Advanced Psychoacoustics: Theory, Practice and Modelling

This 5-day intensive course will address topics in psychoacoustics' theoretical framework, laboratory techniques and methodologies, as well as perceptual-based modelling. While the curriculum has a broad perspective, a special focus will be on researchers who work in the domain of Reverberation and Dereverberation, in an audio signal-processing context, as the School is mainly financed by the European DREAMS project. The course program is designed to provide a collection of advanced topics in psychoacoustics, where experts will provide the participants with a thorough insight to a set of pre-selected topics, over lectures, workshops, ThinkTanks and master classes. Although a brief introduction to general psychoacoustics will be given on the first day, the attendee is expected to be confident with basic and/or audio signal processing, auditory modelling.

Programme at a Glance

Topic 1: Introduction to Psychoacoustics
Speakers: Dorte Hammershøi

Topic 2: Advanced Psychoacoustics –Latest Research Updates
Speakers: Steven van De Par

Topic 3A: Auditory Modelling – Psychoacoustical perspective
Speakers: Jasper van Dorp Schuitman

Topic 3B: Auditory Modelling – Cognitive perspective
Speakers: Jan Larsen

Topic 4A: Experiments in Psychophysics/ Psychometrics
Speakers: Wolfgang Ellermeier

Topic 4B: Perceptual Evaluation & Experimental Design
Speakers: Nick Zacharov & Søren Bech

Topic 5: Binaural Technology and Virtual Reality
Speakers: Alexander Raake & Alexander Lindau

Topic 6: Sound Perception in Rooms
Speakers: Tapio Lokki

Topic 7: Reverberation's Psychoacoustics
Speakers: Tapio Lokki, Alexander Lindau

Workshops

W1 - MATLAB / Signal Processing Workshop (Alexander Lindau, Jasper van Dorp Schuitman)
- Room Acoustic Simulation and Auralisation
- Auditory Modelling

W2 - Perceptual Evaluation (Nick Zacharov)
- Designing and Running an Experimental Design
- Data Analysis

Schedule

The schedule is presented below. The school starts **at 8:00 on Monday, and finishes at 17:00 on Friday**. Please note the full schedule from early morning to late evening.

	Monday	Tuesday	Wednesday	Thursday	Friday	
7:00	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**	7:00
8:00	**Welcome (15mins)** **Topic 1 - Psychoacoustics** Dorte Hammershøi Slot 1 75mins	**Topic 3A - Auditory Modelling** Jasper van Dorp Schuitman Slot 7 90 mins	**Topic 4A - Psychophysics** Wofgang Ellermeier Slot 13 90 mins	**Topic 5 Lecture** Alexander Raake Alexander Lindau Slot 19 90 mins	**Topic 6 Sound in Rooms** Tapio Lokki Slot 25 90 mins	8:00
9:30	**Break 1 (15m)**	**Break 1 (15m)**	**Break 1 (15m)**	**Break 1 (15m)**	**Break 1 (15m)**	9:30
9:45	**Topic 1 - Psychoacoustics** Dorte Hammershøi Slot 2 90mins	**Topic 3A - Auditory Modelling** Jasper van Dorp Schuitman Slot 8 90 mins	**Topic 4A - Psychophysics** Wofgang Ellermeier Slot 14 90 mins	**Topic 5 - Binaural & VR** Alexander Raake Alexander Lindau Slot 20 90 mins	**Topic 6 Sound in Rooms** Tapio Lokki Slot 26 90 mins	9:45
11:15	**Break 2 (15m)**	**Break 2 (15m)**	**Break 2 (15m)**	**Break 2 (15m)**	**Break 2 (15m)**	11:15
11:30	**Topic 1 - Psychoacoustics** Dorte Hammershøi Slot 3 60 mins	**Topic 3A - Auditory Modelling** Jasper van Dorp Schuitman Slot 9 60 mins	**Topic 4A - Psychophysics** Wofgang Ellermeier Slot 15 60 mins	**Topic 5 - Binaural & VR** Alexander Raake Alexander Lindau Slot 21 60 mins	**Topic 7 - Reverberation Psych.** Alexander Lindau Tapio Lokki Slot 27 60 mins	11:30
12:30	**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**	12:30
13:30	**Team / Outdoor Activities** 60 minutes	**Workshop 1 - Introduction** Jasper van Dorp Schuitman Alexander Lindau Slot 10 105 mins	**Topic 4B - Perceptual Audio Evaluation** Søren Bech Nick Zacharov Slot 16 105 mins	**Team / Outdoor Activities** 45 minutes	**Topic 7 - Reverberation Psych.** Alexander Lindau Tapio Lokki Slot 28 90 mins	13:30
14:15				**Topic 5 - Binaural & VR** Al. Raake & Al. Lindau Slot 22 60 mins		14:15
14:30	**Topic 2 - Adv. Psychoacoustics** Steven van de Par Slot 4 45 mins				**Break 3 (15m)**	14:45
15:00					**PANEL - Topic 7 - Rev. Psych** Alexander Lindau Tapio Lokki Slot 29 105 mins	15:00
15:15	**Break 3 (15m)**	**Break 3 (15m)**	**Break 3 (15m)**	**Break 3 (15m)**		
15:30	**Topic 2 - Adv. Psychoacoustics** Steven van de Par Slot 5 105mins	**Topic 3B - Cognitive Modelling** Jan Larsen Slot 11 105mins	**Topic 4B - Perceptual Audio Evaluation** Søren Bech Nick Zacharov Slot 17 105 mins	**Topic 5 - Lecture** Alexander Raake Alexander Lindau Slot 23 105 mins		
16:45					**Coffee Wrap-up** **Taxi-Transports**	16:45
17:15	**Break 4 (15m)**	**Break 4 (15m)**	**Break 4 (15m)**	**Break 4 (15m)**		
17:30	**Topic 2 - Adv. Psychoacoustics** Steven van de Par **Practical Session** Slot 6 105mins	**Topic 3B - Cognitive Modelling** Jan Larsen **Practical Session** Slot 12 105 mins	**Workshop 2 - Perceptual Evaluation** Nick Zacharov Slot 18 105 mins	**Workshop 1 - Modelling** Jasper van Dorp Schuitman Alexander Lindau Slot 24 105 mins		17:30
19:15	**Town Visit** **& DINNER**	**DINNER**	**DINNER**	**DINNER**		19:15
20:30		Break	Break	Break		20:30
21:00	**Outdoor Activities**	**Demo 1** SIP Demos	**Demo 2** Bang & Olufsen	**Demo 3** Aalto "Loudspeaker Orchestra"		21:00
	Topic 1 & 2	**Topic 3**	**Topic 4**	**Topic 5**	**Topic 6&7**	
Workshop		Modelling Intro+		Modelling		
Workshop			Perceptual Evaluation			

