



**12th ICBEN Congress on Noise as a Public Health Problem**  
**June 18 – 22, 2017**  
**Zurich, Switzerland**

Program & Abstracts Booklet



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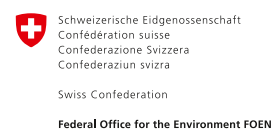
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# Welcome to the 12th ICBEN Congress on Noise as a Public Health Problem

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Dear Colleagues,

It is our great pleasure to welcome you to the 12th ICBEN Congress on Noise as a Public Health Problem and the special Low Frequency Noise and Vibration Conference which are jointly held June 18–22, 2017 in Zurich, Switzerland. The congress is open to everybody interested in the vast field of auditory and non-auditory effects of noise and low frequency noise and vibration.

Several years have passed since the bid to host this ICBEN Congress in Switzerland was accepted by the ICBEN executive committee, until today when all our efforts will hopefully make your attendance to the congress a fruitful and scientifically stimulating experience. We believe the most important thing for any congress is that you feel part of it and have the opportunity to learn and exchange ideas with colleagues and friends from around the world – and of course, have some fun too. Our local organizing committee and the ICBEN officers are dedicated in the ambition that the congress will reach these goals. ICBEN 2017 is organized under the auspices of the International Commission on Biological Effects of Noise (ICBEN), by the Swiss Acoustical Society (SGA-SSA) in collaboration with the Federal Office for the Environment (FOEN), the Swiss Federal Laboratories for Materials Science and Technology (Empa), and the Swiss Tropical and Public Health Institute (Swiss TPH).

As those responsible for the overall program, we would like to thank all authors and session chairs for their numerous contributions to this event, which – last but not least – would not have been possible without the generous financial support of our sponsors and donors. Many thanks to them too!

Our congress takes place on the campus of ETH Zurich (the Swiss Federal Institute of Technology), in the heart of the city itself. We hope you all like the central location and the lively academic atmosphere you will encounter here and that you take pleasure of your stay in Zurich. Take advantage of this little big city! Take a stroll in the old town or tour the shores and beaches of the lake, or take a boat trip on it, and most importantly, enjoy this ICBEN congress!

With kind regards

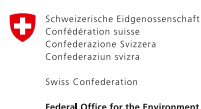
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Congress Chairman

**Mathias Basner**  
President of ICBEN

**Kurt Eggenschwiler**  
President of  
the Swiss Acoustical Society  
SGA-SSA

**Norm Broner**  
Chairman of the Low Frequency Noise and Vibration Conference

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### CONFERENCE VENUE

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Clausiusstrasse 26  
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### OPENING HOURS REGISTRATION DESK

Sunday, June 18, 2017	16:00 – 19:30
Monday, June 19, 2017	08:00 – 17:00
Tuesday, June 20, 2017	08:00 – 17:00
Wednesday, June 21, 2017	08:00 – 17:00
Thursday, June 22, 2017	08:00 – 15:00

### OPENING HOURS SPEAKER ROOM (D53) FOR PRESENTATIONS UPLOAD

Please upload your presentation at the latest one day prior to your scheduled presentation.

Sunday, June 18, 2017	16:00 – 19:30
Monday, June 19, 2017	08:00 – 18:30
Tuesday, June 20, 2017	please go to registration desk
Wednesday, June 21, 2017	please go to registration desk
Thursday, June 22, 2017	please go to registration desk

### WARDROBE

There is an unattended wardrobe close to the registration desk.

### INTERNET

Free WiFi is available within the conference venue. Turn to the registration desk to obtain network and personal login data.

## Social program

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### WELCOME RECEPTION

**Sunday, June 18, 2017 from 17:00 to 19:30**  
**at the ETH Zurich, NO Building, Atrium on D Floor.**  
Please consult the arrival information on page 65 of this program.



### SOCIAL EVENING

**Tuesday, June 20, 2017 starting at 19:00**  
**at the Lake Side Zürichhorn.**

The Lake Side Zürichhorn is beautifully sited directly at the lakeshore and close to popular beaches of the city. We'll have a rich grill buffet both catering to veggies and carnivores alike and a well-equipped bar for refreshments of (hopefully) everyone's taste.

**Access to the social evening is included in the normal conference registration fee.**

#### Location:

Lake Side • Bellerivestrasse 170 • CH-8008 Zurich



### HOW TO GET THERE?

- **By foot:** We recommend to get to the Lake Side by foot, as it's a very nice walk along the lake shore. Gather at the »Bellevue« square. Walk southwards for about 20 mins with the lake always at your right side along the narrow green stretch of »Quaianlagen« and the long-stretched »Zürichhorn« park until you reach the Lake Side which is, as its name says, directly by the lake. On your left you will pass by the popular »Pumpstation« takeaway/grill (if already hungry, grab a grilled Cervelat, »the« swiss national sausage), LeCorbusier House, and the China-Garden.

- **By tram:** From »Central« (or from »Bellevue«), take Tram No 2 or 4 in direction »Tiefenbrunnen« and get off at the »Fröhlichstrasse« stop. Make your way on the Fröhlichstrasse towards the lake. Cross Bellerivestrasse at the traffic lights and you will end up at the Lake Side.

## Congress overview

	Sunday, June 18	Monday, June 19	Tuesday, June 20	Wednesday, June 21	Thursday, June 22			
08:00 – 17:00		Registration 08:00 – 17:00	Registration 08:00 – 17:00	Registration 08:00 – 17:00	Registration 08:00 – 15:00			
09:00 – 09:15		Opening session	Keynote by Christian Koch	Keynote by Stefan Launer	Keynote by Rainer Guski			
09:15 – 09:30								
09:30 – 09:45		Keynote by Stephen Stansfeld	WHO-Guidelines	Overview talks	Parallel Sessions			
09:45 – 10:00								
10:00 – 10:15								
10:15 – 10:30		Coffee break	Coffee break	Coffee break	Coffee break			
10:30 – 10:45		Overview talks	Overview talks	Coffee break	Parallel Sessions			
10:45 – 11:00								
11:00 – 11:15								
11:15 – 11:30								
11:30 – 11:45								
11:45 – 12:00								
12:00 – 12:15								
12:15 – 12:30	Lunch break							
12:30 – 12:45	Satellite Symposium STO AG	Lunch break	Lunch break	Lunch break	Lunch break			
12:45 – 13:00								
13:00 – 13:15	Lunch break	Parallel Sessions	Poster Blitz	Parallel Sessions	Parallel Sessions			
13:15 – 13:30								
13:30 – 13:45								
13:45 – 14:00								
14:00 – 14:15								
14:15 – 14:30								
14:30 – 14:45								
14:45 – 15:00	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break			
15:00 – 15:15		Parallel Sessions	Parallel Sessions	Coffee break	Closing Ceremony			
15:15 – 15:30								
15:30 – 15:45								
15:45 – 16:00								
16:00 – 16:15	Registration 16:00 – 19:30							
16:15 – 16:30								
16:30 – 16:45								
16:45 – 17:00	Coffee break	Parallel Sessions	Parallel Sessions	Parallel Sessions	Farewell drinks			
17:00 – 17:15	Welcome reception	Parallel Sessions	Parallel Sessions	Parallel Sessions				
17:15 – 17:30								
17:30 – 17:45								
17:45 – 18:00								
18:00 – 18:15								
18:15 – 18:30							ICBEN Business Meeting	
18:30 – 18:45								
18:45 – 19:00								
19:00 – 19:15						Social Evening at the Lake Side Zürichhorn		
19:15 – 19:30								



