octave-wide) depended on DPOAE thresholds and associated cochlear compression levels. The amount with which wideband masking noise (1 octave) worsened 4 kHz pure-tone AM thresholds was inversely correlated to DPOAE thresholds in correspondence to a compression loss benefit, while the amounts with which narrowband noise maskers (40 Hz) worsened per-

formance was not. While the latter condition was designed to reduce temporal coding ability within an auditory filter, the correlation with the EFR measures was weak. This study elucidates how psychoacoustic difference measures can be adopted in the differential diagnostics of hearing deficits in listeners with mixed pathologies.

Talk 51: Friday, 11:50

Frequency Tuning of the Human Efferent Effect on Cochlear Gain

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Cochlear gain reduction via efferent feedback from the medial olivocochlear bundle (MOCB) is frequency specific (Guinan, 2010). The present study with humans used the Fixed Duration Masking Curve (FDMC) psychoacoustical method (Yasin et al., 2013a,b, 2014) to estimate the frequency specificity of the efferent effect at the cochlear level. The combined duration of the masker-plus-signal stimulus was 25 ms, within the efferent onset delay of about 31-43 ms (James et al., 2002). Masker level (4.0 or 1.8 kHz) at threshold was obtained for a 4-kHz signal in the absence or presence of an ipsilateral 60-dB SPL, 160-ms precursor (200-Hz bandwidth) centred at frequencies between 2.5 and 5.5 kHz. Efferent-mediated cochlear gain reduction was greatest for precursors with frequencies the same as, or close to that of, the signal (gain was reduced by about 20 dB), and least for precursors with frequencies well removed from that of the signal (gain remained at around 40 dB). The tuning of the efferent effect filter (tuning extending 0.5 to 0.7 octaves above and below the signal frequency) is within the range obtained in humans using otoacoustic emissions (OAEs) (Lilaonitkul and Guinan, 2009; Zhao and Dhar, 2012). The 10-dB bandwidth of the efferent-effect filter at 4000 Hz was about 1100 Hz (Q10 of 3.5). The FDMC method can be used to provide an unbiased measure of the bandwidth of the efferent effect filter using ipsilateral efferent stimulation.

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