Expected preparation

Besides having basic knowledge about the auditory system and auditory processing, the invited lecturers have been encouraged to recommend papers or material providing a sound basis for understanding the topics covered. The list below will be regularly updated with recommendations. This preparatory list is accounted towards ETCS of the school.

Each topic lists a required material to be covered before the course commences. This material accounts towards better understanding of the lecture, and also the ECTS points awarded for the school as whole.

Course Details

Topic 1 – Introduction to Psychoacoustics (Slot 1,2,3)

Speaker: Dr. Dorte Hammershøi, *Professor Aalborg University.*



Dorte Hammersøi will provide a crash course on basic psychoacoustics, as a quick review for people who have already been exposed to psychoacoustic research before, through books or research studies; i.e. the required reading prior to join the PhD School. This 4-hour lecture should provide a solid background in psychoacoustic discoveries, and support these with the 'biggest discoveries' in psychoacoustics over the last decade. Within this lecture, Dorte will create the framework of the whole course, linking physiology and psychoacoustic findings to higher levels of auditory cognition, and their simulations, the auditory models, and testing methodologies.

Subjects include:

a. Physiology of the auditory system
b. Frequency selectivity, Masking, Frequency decomposition
c. Timbre, Pitch Processing and Loudness
d. Sound Localisation
e. Temporal Processing / Precedence effect
f. Perceptual Effects
g. Binaural Hearing – Basics

Pre-requisites:

1. Chapter 1-3*: Blauert J., (1997), Spatial Hearing the Psychophysics of human Sound Localisation. MIT Press.
2. Chapter 1-4: Moore B.C. (2012), An introduction to Psychology of hearing, 6th Edition Cambridge: Emerald

Recommended:

3. Chapter 4-5*: Blauert J., (1997), Spatial Hearing the Psychophysics of human Sound Localisation. MIT Press.
4. Chapter 5-6,8: Moore B.C. (2012), An introduction to Psychology of hearing, 6th Edition Cambridge: Emerald

* Chapter 1 (all), Chapter 2: pages 36-54 (54-63 cursory), 63-70 (71-77 cursory), 78-116 (116-137 cursory), 137-177 (177-200 optional), Chapter 3: pages 201-237, (238-271 cursory), 271-282, (282-287 cursory).

Topic 2: Advanced Psychoacoustics – Latest Research (Slot 4-6)

Speaker: Dr. Steven van de Par, Professor *University of Oldenburg.*



Steven van de Par will provide a thorough overview of more complex auditory processes, i.e. Binaural Hearing, Binaural Dereverberation, Binaural Correlation Perception, Auditory Segregation and extend to higher levels of processing such as auditory attention, auditory memory, bottom-up versus top-down processing.