	C60	C44	C6	D1
09:00	Opening Session			
09:15				
09:30	Keynote by Stephen Stansfeld			
09:45				
10:00				
10:15	Coffee break (Atrium)			
10:30				
10:45	Overview talk: Noise induced hearing loss		Low frequency noise and vibration	
11:00				
11:15	Overview talk: Non-auditory health effects of noise			
11:30				
11:45	Overview talk: Effects of noise on sleep			
12:00				
12:15	Lunch break (Atrium)			
12:30	Satellite Symposium STO AG			
12:45				
13:00				
13:15	Non-auditory health effects of noise	Noise-induced hearing loss	Low frequency noise and vibration	
13:30				
13:45				
14:00				
14:15				
14:30				
14:45	Coffee break (Atrium)			
15:00				
15:15	Effects of noise on sleep	Noise-induced hearing loss	Low frequency noise and vibration	
15:30				
15:45				
16:00				
16:15				
16:30				
16:45	Coffee break (Atrium)			
17:00	Effects of noise on sleep	Noise-induced hearing loss		
17:15				
17:30		Noise and communication		
17:45				
18:00	Meeting Subject area 5	Meeting Subject area 2	Meeting Subject area 1	Meeting Subject area 8/9
18:15				
18:30				

09:00 – 09:30 | C60

**OPENING SESSION**

**Chair:** Mark Brink • Mathias Basner • Kurt Eggenschwiler • Larry Finegold

The opening session of IC BEN 2017 will see the welcome addresses of the congress chairpersons and the IC BEN officers, announcements of general interest, and the award ceremony for the IC BEN Award for Excellence in Research on the Biological Effects of Noise.

09:30 – 10:15 | C60

**KEYNOTE BY STEPHEN STANSFELD**

**4161 Noise sensitivity, health and mortality – a review and new analyses**

Stephen Stansfeld

This talk presents a review of noise sensitivity and health as well as new longitudinal analyses of road traffic noise, noise sensitivity and cardiovascular and mental health outcomes. Self-reported noise sensitivity is a moderator of the association of environmental noise and annoyance. There is less certainty over whether it also moderates the effects of environmental noise on health outcomes. It has been suggested that noise sensitivity may be an indicator of vulnerability to environmental stressors in general but the biological basis of this remains undetermined. However, there is evidence for heritability of noise sensitivity from twin studies. Analysis of follow up data from men in the Caerphilly Collaborative Heart Disease study demonstrates that high noise sensitivity has a protective effect on mortality risk and does moderate the effect of traffic noise exposure on psychological distress. High noise sensitivity is linked to trait anxiety but it is not clear whether they are the same construct. Understanding vulnerability to environmental stressors is important for developing resilience and preventing disease in the future.

10:15 – 10:45 | Atrium

**Coffee break**

10:45 – 11:15 | C60

**OVERVIEW TALK: NOISE-INDUCED HEARING LOSS**

**3955 Noise-induced hearing loss: a three-year update**

Małgorzata Pawlaczyk-Łuszczynska • Mariola Śliwińska-Kowalska

Noise-induced hearing loss (NIHL) is still a world-wide leading environmental and occupational health risk in industrialized countries and the second most common form of sensorineural hearing impairment, after presbycusis. According to Medline database, almost 800 papers on NIHL were published in the last three years (2014–2016), exceeding by almost 200 the number of publications from previous reporting period. Excessing basic research was designed to evaluate pathomechanisms of NIHL, with special regards to cochlear synaptopathy, genetic background of susceptibility to noise, as well as putative causes of tinnitus after exposure to noise. Further studies were developed on the prevalence of NIHL in different populations, the role of individual risk factors for NIHL as well as medico-legal and clinical aspects of NIHL and tinnitus. Progress was continued in developing new strategies for preventing acoustic traumas (diet, pharmacological intervention), noise control engineering, and assessing the effectiveness of hearing loss preventive campaigns. Economic impact of hearing loss was also assessed. This presentation will discuss the most important research results on NIHL in humans.

11:15 – 11:45 | C60

**OVERVIEW TALK: NON-AUDITORY HEALTH EFFECTS OF NOISE**

**3705 Recent progress in the field of non-auditory health effects of noise – trends and research needs**

Yvonne de Kluizenaar • Toshihito Matsui

With the aim to identify recent research achievements, current trends in research, remaining gaps of knowledge and priority areas of future research in the field of non-auditory health effects of noise, recent research progress was reviewed. A search was performed in PubMed (search terms »noise AND health«), for peer reviewed journal articles, published between 1 January 2014 and 1 January 2017 in English. Resulting references were screened for relevance by title and abstract were needed in case of doubt. Inclusion criteria: Original research papers on health effects of environmental or occupational noise exposure. Studies on auditory health effects (hearing loss) and on Health Impact Assessment calculations based on existing relationships were excluded. The search resulted in over 3000 references. A total number of about 150 papers was included in the review, 14 papers focused on mental health effects, a majority focused on (a wide range of) physiological health effects. A wealth of new research on non-auditory health effects of noise has been published over the last 3 years. Current trends, knowledge gaps and priority future research areas will be discussed.

11:45 – 12:15 | C60

**OVERVIEW TALK: EFFECTS OF NOISE ON SLEEP**

**3999 Review of research on the effects of noise on sleep over the last 3 years**

Sarah McGuire • Gunn Marit Aasvang

Undisturbed sleep is important for next day performance, well-being, and health. It is known from laboratory and field studies that environmental noise can affect both sleep physiology and subjectively assessed sleep quality. To provide an overview of recent findings on the effects of noise on sleep, a literature review was conducted. Articles published since June 2014 was identified through a search of available databases. Studies on transportation, wind turbine, and hospital noise were included in this review. Based on the identified studies, there has been an ongoing interest in examining the acute effects of noise on sleep. Among the new actigraphy and polysomnographic field studies are the first studies on wind turbine noise which have used objective measures of sleep, as well as a study examining the potential benefit of nighttime air-traffic curfews. Also there have been new epidemiological studies which have added to the knowledge on the effects of noise on self-reported sleep disturbance. This review will include important findings over the last three years and recommendations for future research.

10:45 – 12:15 | C6

**LOW FREQUENCY NOISE AND VIBRATION**

Chair: Norm Broner • Geoff Leventhall

10:45 – 11:15

**3872 Case Report: Cross-Sensitisation to infrasound and low frequency noise**

Bruce Rapley • Huub Bakker • Mariana Alves-Pereira • Rachel Summers

Sensitisation is a non-associative learning process in which repeated administration of a stimulus results in the progressive amplification of a response. Sensitisation often is characterised by an enhancement of response to a whole class of stimuli in addition to the one that is repeated. For example, repetition of a painful stimulus may make one more responsive to a loud noise, alternatively called cross-sensitisation. This paper describes a case of cross sensitisation in two human subjects who were subjected to prolonged exposure to low-frequency noise from a large underground coal mine, and a coal-fired power station, in Lithgow, New South Wales, Australia. The two subjects later exhibited a sudden, extreme involuntary physiological response to the low-frequency, amplitude modulation of wind turbine noise exposure consistent with an acoustic startle reflex response in the context of a waveguide formed by the built environment.

11:15 – 11:45

**3574 Hearing threshold measurements of infrasound combined with audio frequency sound**

Elisa Burke • Johannes Hensel • Thomas Fedtke

Within the framework of the European project EMPIR 15HLT03 »Ears II« this study aims at a better understanding of the human response to infrasound. The purpose of this study is to examine which role the combination of infrasound (< 20 Hz) and sound in the audio frequency range (between 20 Hz and 20 kHz) plays for the perception of infrasound. One hypothesis to be validated is that the interaction between infrasound and audio frequency sound may explain the perceptibility of infrasound. Another aim is to investigate whether the presence of infrasound influences the hearing threshold of audio frequency sound. In order to test these hypotheses detection threshold measurements were performed for infrasound and audio frequency sound stimuli. Then thresholds were measured for infrasound stimuli in the presence of audio frequency sound and for audio frequency sound stimuli in the presence of infrasound. The measurement setup consisted of an infrasound source and an audio frequency sound source, each coupled by a sound tube to the same ear tip that was used for monaural presentation of the acoustic stimuli.

11:45 – 12:15

**3956 Effect on Measured Hearing Threshold of Low Frequency Noise by Various Test Methods**

Toshiya Kitamura • Yoshitaka Ashikawa • Shinji Yamada • Satoshi Yamada

We have been studying psychological and physiological effects of low frequency noise. Hearing thresholds of all subjects are measured before experiments of low frequency noise exposure. Once in a while, the measurement systems and ways were renewed for shortening of test times and reduce a load on subjects. The threshold values changed at renewal of the measurement way. We anticipate that the change is caused by an influence of difference of subject's response delay by change of measurement ways. We have been using up-down method for measuring threshold by ordinary, but some subjects who are complaints of low frequency noise allow up method only because they feel dislike stronger on low frequency noise than other general subjects and they reject a level inconsiderably over the themselves threshold. We had dubiety on correctness of these measured thresholds. Therefore we evaluate differences and variances of thresholds of low frequency sound by measurement ways.

12:15 – 13:15 | Atrium

**Lunch break**

12:30 – 13:00 | C44

**SATELLITE SYMPOSIUM STO AG (SPONSORED EVENT)****4336 Silence at work – noise at home: a case study**

Andreas Niermann

Plenty of normative handle too high noise impact at work, either in offices, factories or similar, in order to limit stress, increase productivity and for health protection. For private homes, structural acoustics becomes regulated, concerning air borne and tapping noise transmission plus noise from the outside. Private homes are not subject to limitation of noise, produced by residents in their own rooms. After a working day full of effort, you are looking forward to a home to recover. In many cases, however, self-produced noise inhibits to relax. There is a remarkable difference in the acoustical quality between »grandma's living room« and a designed modern eat-in kitchen plus large living room. Sound reflecting surfaces, large windows, designed furniture and big volume result in a noisy home. In contrary to that, in a room full of curtains, carpets and thick upholstered sofas the acoustical comfort is higher. This case study shows both, a noisy home and a silent one. The acoustical effect of an invisible technical solution and an approach to reduce sound transmission through an open staircase for private homes are presented.

13:15 – 14:45 | C60

**NON-AUDITORY HEALTH EFFECTS OF NOISE**

Chair: Yvonne de Kluizenaar • Toshihito Matsui

13:15 – 13:30

**3663 The role of noise sensitivity in acute physiological effects of noise**

Kim White • Adelbert Bronkhorst • Martijn Meeter

A body of literature exists linking exposure to environmental noise to faster heart rates, ischemic heart disease and higher blood pressure. Acute effects of noise are less clear. Noise sensitivity is a known predictor of noise annoyance. With this experiment, differences in acute responses to noise between high and low noise sensitive groups were addressed. Sensitivity groups were formed, based on NoiSeQ scores (median split). All participants completed three, 8 minute lasting, conditions while heart rate and torso impedance were measured: a baseline condition and two (cognitive) task conditions, one with aircraft noise (noise condition) and one without (silence).

Heart rate variability analyses of preliminary data (n = 11) showed that noise sensitive individuals had marginally faster heart rates and lower power of the high frequency band, indicating lower levels of parasympathetic activity. These results indicate that the heart and nervous system of noise sensitives may be less able to adjust to the noise.

13:30 – 13:45

**3661 Noise sensitivity modifies the effect of recorded noise on sympathovagal balance in young men**

Katarina Paunovic • Branko Jakovljevic • Goran Belojevic • Vesna Stojanov

Background: This is a re-analysis of the data from a large experimental study conducted in 2012 in Belgrade. The aim of the study was to assess changes in the sympathetic and parasympathetic activity of the autonomous nervous system (sympathovagal balance) provoked by recorded traffic noise in men in relation to their noise sensitivity level. Methods: The study comprised 35 healthy men, aged 24.8±2.6 years. Sympathovagal balance was monitored with thoracic electrical bioimpedance device (Task Force® Monitor) during a 10-minute noise exposure, and compared to quiet conditions before and after noise. All participants were categorized as weakly, moderately or highly noise sensitive (n = 11, 15, and 9) according to Weinstein noise sensitivity scale. Changes were tested with t-test for related samples. Results: Moderately and highly noise sensitive participants showed significant changes in the sympathovagal balance during noise exposure in comparison to quiet conditions before and after noise exposure, unlike weakly noise sensitive men. Conclusion: Noise sensitivity may be an important moderating factor accounting for the effects of noise on the changes in the sympathovagal balance in young men.