Subjects include:

a. Advanced Topics in Binaural Hearing (Extend from Topic 1)
    a. Auditory Representation
    b. Precedence effect
    c. BMLD
    d. Correlation Perception
b. Higher Auditory Processing
    a. Auditory Scene Analysis
    b. Auditory Segregation
    c. Auditory Attention
    d. Multi-modal integration
c. Reverberation
    a. What does Reverberation change at the signal level?
    b. What does it change in the auditory representation?
d. Sound Reproduction: the Room-in-room phenomenon
    a. Consequences at the signal level
    b. Perceptual effects
e. Modelling of speech intelligibility
    a. Measuring speech intelligibility
    b. Monaural models of speech intelligibility
    c. Binaural models of speech intelligibility
f. Latest research in auditory modeling

The last part of the lecture will include Q&A session where the audience and the lecturer will bounce front and back ideas and discussion allowing the discussion of audience's specific projects.

Pre-requisites:

1. Cooke, M. (2006). "A glimpsing model of speech perception in noise," J. Acoust. Soc. Am., 119, 1562–1573.
2. Beutelmann, R., and Brand, T. (2006). "Prediction of speech intelligibility in spatial noise and reverberation for normal-hearing and hearing-impaired listeners," J. Acoust. Soc. Am., 120, 331–342.

Topic 3A: Auditory Modelling – Psychoacoustical perspective (Slot 7-9)

Speakers: Dr. Jasper van Dorp Schuitman, *Senior Scientist at Civolution*



Jasper will review the major auditory models existing to date, and provide his insights regarding the state-of-the-art, the models' ability to predict JNDs, or higher levels of processing (i.e. localisation, loudness), as well as their known limitations and potential advances. As an educative follow up, it is expected a detailed description of each modelling step will be given, i.e. outer ear-to-cochlea for spectral perception, auditory nerve capacitance for excitation patterns.

Subjects include:

a. Auditory Modelling
   I. Various stages of Auditory system
   II. Common models for the various stages and their (dis)advantages
   III. Fitting all blocks together – What do we need?

b. Applications of Auditory Modelling
   I. Audio Coding
   II. Loudness Estimation
   III. Evaluation of Audio Quality
   IV. And more..!

c. Auditory modelling and Room Acoustics
   I. Quality assessment of room acoustics

Pre-requisites:

1. Van Dorp Schuitman, J.; De Vries, D. & Lindau, A. (2013), "Deriving content-specific measures of room acoustic perception using a binaural, nonlinear auditory model", Journal of the Acoustical Society of America, vol. 133 (3), pp. 1572-1585
2. Breebaart, D. J.; van de Par, S. & Kohlrausch, A. (2001), "Binaural processing model based on contralateral inhibition. I. Model structure", Journal of the Acoustical Society of America, vol. 110 (2), pp. 1074-1088
3. Thiede, T.; Treurniet, W.; Bitto, R.; Schmidmer, C.; Sporer, T.; Beerends, J. & Colomes, C. (2000), "PEAQ -- The ITU standard for objective measurement of perceived audio quality", Journal of the Audio Engineering Society, vol. 48, pp. 3-29

Topic 3B: Cognitive Audio Information Modelling (Slot 11,12)

Speakers: Dr Jan Larsen, Associate Professor, Technical University of Denmark, DTU.



We will address cognitive audio information modelling as the possibilities to extend the current systems engineering paradigm in order to perceive, learn, reason and interact robustly in open-ended changing environments integration all available information – from raw audio information sources to user-driven feedback, annotations and description.

Machine learning models that learn from audio and metadata and previous knowledge will play an increasingly important role in all levels of cognition as large real world digital environments (such as the Internet) usually are too complex to be modeled within a limited set of predefined specifications.

There is further a need for automatic extraction and organization of meaning, purpose, and intentions in interplay with the environment (machines, artefacts and users) beyond current systems with build-in semantic representations —in particular in terms of the interaction with users (users-in-the-loop models) through user models and user interaction models.

Cognitive information modelling is an emerging trends and will likely play an increasing important role in the audio and sound communities in the coming years.

Subjects Include:

a. Modeling emotional expressions in music
b. Learning users audio preference
c. Matlab exercise in audio preference learning

Pre-requisites:

1. Kenneth E. Train: Discrete Choice Methods with Simulation, Cambridge, 2009. Chapters: 1,2,3.1-3.3.
2. C. E. Rasmussen & C. K. I. Williams; Gaussian Processes for Machine Learning, MIT Press, 2006,
3. Chapters 1,2: Patrick N. Juslin and Daniel Västfjäll: Emotional responses to music: The need to consider underlying mechanisms, Behavaioral and Brain Sciences, vol. 31, pp. 559–621, 2008.

Specific modelling used in exercise:

1. Jens Madsen, Bjørn Sand Jensen, Jan Larsen: Predictive Modeling of Expressed Emotions in Music Using Pairwise Comparisons, 9th International Symposium, CMMR 2012, London, UK, June 19-22, 2012, Revised Selected Papers, Part IV, pp. 253-277, 2013.
2. Jens Brehm Nielsen, Bjørn Sand Jensen, Toke Jansen Hansen, and Jan Larsen: Personalized Audio Systems - a Bayesian Approach, Proceedings AES 135th Convention, NYC, 17-20 Oct., 2013.