13:45 – 14:00

**3754 Studying noise sensitivity on the brain level**

Marja Heinonen-Guzejev • Marina Kliuchko • Peter Vuust • Mari Tervaniemi • Elvira Brattico

Noise sensitivity (NS) is a common trait. We are still lacking a model for the mechanism of NS. Some studies have suggested psychological origins but there are recent studies addressing the neural mechanism of NS. In our study investigating neuronal sound processing in relation to NS with combined electroencephalography (EEG) and magnetoencephalography (MEG) measures, noise sensitive individuals demonstrated compromised neuronal sound processing as compared to noise-resistant individuals (Kliuchko et al., 2016). Subjects were presented with a fast multifeature Mismatch Negativity (MMN) paradigm including six types of sound feature deviations. Noise sensitive subjects had smaller amplitudes of P1 component than less sensitive subjects, suggesting that they may have difficulties with sound feature encoding and they demonstrated diminished MMN responses especially for the deviant with increased noisiness. Thus, NS is specifically related to the processing of noise, but not to any other sound features. Shepherd et al. (2016) found that noise-sensitive individuals exhibit less sensory gating than noise-resistant individuals. Thus, NS is related to primary auditory functions of the brain and calls for further investigations on the neuroanatomical structure of these individuals.

14:00 – 14:15

**3660 Night-time aircraft noise and vascular diseases – the Cologne-Bonn Airport Study**

Eberhard Greiser • Katrin Janhsen • Karin Halina Greiser

A retrospective case-control study was conducted to investigate the impact of aircraft noise on cardiovascular and vascular diseases in the vicinity of a Cologne-Bonn International Airport, an airport with unlimited night-time air traffic. The study region comprised the City of Cologne, and two counties adjacent to the airport. Residency-specific environmental noise data and data from 8 compulsory sickness funds (531.172 persons, aged 40 years and older, covering 53.4% of the population of the study region) were used including data on prescriptions of therapeutic drugs and hospital discharge diagnoses. Target diseases were a combination of specific cardiovascular diseases [myocardial infarction (MI), coronary heart disease (CHD), heart failure, stroke], MI, CHD, stroke, atherosclerosis of peripheral arteries, dementia, and kidney failure. There were dose-dependent risk increases for all diagnostic entities in persons not entitled to reimbursement for noise protection, indicating a protective effect of noise protection measures. ORs larger than 2.0 were detected in dementia and in chronic kidney failure. In general, this study demonstrated decreasing risks with increasing age. Risk increases in all analyses were larger in women than in men.

14:15 – 14:30

**3969 Blood pressure monitoring (NORAH study): Exposure to maximum sound levels of nocturnal aircraft noise and self-measured blood pressure**

Anja zur Nieden • Doreen Ziedorn • Karin Römer • Jan Spilski • Dirk Schreckenberger • Ulrich Möhler • Susanne Harpel • Thomas Eikmann

Based on the concept that noise may trigger repeatedly unavoidable autonomous physiological reactions, which each can cause an increase of blood pressure (BP), the blood pressure monitoring of the NORAH study examined the effects of chronic aircraft noise on self-measured blood pressure (SBPM). Study region included areas within the 40 dB(A) equivalent continuous sound level contours of aircraft noise for day and night-time, targeting on voluntary adults residing in the defined region. Nocturnal aircraft noise exposure was assigned to participants' addresses. Telemedical blood pressure devices were issued for SBPM. Questionnaires with reference to current health, medications, lifestyle, individual factors, and noise sensitivity were completed. After being trained, participants performed 2 daily measurements for 21 days. Whereas multiple regressions reveal a statistically non-significant tendency of association of BP with nocturnal continuous sound levels (b=0.10; 95%CI [-0.02;0.21]) the model for systolic BP (n = 844) including mean LpA,max,22 – 06h, adjusted for age, gender, social status, tobacco smoke, and physical activity shows a marginal noise-related increase in systolic BP (b=0.11; 95%CI [0.02;0.20]).

14:30 – 14:45

**3602 Residential exposure to traffic noise and leisure-time sports – a population-based study**

Nina Roswall • Gunn Ammitzbøll • Jeppe Schultz-Christensen • Ole Raaschou-Nielsen • Matthias Ketzler • Anne Tjønneland • Mette Sørensen

Background: A recent study found traffic noise annoyance associated with physical inactivity. We investigated associations between modelled residential traffic noise and leisure-time sports. Methods: In the Diet, Cancer and Health cohort, we performed cross-sectional analyses using baseline data (1993–97) and longitudinal analyses of change between baseline and follow-up (2000–2). People reported participation (yes/no) and hours of leisure-time sport, from which we calculated MET-score. Address history was retrieved from national registries, and traffic noise was modelled. Analyses were performed using logistic and linear regression. Results: 5-year time-weighted mean traffic noise exposure was associated with higher probability of non-participation in sports at baseline; significantly for road traffic (OR1.10, 1.07–1.13) and borderline for railway noise (OR1.03, 0.99–1.07), per 10 dB. In longitudinal analyses, road traffic noise was associated with a higher probability of ceasing and a lower probability of initiating sports. Railway noise was negatively associated with baseline MET-score, whereas no association was found in longitudinal analyses or for road traffic noise. Conclusion: Long-term exposure to residential traffic noise may be associated with physical inactivity.

13:15 – 14:45 | C44

**NOISE-INDUCED HEARING LOSS**

Chair: David Welch • Małgorzata Pawlaczyk-Łuszczynska

13:15 – 13:30

**2331 Significant Hearing Loss is Probably Not Part of Normal Aging**

Daniel Fink

Significant (25–40 dB) hearing loss is probably not part of normal aging but rather represents sociocusis or pathological aging due to noise exposure. Seven lines of evidence support this conclusion: 1) preservation of auditory acuity throughout life in primitive populations; 2) occupational studies correlating noise exposure with hearing loss; 3) studies showing that females have better hearing than males, presumably from less noise exposure; 4) significant variations in the prevalence of hearing loss in different population groups; 5) the frequencies in which hearing loss is most common are those most common in everyday life; 6) the prevalence of hearing loss increases with lifetime noise exposure; and 7) basic science research showing changes in auditory cells caused by noise, leading to cell damage and death. Many changes considered part of normal aging, e.g. wrinkled skin or tooth loss, are normative but not physiologically normal. These changes result from exposures, poor quality diet, disuse, or suboptimal medical care. Significant hearing loss with age can likely be prevented by reducing lifetime noise exposure.