Danish PhD students may request the material from Psychoacoustics@dreams-itn.eu , as part of Danish Universities regulations (CopyDAN).

Topic 4A: Experiments in Psychophysics/ Psychometrics (Slot 13-15)

Speakers: Wolfgang Ellermeier, Professor, Technical University of Darmstadt



Wolfgang Ellermeier will review the existing experimental procedures in psychophysics and focus on techniques adapted for psychoacoustics, i.e. measuring thresholds, distinguishing sensitivity and bias, scaling suprathreshold sensations, and identifying relevant auditory attributes in the first place. He will cover the merits and shortcomings of each technique and specify 'best practice' to given applications., and issues raised with individual differences.

a. What Is 'Measurement' In Psychophysics?
    i. Axiomatic measurement theory
    ii. An application to fluctuation strength
b. Measuring Thresholds
    i. Fechner's classical methods
    ii. Criterion problem
    iii. Adaptive procedures
c. Signal Detection Theory
    i. Theory, Procedures, Applications
d. Suprathreshold Measurement Of Auditory Sensations
    i. Determining equal sensation: Intramodal matches
    ii. Indirect Scaling vs. direct Scaling
    iii. Scaling based on paired comparisons
    iv. Stevens' magnitude estimation
    v. Scaling via reaction time (RT)
e. Problems In Suprathreshold Scaling
    i. Multi-dimensionality
    ii. Individual vs. group data: Strategies
    iii. Scaling extraaural sound effects, e.g. annoyance
f. Identifying Sound Attributes
    i. Descriptive analysis
    ii. Repertory grid method
    iii. Perceptual structure analysis

<u>Suggested Reading:</u>

Gelfand, S.A. (2009). Hearing. An introduction to psychological and physiological acoustics (5th edition). Colchester, U.K.: Informa. [Chap. 7: Psychoacoustic methods. pp. 146-159]

Gescheider, G.A. (1997). Psychophysics. The fundamentals (3rd edition). Mahwah, N.J.: Lawrence Erlbaum. [Chap. 5, pp. 105-124,``The Theory of Signal Detection'']

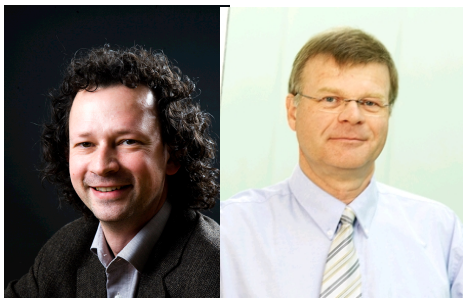
Susini,P., Lemaitre,G. & McAdams, S. (2012). Psychological measurement for sound description and evaluation. In B. Berglund, G.B. Rossi, J.T Townsend

L.R. Pendrill (Eds.), Measurement with Persons: Theory, Methods, and Implementation Areas (pp. 227-253). New York: Psychology Press.

Bech, S. & Zacharov, N. (2006). Perceptual Audio Evaluation. Chichester, U.k.: Wiley. [Chap. 4: Quantification of Impression, pp. 39-96]

Topic 4B: Perceptual Evaluation & Experimental Design (Slot 16,17)

Speakers: Nick Zacharov, Senior Acoustic and Sensory Technologist, DELTA A/S (on Left)
Søren Bech, Head of Research, Bang & Olufsen, Professor, Aalborg University (on Right)



Søren's and Nick's lectures will provide an overview of the topic of Perceptual Audio Evaluation. In practical terms the lecture will walk you through the process of designing listening tests and running then, taking into consideration matters such as defining a test hypothesis, selection of a suitable test and scaling method, thought to the basics of experimental design and statistical analysis. The lectures will also look at the differences between affective consumer testing and expert descriptive analysis and finally some important technical considerations will be discussed. Following the lectures a tutorial will occur allowing all students to build, perform and analyse a listening tests. This dense tutorial will allow all student to experience first hand the process and gain an understanding of practical analysis of data.

Subjects include:

a. Definition of research question and hypothesis
b. Definition of the question to the assessor
c. Definition of the response format
d. Basic statistical design of tests
e. Listening panels, assessors type and selection procedures
f. Affective and descriptive analysis methods
g. Introduction to workshop on Perceptual evaluation in practice

Pre-requisites:

1. Chapter 4-6: Søren Bech & Nick Zacharov, "Perceptual Audio Evaluation - Theory, Method and Application", Wiley ISBN:9780470869246
2. Each participant with a laptop and internet Connection
3. Preinstall Microsoft SilverLight

Recommended:

Chapter 1-3 & 8 in Bech and Zacharov (2006)

Tormod Næs, Per Brockhoff, Oliver Tomic, (2011), Statistics for Sensory and Consumer Science, John Wiley & Sons ISBN: 1119957249, 9781119957249

Topic 5: Binaural Technology and Virtual Reality (Slot 19-23)

Speakers: Professor, Dr. Alexander Raake – Assessment of IP-based Applications, Deutsche Telekom Innovation Labs (T-Labs), TU Berlin (on Left) *and Dr. Alexander Lindau* Senior Researcher at Audio Communication Group, TU Berlin



Our speakers will review, present and analyze the state of the art procedures employed in Virtual Acoustic Reality (VAR),today. Physical characteristics of the presented technologies will be put into perspective with reference to their psychoacoustic impact and their relation to the human auditory system.

Topics will include:

a. What is Virtual Acoustic Reality? Why it is useful to Scientists? – Pros and Cons of using VAR for Perceptual Research.
b. Acoustic Virtual Reality: Applications in Perceptual Research
c. VAR-Technology: State of the Art
    i. Model- vs. Data-Based Simulations
    ii. Wave-based vs. Geometrical Room Acoustics
    iii. Binaural vs Sound Field Synthesis
    iv. Excursus: Importance of HRIRs and Techniques for HRIR-Acquisition
    v. Review of Loudspeaker Based Approaches to Sound Field Synthesis (WFS, HOA, Ambisonics), VBAP
d. Physical Evaluation of VAEs
    i. Is Physical Assessment Worthwhile Without Psychoacoustic Knowledge?
    ii. Spectral, Temporal and Spatial Error Measures for VAEs
e. The Proof is in the Listening: Perceptual Evaluation of VAEs
    i. Assessment of singular auditive qualities (coloration, localization, localization errors)
    ii. Overall quality concepts: Quality of Experience, Plausibility, Authenticity
    iii. Quality Concepts used in VR-Contexts: Immersion, Presence
    iv. Detailed Sensory Profiles: Quality Features/Quality Elements
f. Special Topic: Data-based Dynamic Binaural Synthesis: Technology and Perceptual Evaluation
g. Outlook – The Future of Spatial Audio

Pre-requisites

1. Hammershøi, Dorte & Møller, Henrik (2005): "Binaural Technique - Basic Methods for Recording, Synthesis, and Reproduction", in: Blauert, Jens (ed.): *Communication Acoustics*. Berlin u.a.: Springer
2. Majdak, Pjotr & Noisternig, Markus (2013?): *SOFA Format and Toolbox 0.6*, white paper
3. Nicol, Rozenn (2010): *Binaural Technology*. AES Monograph. New York: Audio Engineering Society Inc.
4. Novo, Pedro (2005): Auditory Virtual Environments, in: Blauert, Jens (ed.): *Communication Acoustics*.
5. Vorländer, Michael (2008): *Auralization. Fundamentals of Acoustics, Modelling, Simulation, Algorithms and Acoustic Virtual Reality*, Berlin: Springer
6. Spors, Sascha; Ahrens, Jens (2008): "A Comparison of Wave Field Synthesis and Higher-Order Ambisonics with Respect to Physical Properties and Spatial Sampling", in: *Proc. of the 125th AES Convention*. San Francisco, preprint no. 7556
7. Spors, Sascha; Wierstorf, Hagen; Raake, Alexander; Melchior, Frank; Frank, Matthias; Zotter, Franz (2013): "Spatial Sound With Loudspeakers and Its Perception: A Review of the Current State", in: *Proc. of the IEEE*, Vol. 101, No. 9, pp. 1920-1938
8. Baldis, J. (2001), Effects of Spatial Audio on Memory, Comprehension, and Preference during Desktop Conferencing, Human Factors in Computing Systems Conference (CHI), 3, 166-173.

Recommended readings

1. Bech, S., & Zacharov, N. (2007). Perceptual audio evaluation, Theory, method and application. John Wiley & Sons.
2. Möller, S. & Raake, A. (2014). Quality of Experience: Advanced Concepts, Applications and Methods. Springer

Topic 6: Sound Perception in Rooms (Slot 25-26)

Speakers: Tapio Lokki, Associate Professor, Aalto University, Finland.



The lecture will cover the work done in Aalto University since 2008 on the Sensory Evaluation on Concert Hall Acoustics. After the motivation to sensory evaluation , the techniques required to record concert halls for such evaluation are overviewed, including the anechoic recordings of the symphony orchestra, the construction of the loudspeaker orchestra, the measurements of spatial impulse responses, and the multichannel rendering of spatial sound. As a case study, the recent listening test with individual vocabulary profiling of six concert halls is presented with the analysis of paired comparison data.

Subjects include:

a. Motivation to sensory evaluation
b. Creating spatial sound samples for immediate comparison
    i. Anechoic recordings of the symphony orchestra
    ii. Construction of the loudspeaker orchestra
    iii. Measurements of spatial impulse responses
    iv. Spatial Decomposition Method (SDM)
c. Multichannel rendering of spatial sound
d. Individual Vocabulary Profiling
e. Comparison of 6 concert halls with two different music
    i. Listening test design
    ii. Analysis of paired comparison data
    iii. Linking together preference, subjective and objective data
f. Conclusions

Pre-requisites:

1. Lokki, T., Pätynen, J., Kuusinen, A., Vertanen, H., and Tervo, S., "Concert hall acoustics assessment with individually elicited attributes," Journal of the Acoustical Society of America, vol. 130, no. 2, pp. 835-849, August 2011.
2. Lokki, T., Pätynen, J., Kuusinen, A., and Tervo, S., "Disentangling preference ratings of concert hall acoustics using subjective sensory profiles," Journal of the Acoustical Society of America, vol. 132, no. 5, pp. 3148-3161, November 2012.
3. Lokki, T., "Tasting music like wine: Sensory evaluation of concert halls," Physics Today, vol. 67, no. 1, pp. 27-32, 2014.