13:30 – 13:45

**3812 Hearing conservation in Switzerland – long-term perspective and latest results**

Beat W. Hohmann

According to ISO 1999, noise-induced hearing loss (NIHL) occurs in the first years of noise exposure whereas the age-related hearing loss adds gradually as we grow older. Therefore, if NIHL wants to be prevented, hearing must be protected from the very first moment of noise exposure. Since 1973, the Swiss National Accident Insurance Fund Suva runs a comprehensive hearing conservation programme for all noise-exposed workers. The audiometric database contains the results of the hearing examination as well as data about occupation, noise exposure and hearing protection. The percentage of workers showing NIHL decreased from 37% in 1973 to 8% in recent years. In order to prevent occupational NIHL completely, an indicator for early detection of NIHL was developed: dHV346 is the yearly average additional hearing loss at 3, 4 and 6 kHz (where NIHL occurs) and applicable to individuals or groups. If the percentage of workers with unacceptable dHV346 exceeds 10%, the company has to verify if their workers are protected sufficiently and take action for example by using Suva's new low-cost »earplug check«.

13:45 – 14:00

**3690 Hearing tests combined with noise awareness action in elementary schools**

Sonja Jeram • Bojana Bažec • Helena Pavlič • Helena Repič

Exposure to loud music assumedly affects hearing in youth. Results of our study in Slovenia showed that more than 12% of adolescent students involved might be at risk due to prolonged listening of loud music and visiting concerts and clubs. Systematic examination of hearing in youth is one of the activities of our health preventive program. Results are published in Health Statistics Yearbook cumulatively for nine Slovenian regions. Data gathered from 2001 to 2012 were analysed and will be presented. In order to raise awareness of possible hearing damage due to exposure to noise, we have introduced a questionnaire for students that are visiting a doctor for hearing examination. Pilot studies were performed in two elementary schools in order to test the procedure and to establish a common protocol. The physician fills in data on testing method and hearing results. Student of 7th or 8th grade were selected for this study based on the evaluation that this generation of youth is the most suitable for raising awareness on noise hearing damage.

14:00 – 14:15

**3621 Objectification of auditory and non-auditory effects of environmental noise from different sources in a sample of Slovak students**

Alexandra Filová • Martin Samohýl • Jana Jurkovičová • Ľudmila Ševčíková • Ľubica Argalášová

Various noisy activities may be responsible for auditory and non-auditory effects on individuals. The study is aimed to quantify the effects of social noise exposure (personal music players (PMP), high noise exposure events) and road traffic noise in the sample of Slovak students. There were 837 university students (256 males, average age 23,09±2,23) enrolled into the study so far; 267 in the housing facility exposed to road traffic noise (LAeq = 67,6

dB) and 570 in the control one (LAeq = 53,4 dB) in Bratislava. From the total sample 663 (79,2%) students reported the use of PMP in the last week; average time of 293 minutes. There was a significant difference in PMP use between the exposed (86,9%) and the control group (75,6%) ( $p = 0,01$ ). Among PMP users 30,7% exceeded the LAV (lower action value for industry = 80 dB). On a pilot sample of volunteers ( $n = 29$ ) audiometry testing was performed indicating hearing threshold shift at higher frequencies in 20% of subjects. The results showed the importance of social noise as well and the need for prevention and intervention.

14:15 – 14:30

**3645 Personal audio devices use patterns associated with risks of hearing loss and compromised road safety among medical students in Delhi, India**

Saurav Basu • Suneela Garg • M. Singh • Charu Kohli

Background: Over 1 billion young people globally are at risk of hearing loss and road traffic accidents due to unsafe listening practices while using personal audio devices (music players, smartphones). Objective: Our objective was to ascertain the knowledge of risks and patterns of usage of personal audio devices (PADs) among medical undergraduates at a medical college in Delhi, India. Participants aged  $\geq 18$  years were selected through simple random sampling and those willing were enrolled after written informed consent. Data was collected using a pretested self-administered questionnaire during December 2016 – January 2017. Ethical approval was granted by the Institutional Ethics Committee, Maulana Azad Medical College, Delhi. Results: We conducted a cross sectional study and enrolled 154 male and 96 women students ( $n = 250$ ). The practice of listening to music using PADs at loud volume for  $\geq 2$  hours/day and  $\geq 4$  days per week was reported by 48 (19.2%) participants. Unsafe pedestrian or driving practices during PAD use was reported by 67 (26.8%) participants. Discussion: Unsafe listening practices using PADs is potentially compromising the health and safety of young people in India.

14:30 – 14:45

**2768 Hearing Function in Music Player Users: Georgian Material**

Nana Saralidze • Nino Sharashenidze • Zurab Kevanishvili

Hearing function has been estimated in 277 university students of Georgia. 150 from were regular music player users while remainder 127 have been not utilized habitually any aural music device and constituted thus the control group. Ages of individuals in both sample collections were in the range of 18–25 years. Hearing thresholds were measured by the tonal audiometer within the frequency band of 0.125–12 kHz. Hearing thresholds in music player followers were found to fluctuate generally inside of normal limits and did not differ statistically from those in the control group. The analysis of individual data showed however that hearing thresholds happened to exceed 20 dB nHL preferentially just in player followers. The selective hearing threshold augmentation in player users occurred particularly at 8- and 12-kHz frequencies. The process of hearing disturbances seemed thus to possess mostly the personal character. No gender dependence had been found furthermore in player consumers. Regular audiometrical inspection seems advisable to perform in player users for in-time revealing of hearing disorders and for an execution then of respective treatment and preventive procedures.

13:15 – 14:45 IC6

**LOW FREQUENCY NOISE AND VIBRATION**

Chair: Geoff Leventhall • Norm Broner

13:15 – 13:45

**4050 Frequency Weighting for the Evaluation of Human Response to Low-Frequency Noise based on the Physiological Evidence of the Vestibular System**

Junta Tagusari • Shou Satou • Toshihito Matsui

A number of case studies were found regarding adverse health effects due to low-frequency noise emitted by industrial machines including wind turbines. However, the causal chain between low-frequency noise and health effects still remains unclear despite a number of epidemiological studies. Meanwhile, from the physiological viewpoint, low-frequency noise may stimulate hair cells in the vestibular system, which would cause health effects i.e. dizziness, vertigo, headache and nausea. The stimulating process is different from the hearing process in the cochlea, which implies that the A-weighting is not appropriate for evaluating the risk of low-frequency noise. In this study, we developed an alternative frequency weighting for low-frequency noise based on existing physiological evidences of the vestibular system and a psychological experiment on vibration and/or pressure sensation. Obtained frequency weighting showed steep peak around 80Hz, which was distinctly different from A-weighting. We also derived the dose-response relationship between the weighted sound level and the sensation of vibration and/or pressure which would be caused in the vestibular system.