Topic 7: Reverberation's Psychoacoustics (Slot 27,28,29)

Speakers: Alexander Lindau, Tapio Lokki,



Alexander Lindau's talk is intended as a resume of the whole school and shall also serve as an introduction for the final round table. The presenter will sum up what has been learned about auditory perception in reverberant spaces.

Topics will include:

a. Review of Research in Psychoacoustics of Reverberant Spaces
b. Excursus: Concert Hall Acoustics
    i. Classical and New "Room Acoustic Parameters"
    ii. JNDs for Room Acoustic Parameters
c. Research Results from Different Fields: Impacts of Reverberation on/on the …
    i. Aesthetical Appreciation of Musical Performances,
    ii. Musical Performances,
    iii. Audibility of Sound Source Movements,
    iv. Speech Understanding.
d. Examples for Modeling Aspects of Room Acoustic Perception:
    i. Perceptual Mixing Time in Reverberant Spaces
    ii. Audibility of Singular Reflections
e. Open Questions? Research Questions?



Tapio's talk is intended to bring together his findings in combining objective and perceptual evaluations, discussing our ability to pinpoint the expected perceptual outcome based on the geometry of a space, such as alteration of the perceptual source's width, perceived distance, clarity and others, with his main focus in concert halls acoustics.

Pre-requisites

1. Heinrich Kuttruff (2009): "Chapter 7: Subjective room acoustics", in *Room Acoustics*, 5th ed, Oxon: Spon Press
2. Alexander Lindau, Linda Kosanke & Stefan Weinzierl (2012): "Perceptual evaluation of model- and signal-based predictors of the mixing time in binaural room impulse responses", in: *J. Audio Eng. Soc.*, **60**(11), 887-898
3. Max Röhrbein & Alexander Lindau (2011): "Reducing the temporal resolution of spatial impulse responses with an auditory model", in: *Fortschritte der Akustik: Tagungsband d. 37. DAGA*. Düsseldorf, pp. 327-328

*Workshop 1 – Signal Processing** (Slot 10, Slot 24)*

Speakers: Jasper van Dorp-Schuitman, Alexander Lindau

The attendees will be given an introduction in to geometrical room acoustic modelling, auralization and binaural modelling. From programming small processing blocks (such as, e.g., mirror source imaging, plausible, reverberation, static and dynamic HRTF-based auralization (i.e. convolution) in a distributed manner among several groups of students a small framework for room acoustic modelling shall evolve. Auralization results of different acoustic conditions shall then be assessed by means of listening and assessment with binaural models. For the latter, modules form the Binaural Modelling Toolbox shall be applied.

**** Requires a laptop with MATLAB installed**

Additional Reading:

1. Majdak, P. & Noisterning, M.: *SOFA Format and Toolbox 0.6*, white paper
2. Søndergaard, P. & Majdak, P. (2013): "The Auditory Modeling Toolbox", in: Blauert, J. (ed.): *The Technology of Binaural Listening,* Berlin: Springer
3. Takanen, M. et al (2014): Visualization of functional count-comparison-based binaural auditory model output, in: *Hearing Research*
4. Vorländer, Michael (2008): *Auralization. Fundamentals of Acoustics, Modelling, Simulation, Algorithms and Acoustic Virtual Reality*, Berlin: Springer

Additional Instructions:

Installing the Auditory Modeling Toolbox

NOTE: These instructions should work for Matlab as well as for GNU Octave.

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1. Install the SOFA toolbox

- Download the SOFA toolbox from:
http://sourceforge.net/projects/sofacoustics/files/latest/download

- Extract the zip file to a directory of your choice (for example C:\users\myname\matlab\sofa)
- Add the directory and its subdirectories to Matlab's search path:

```
> addpath(genpath(C:\users\myname\matlab\sofa));
```

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2. Install the LTFAT toolbox

- Download the LTFAT toolbox from:
https://sourceforge.net/projects/ltfat/files/latest/download?source=files
- Extract the zip file to a directory of your choice (for example C:\users\myname\matlab\ltfat)
- Add the directory and its subdirectories to Matlab's search path:

```
> addpath(genpath(C:\users\myname\matlab\ltfat));
```

- Start the toolbox from Matlab:

```
> ltfatstart
```

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3. Install the Auditory Modeling toolbox

- Download the AM Toolbox from:
http://sourceforge.net/projects/amtoolbox/files/latest/download?source=files
- Extract the zip file to a directory of your choice (for example C:\users\myname\matlab\amtoolbox)
- Add the directory and its subdirectories to Matlab's search path:

```
> addpath(genpath(C:\users\myname\matlab\amtoolbox));
```

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4. Test the Auditory Modeling toolbox

- From Matlab, run:

```
> demosinit
> demo_absolutethreshold
```

- When the demo is ready you will see a plot with different threshold of hearing models.
- Run another demo:

```
> demo_lindemann1986
```

- This will show a demo of the Lindemann binaural model (see the demo's help for more info).

*Workshop 2 – Perceptual Audio Evaluation *** (Slot 18)*

Speakers: Nick Zacharov

The attendees will be given an introduction to designing a listening test using SENSELAB™ and the steps behind setting up a listening experiment in practice. Given stimuli the attendees will then design their own experiments. Data will be collected in a central server and analysis methods will be given including 'expert assessor' performance, interpretation of certain attributes for both clean and complex datasets

Additional Instructions:
*****Requires a laptop with Microsoft Silver Light Installed. Headphones will be provided.**

Application

The school will be open to 50 qualified and motivated candidates to stimulate interaction among students and lecturers. PhD students, Post-docs and Researchers (both from the Industry and Academia) are encouraged to apply. To apply fill out the **Registration form** online goo.gl/nYDEYz. A pdf version is also available at www.dreams-itn.eu; please forward this to psychoacoustics@dreams-itn.eu. Please note that the registration process will operate on First-Come First-Served.

School Fees

The school fees are listed below:

Fee Structure – EURASIP members	
PhD Student	**€370**
DREAMS Fellow	**€370**
Post-Doctoral Researcher	**€370**
Researcher/Scientist (Industrial)	**€1450**

Fee Structure – Non-EURASIP members**	
PhD Student	**€400**
DREAMS Fellow	**€400**
Post-Doctoral Researcher	**€400**
Researcher/Scientist (Industrial)	**€1500**

***The Non-EURASIP fee structure includes a yearly EURASIP membership, providing you a worth of benefits such as: access to EURASIP electronic newsletter, special prices on EURASIP-Elsevier and EURASIP-Springer Journals, 30% Discount on Artech House Books, discounted registration to Conferences/Workshops/Schools sponsored by EURASIP, and financial support for local events.*

The fee includes attendance at the courses, handling material, equipment, specialised rooms, lunch, coffee breaks, and social events / outdoors activities.

Lecturers

- Dorte Hammershøi (Aalborg University, DK)
- Steven van De Par (University of Oldenburg, DE)
- Jasper van Dorp Schuitman (Civolution, NL)
- Jan Larsen (Technical University of Denmark, DK)
- Wolfgang Ellermeier (TU Damstadt, DE)
- Nick Zacharov (DELTA SenseLab, DK/FI)
- Søren Bech (Aalborg University & Bang & Olufsen A/S, DK)
- Alexander Raake (Technical University of Berlin, DE)
- Alexander Lindau (Technical University of Berlin, DE)
- Tapio Lokki (Aalto University,FI)

Social Events

TBA

Dinner

TBA

Demo 1

Signal Processing and Information Department (SIP) will host demonstrations based on the current research work at the Department. More information will be provided on the day.

Demo 2

Bang & Olufsen, a main network partner of DREAMS, and Aalborg University, will present their current research in Automotive sound, focussing on Simulation of such spaces. Demos will follow the presentation.