13:45 – 14:15

**2487 Evaluation of the health effects related to low frequency noise and infrasound from wind farms: results and conclusions from an independent collective expertise in France**

Philippe Lepoutre • Paul Avan • Anthony Cadene • David Ecotièrre • Anne-Sophie Evrard • Frédérique Moati • Esko Toppila

Several complaints were expressed by some residents of French wind farms, putting forward infrasound and low frequency noise (ILFN) as a potential source of annoyance. Since available information on this subject are multiple and often contradictory, the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) was mandated by the French Ministry of Environment to conduct an independent collective expertise on the evaluation of the health effects related to ILFN from wind farms. The objective was first to produce a complete review on auditory and non auditory health effects due to WTN, focusing on ILFN ; then, to collect experimental ILFN data from some wind farms in order to compare with data from the literature ; and finally to propose some

improvements in the process of wind farm assessment or of impact studies, concerning ILFN. This paper presents the main results and conclusions of this expertise.

14:15 – 14:45

**3584 Evaluation of Wind Turbine Noise in Japan**

Akira Shimada • Mimi Nameki

In Japan, wind turbines located in quiet rural areas and their unique acoustical character such as amplitude modulation, sometimes raise complaints about noise by neighborhood residents even if the wind turbine noise (WTN) is not very loud compared to other environmental noise. Ministry of the Environment of Japan (MOEJ) set up a committee to discuss issues related to WTN in 2013. In November 2016, the committee has published a report on investigation, prediction and evaluation methods of WTN. The report compiles recent scientific findings on WTN, including the results of nationwide field measurements in Japan and the results of review of the scientific literature related to health effects of WTN. The report sets out methodology for investigation, prediction and evaluation as well as case examples of countermeasures. A noise guideline for wind turbine, which suggests WTN should not be more than 5dB above the background noise where background noise levels are above 35–40dB, is also presented in the report. MOEJ plans to develop a detailed technical manual for WTN investigation based on the methodology presented by the report.

14:45 – 15:15 | Atrium

**Coffee break**

15:15 – 16:45 | C60

**EFFECTS OF NOISE ON SLEEP**

Chair: Gunn Marit Aasvang • Sarah McGuire

15:15 – 15:30

**3943 WHO Environmental Noise Guidelines for the European Region: A systematic review on environmental noise and effects on sleep**

Sarah McGuire • Mathias Basner

To evaluate the strength of evidence on the effects of environmental noise on sleep, a systematic literature review was conducted. A meta-analysis of surveys and a pooled analysis of polysomnographic studies on the effects of transportation noise on sleep were conducted. A narrative review was conducted for motility, cardiac and blood pressure outcomes, and children's sleep. The effect of wind turbine and hospital noise on sleep was also assessed. The unadjusted odds ratio for the percent highly sleep disturbed for a 10 dB increase in L<sub>Night</sub> was significant for aircraft (1.936; 95% CI 1.608–2.332), road (2.126; 95% CI 1.820–2.483), and rail (3.058; 95% CI 2.378–3.933) noise. The unadjusted odds ratio for the probability of awakening for a 10 dB increase in the indoor L<sub>max</sub> was significant for aircraft (1.351; 95% CI 1.218–1.499), road (1.360; 95% CI 1.192–1.550), and rail (1.354; 95% CI 1.209–1.515) noise. Based on the evidence, transportation noise affects objectively measured sleep physiology and subjectively assessed sleep disturbance. For other outcome measures and noise sources evidence was conflicting or only emerging.

15:30 – 15:45

**3939 The significance of autonomic arousals during sleep**

Barbara Griefahn

Noise causes non-specific transient excitations

- of the central nervous system as measured with the EEG
- of the autonomic nervous system as indicated by alterations of autonomic functions.

During wake autonomic arousals occur as gradually decreasing orienting reflexes or as persistent defensive reflexes. During sleep responses are only defensive with lower thresholds and greater magnitudes than during wake. Their patterns and magnitudes are modified by physical parameters of noise, by individual and situational influences and vary systematically with the duration of associated cortical arousals. They are bi- or triphasic if sleep continues and become monophasic, larger and inert against most influences in case of awakening. The sleep-wake-transition is obviously the dominating stress that is only influenced by the momentary sleep stage. Patterns of spontaneous and evoked arousals are similar but magnitudes of the latter are larger. The sum of spontaneous and noise-evoked arousals remains stable indicating a redistribution i.e. a disturbance of the endogenous ultradian rhythm. This imposes the possibility that noise acts as a health hazard in particular as people do not habituate to noise during sleep.

15:45 – 16:00

**3913 Spindle density and arousability from acoustic stimulation during sleep**

Franziska Rudzik • Laurie Thiesse • Reto Pieren • Jean Marc Wunderli • Mark Brink • Maria Foraster • Harris Héritier • Ikenna C. Eze • Danielle Vienneau • Nicole Probst-Hensch • Martin Rössli • Christian Cajochen

Night-time transportation noise can disturb sleep by causing awakenings, sleep-stage changes or EEG arousals. However, not all acoustic stimuli disrupt sleep. Processing of sensory stimuli is modulated by transient EEG rhythms during sleep as sleep spindles where sensory relay is hindered at a sub-cortical level. Thus, we investigated whether sleep spindle density rhythms predict arousability from acoustic stimulation (traffic noise) during sleep. Twenty-six healthy participants (age: 19–33y) were exposed to 80 pre-recorded railway noise events (RNE) that were played back during an 8-h night. Polysomnography was recorded throughout the night. Sleep and EEG arousals were scored according to standard criteria. Spindles on central channels were detected using an automatic scoring algorithm. Single RNE's that occurred during stage 2 sleep were post-hoc classified as Non-arousal or Arousal trials depending on whether an EEG arousal occurred during the particular RNE duration.

Associations were evaluated using logistic regression models. The mean spindle density during RNE duration was a significant predictor for arousal probability. We have first evidence that arousability from noise during sleep is modified by the spindle density.

16:00 – 16:15

**3938 Temporal variation of transportation noise during sleep impacts on glucose metabolism**

Laurie Thiesse • Franziska Rudzik • Reto Pieren • Jean Marc Wunderli • Karine Spiegel • Rachel Leproult • Maria Foraster • Harris Héritier • Ikenna C. Eze • Danielle Vienneau • Mark Brink • Nicole Probst-Hensch • Martin Röösli • Christian Cajochen

Intermittency ratio (IR) has been proposed as a new metric to reflect short-term temporal variations of noise exposure. As transportation noise is linked to higher risk for incident type 2 diabetes, we investigated the short-term effect of IR on glucose metabolism. Twenty-three volunteers (age:  $24.6 \pm 0.7$  y; BMI:  $22.1 \pm 0.4$ ; 11 females) participated in a laboratory study starting with a noise-free baseline night followed by four nights with night-time noise scenarios differing in IR (low IR: distant highway, dense traffic vs. high IR: short distance, residential street or railway line) with a constant hourly Leq of 45 dB(A) at the ear of the sleeper. The study ended with a noise-free recovery night. Glucose levels significantly increased after four nights of nocturnal transportation noise compared to baseline. After one recovery night glucose returned to baseline levels for low IR, but not for high IR. Four nights of nocturnal traffic noise significantly impaired glucose tolerance in lean young volunteers. We have first evidence that short-term effect of highly intermittent night noise is more deleterious for glucose metabolism than low intermittency.

16:15 – 16:30

**3957 Pilot Study Examining the Effects of Aircraft Noise on Sleep in Communities Near Philadelphia International Airport**

Mathias Basner • Maryam Witte • Anjana Kallarackal • Sarah McGuire

Aircraft noise can disturb sleep and impair recuperation. Representative field studies are needed for health impact assessments and to inform noise policy. To evaluate feasibility of a new unobtrusive methodology that objectively monitors sleep and identifies awakenings based on heart rate and actigraphy, an unattended pilot field study was conducted near Philadelphia International Airport. Seventy-nine participants (39 exposed, 40 controls) were monitored for 3 consecutive nights with concurrent sound recordings in the bedroom. Blood pressure measurements and brief questionnaires were completed each morning. Based on linear mixed models controlling for age, gender, and BMI, individuals living near the airport reported poorer sleep quality on the PSQI ( $p = 0.0180$ ) and worse health on the SF-36 ( $p = 0.0074$ ) surveys. No statistically significant differences were found for morning sleep assessments, diastolic ( $p = 0.7108$ ) and systolic ( $p = 0.3255$ ) blood pressure, or the sleep fragmentation index ( $p = 0.6986$ ) (calculated based on the ECG and actigraphy data). Indoor maximum sound pressure levels of single aircraft events were positively associated with awakening probability ( $p = 0.0094$ ). This study demonstrates feasibility of unattended physiological and noise measurements.

16:30 – 16:45

**3726 A comparison of the effects of night time air traffic noise on sleep at Cologne/Bonn and Frankfurt Airport after the night flight ban**

Uwe Müller • Eva-Maria Elmenhorst • Franco Mendolia • Julia Quehl • Mathias Basner • Sarah McGuire • Daniel Aeschbach

In the STRAIN study (2001/2002) the German Aerospace Center (DLR) measured the sleep of 64 residents (19–61 years) around Cologne/Bonn airport for 9 consecutive nights each with polysomnography. Cologne/Bonn airport has no night time restrictions for chapter 3 airplanes and is one of the busiest airports in Germany during the night. Frankfurt is the airport with the highest traffic volume in Germany. A night flight ban (11 p.m.–5 a.m.) was implemented in October 2011. Traffic density during shoulder hours is high. DLR examined 83 Frankfurt airport residents (18–77 years) with polysomnography as part of the NORAH study in 2012. In both studies SPL and noise events were recorded with microphones near the sleeper's ear. Participants filled out questionnaires each morning. The analysis shows that aircraft noise induced awakening probabilities are 3.8–7.5% higher for maximum indoor levels from 30–70 dB(A) at Cologne/Bonn Airport whereas night time aircraft noise annoyance is considerably increased in Frankfurt. The results of both studies are compared, and limitations of the comparisons are discussed.

15:15 – 16:30 | C44

**NOISE-INDUCED HEARING LOSS**

Chair: David Welch • Małgorzata Pawlaczyk-Łuszczynska

15:15 – 15:30

**3762 Music exposure and hearing loss in Switzerland – a long-term perspective**

Beat W. Hohmann • Anna Schoeni

Adolescents often expose themselves to loud music during social and music events. Another source of leisure noise is the use of personal listening devices. Frequent leisure noise at high volume and for a long duration can pose a serious threat to one's hearing. A study in 1997 showed that about 7% of the users of personal listening devices exceeded a long-term dose of 85 dB(A). According to another study 10 years later using the same measuring equipment, this percentage remained almost unchanged, despite the vastly improved (digital) quality and prolonged battery life of personal listening devices. Additionally the average listening level stayed almost the same. Suva's audiometric database of noise-exposed workers contains data of about 1,000 apprentices for every year who had not been exposed to occupational noise at the time of the hearing check. If noise-induced hearing



loss was identified for those apprentices, it would probably be due to leisure noise. However, the evaluation of these data revealed that the hearing of the apprentices had improved over the years. The expected degradation could not be shown.

15:30 – 15:45

### 3620 The hearing status of employees exposed to noise generated by ultrasonic welding devices

Adam Dudarewicz • Kamil Zaborowski • Paulina Rutkowska-Kaczmarek • Małgorzata Zamojska-Daniszewska • Małgorzata Pawlaczyk-Łuszczczyńska

The aim of the study was to assess the effect of ultrasonic noise (10–40 kHz) and audible noise on welder operators' hearing status and to compare the results with the results obtained in group of workers exposed exclusively to audible noise. In the group of 90 operators of ultrasonic welding devices the hearing examinations were performed, using pure tone audiometry at frequencies from 0.5–16 kHz and otoacoustic emission tests (DPOAE, TEOAE). The results of hearing tests were compared with the results in the reference group of workers exposed exclusively to audible noise. Hearing thresholds at a frequency of 0.5–6 kHz are comparable in both groups, and at frequencies of 9–14 kHz the thresholds are higher in the welder operators group. Amplitudes of otoacoustic emission are comparable in the lower frequency ranges of the test frequency bands, and in the upper ranges the amplitudes are greater in the reference group. These differences in hearing may result from differences in spectral composition of noise.

15:45 – 16:00

### 3998 Hearing loss and morbidity among construction site workers in National Capital Region of Delhi, India

Anshul Shukla

Background: Among construction workers hearing deficiencies caused by noise is one of the most important occupational diseases. Hearing difficulty, tinnitus, ear discharge and posture disturbances, and auditory disorders, particularly noise induced hearing loss (NIHL) have become common problems throughout industry. Objectives: To assess the morbidity profile and Risk factors for occupational hearing loss among construction site workers. Methods: Multistage Random Sampling Design was used to select the study subjects of construction sites from National Capital Region of Delhi, India. A total sample size of 451 was selected depending on the number of workers in each of the sites identified in the seven zones. Results and conclusion: About one third of the workers were exposed to loud noises at the workplace. It was seen that 16.4% of the respondents perceived the workplace noise control to be bad. Further assessment revealed hearing loss of varying degree in up to 40% of the sample size on audiological assessment. Based on findings, interventions for workplace control of noise and use of other protective measures and health education was advocated.