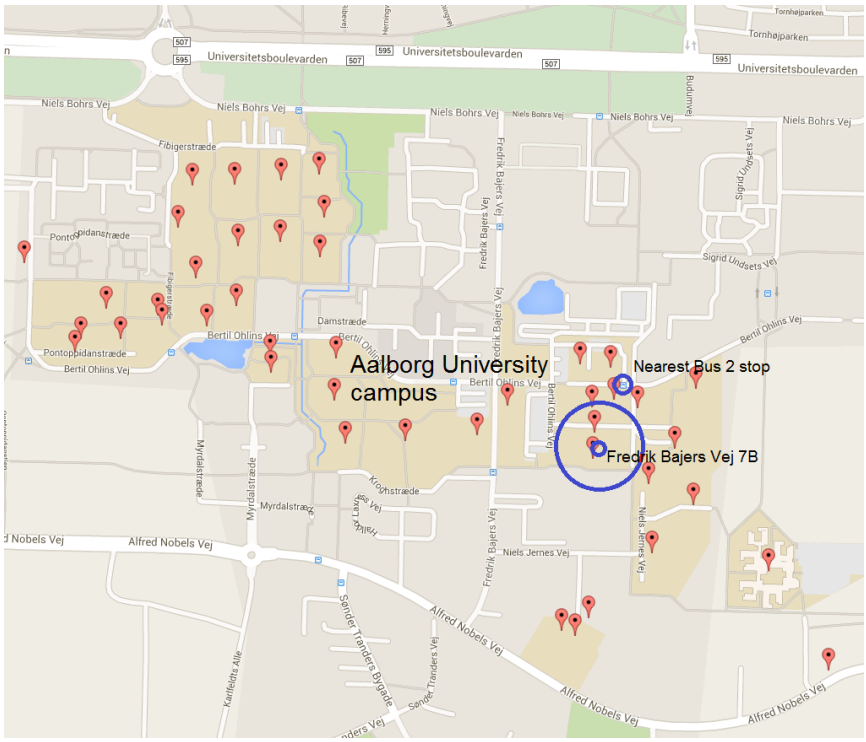
Demo 3

Tapio Lokki (Aalto University) will present his experimental work in capturing the sound of famous European Concert Halls during the ”Loudspeaker Orchestra Tour” and a demonstration of the multichannel auralisation method will be presented.

Venue

The school will be held at Aalborg University in the northern part of Denmark. The Aalborg University campus is in the southeast part of the Aalborg city. The map below shows the campus and

the location of the Advanced Psychoacoustics School at **Fredrik Bajers Vej 7B, DK-9000 Aalborg**. You can find further information about locations of the buildings on campus at http://map.aau.dk/.



Travel info

Getting to Aalborg, Denmark: Aalborg has just one airport, Aalborg airport. It is possible to fly directly to Aalborg airport from some countries, but otherwise you will need to fly to Copenhagen airport and take a national flight to Aalborg. We recommend using the Danish developed website Momondo for finding the best and cheapest route. The website is available in a large number of languages.

Notice that Aalborg airport is a small airport, so you will only need to arrive 45-60 minutes prior to your departure time when flying back home.

Getting to Cabinn Aalborg Hotel from Aalborg airport: Bus 2 (2A, 2B, etc.) will take you to the participant hotel, Cabinn Aalborg Hotel. Get off at the bus stop Nytorv (Østeraagade). You can pay in cash in the bus. The price is 20 DKK.

Getting to Aalborg University from Aalborg airport: Bus 2 will take you directly to Aalborg University. You can pay in cash in the bus. The price is 30 DKK. Notice that some are called 2A, 2B, etc. All of them will stop at Aalborg University, but only Bus 2A, 2B, and 2M will take you from Aalborg University to Aalborg airport. Note that Bus 2 also stops at Aalborg train station / Bus terminal, so participants from Denmark can take Bus 2 to Aalborg University as well.

Taking a Taxi from Aalborg airport to Aalborg University will take 20-25 minutes and cost around ~330 DKK.

Getting from Cabinn Aalborg Hotel to Aalborg University: Walk to the bus stop *Politigården (Jyllandsgade)* and take Bus 2 to the bus stop *Mejrupstien (Bertil Ohlins Vej)*. Walk 4 minutes to get

to Frederik Bajers Vej 7B. The trip takes approximately 35 minutes. You can pay 20 DKK in cash in the bus

Getting from First Hotel Europa to Aalborg University: Walk to the bus stop *at Aalborg Busterminal* and take Bus 2 to the bus stop *Mejrupstien (Bertil Ohlins Vej)*. Walk 4 minutes to get to Frederik Bajers Vej 7B. The trip takes approximately 30 minutes. You can pay 20 DKK in cash in the bus.

Getting around Aalborg city: We recommend that you use the website Rejseplanen (travel planner) whenever you need to go somewhere. It can help you find the best route using public transportation from A to B anywhere in Denmark, and is available in Danish, English and German.

Busses and trains in Denmark are usually on time, but delays of 5-10 minutes are common during rush hour and delays of 20-30 minutes can occur at rare occasions.

Accommodation

Cabinn Aalborg Hotel. Fjordgade 20, 9000 Aalborg. Phone: +45 96 20 30 00. E-mail: aalborg@cabinn.comquoting "Dreams17516".

The pre-booked rooms for the event are on Economy Class (Single) and price is set on a discount rate of 515DKK (~55GBP, 60Euro) per day including Breakfast.

First Europa Hotel in Aalborg. Europaplads 1, 9000 Aalborg.Please contact psychoacoustics@dreams-itn.eu for your booking. ~ 130 Euro / Night.

Please note that you are free to arrange your accommodation and your needs.

Organising committee

Professor Søren Bech (Aalborg University, Bang & Olufsen A/S)
Professor Søren Holdt Jensen (Aalborg University)
Associate Professor Dr. Toon van Waterschoot (KU Leuven)
Neo Kaplanis (Bang & Olufsen A/S)
Christer P. Volk (DELTA)
Charlotte Skindbjerg Pedersen (Aalborg University)
Staff at the Signal and Information Processing section (SIP) at Aalborg University.

Contact info

For questions regarding the academic content of the school, please write to psychoacoustics@dreams-itn.eu.

For questions regarding travel arrangements, payment issues, and accommodation please contact Charlotte Skindbjerg Pedersen (csp@es.aau.dk) , the SIP section administrator at Aalborg University.