16:00 – 16:15

### 3664 Noise exposure and hearing threshold levels in call center operators

Małgorzata Pawlaczyk-Łuszczczyńska • Adam Dudarewicz • Małgorzata Zamojska-Daniszewska • Kamil Zaborowski • Paulina Rutkowska-Kaczmarek

The overall objective of the study was to analyze the risk of noise-induced hearing loss (NIHL) in call center operators. Conventional pure-tone audiometry and high-frequency audiometry were performed in 78 subjects, aged 19–44 (28.1±6.3) years, employed up to 12 (2.7±2.9) years at one call center. All subjects were also inquired about their headphones usage habits, hearing-related symptoms and risk factors for NIHL. Noise exposure from communication headsets was evaluated using MIRE technique as specified by the ISO 11904–1:2002 standard. The background noise prevailing in offices was also measured according to ISO 9612:2009. A personal daily noise exposure level calculated by combining headset and non-headset work activities ranged from 69–79 (74.7±2.5) dB. In majority (90%) of subjects, mean hearing threshold level in the frequency range of 1–8 kHz did not exceed 20 dB. Nevertheless, high frequency notches were found in 15% of audiograms. Moreover, some of call center operators reported hearing-related symptoms. Further studies are needed before firm conclusions concerning the risk of NIHL in this professional group can be drawn.

16:15 – 16:30

### 3941 The effect of occupational noise on hearing-related symptoms – exploring mediating and modifying effect of annoyance and stress

Sofie Fredriksson • Laith Hussain-Alkhateeb • Kerstin Persson-Waye

Noise-induced hearing disorder is under reported in female-dominated occupations, hindering knowledge on associated risk factors. We performed a cross-sectional study in Sweden, including 4,718 female preschool teachers and 4,122 randomly selected women age 24–65. In hypothesised causal models, we explored the effect of occupational noise exposure (e.g. self-reported retrospective and current exposure, hearing protection) on hearing-related symptoms (hearing loss, speech perception, tinnitus, hyperacusis, sound-induced auditory fatigue). Noise annoyance, work-related stress and stress arousal were assessed for mediating and modifying effects. Exposure to occupational noise significantly increased the risk of hearing-related symptoms among preschool teachers (RRs 1.19–1.42 in adjusted log-binomial regression models). Consistent with our hypothesis, annoyance mediated the effect of noise exposure on sound-induced auditory fatigue (indirect effect  $\beta = 0.28$ ). In contrast, annoyance modified the effect of noise exposure on both hyperacusis and speech perception. For sound-induced auditory fatigue and hyperacusis, stress exposure and stress arousal both modified the effect and significantly interacted with noise exposure. The models provide better understanding of possible mechanisms for developing hearing-related symptoms. These findings will be further explored using longitudinal design.

15:15 – 16:45 | C6

**LOW FREQUENCY NOISE AND VIBRATION**

Chair: Norm Broner • Geoff Leventhall

15:15 – 15:45

**3581 Resolution Improvement of Low Frequency Noise Sources in Acoustic Holography**

Hee-Min Noh • Jae Chul Kim • Duckshin Park

The delay-and-sum beamforming method, which has been used in previous studies, is a useful technique to identify noise sources in a high-speed train. However, the method does not provide detailed noise source position in the low-frequency range. Thus, the low-frequency noise sources of a high-speed train were not identified. Therefore, in this paper, a resolution improvement study was conducted to identify low-frequency noise sources in a high-speed train. The relation between an actual noise source and a beamforming output was first derived using the point spread function. The deconvolution approach of the relation was used to obtain an actual noise source, which was then transferred to an inverse problem. To solve the ill-conditioned inverse problem, an optimization problem was applied and the iteration method was conducted to solve the problem. The algorithm developed in this research was verified with a moving vehicle test.

15:45 – 16:15

**3795 Low frequency and tonal properties of noise transmission through acoustical enclosures**

Jie Pan • Qisen Tan • Ming Jin • Hongmei Sun

Acoustical enclosures are widely used in electric power substations to protect environment from low frequency noise radiation by electric facilities. The noise transmission loss of these enclosures are often evaluated in  $\frac{1}{3}$  octave frequency bands. However, as the noise from electric facilities is concentrated at discrete frequencies (e.g. 100 Hz and its harmonics), the property of the designed acoustical enclosures in narrow frequency bands is more relevant. This paper demonstrates that the sound transmission properties of acoustical enclosures for low frequency and tonal noise is dependent upon the couplings between the noise sources, interior sound field, enclosure structure and external sound field. Understanding of the coupling mechanisms involved in the noise transmission may be useful for designing acoustical enclosures with large transmission loss at these frequencies of interests.

16:15 – 16:45

**3586 Project review: elastic decoupling of a large roller grinder**

Thomas Schönherr

Getzner as a manufacturer of polyurethane-material is involved in a broad variety of projects for elastic decoupling of machines. In this conference-contribution a detailed insight-view of a particular project is given. The project is about the elastic decoupling of a roller grinder. The roller grinder is situated in the vicinity of other machines; so the machine is exposed to high levels of shock and vibrations. To ensure the accuracy of this high-precision-machine over the total service life a passive vibration protection with polyurethane-bearings was requested. Studies were performed and a solution with discrete polyurethane-bearings was suggested. This solution was approved by the customer and installed in April 2015. The background of the studies will be presented including explanations of the distinctive features of non-linear polyurethane-material. Recommendations for handling and processability of the material will be given. Finally the constructional execution of the decoupling will be introduced. Fact box: machine: roller grinder, machine weight: 170to, foundation: 17m x 4,6m with depth 2,5m, foundation weight: 490to, vibration isolation: discrete polyurethane-bearings (type Sylodyn NE-75mm), commissioned: sept 2015

16:45 – 17:00 | Atrium

**Coffee break**

17:00 – 18:00 | C60

**EFFECTS OF NOISE ON SLEEP**

Chair: Gunn Marit Aasvang • Sarah McGuire

17:00 – 17:15

**3893 Association between residents' attitude towards air traffic and their objective sleep quality at Frankfurt Airport**

Eva-Maria Elmenhorst • Uwe Müller • Franco Mendolia • Julia Quehl • Mathias Basner • Daniel Aeschbach

Sleep disturbances and impaired quality of life are among frequent complaints from residents around airports. This paper aims at investigating whether psychological factors such as subjective attitude towards air traffic are related to the objective sleep quality of an individual. In 2012 as part of the NORAH sleep study, 74 residents around Frankfurt Airport rated their attitude towards air traffic and assessed its necessity. Polysomnography was recorded in residents' home environment. In the NORAH study, a negative attitude towards air traffic was associated with a significantly impaired sleep quality (i.e. prolonged sleep onset latency:  $\Delta$  5.6 min, increased wake after sleep onset:  $\Delta$  12.3 min, reduced sleep efficiency:  $\Delta$  3%, and less deep sleep:  $\Delta$  12.3 min). The assessment of air traffic as less necessary was related to a significant reduction in deep sleep duration ( $\Delta$  15.1 min). These results suggest that residents' objective sleep quality and their subjective assessment of air traffic are related. Cause and effect of the relationship remain to be identified.

17:15 – 17:30

**3750 Investigating the impact of nocturnal aircraft noise on children's sleep, cognitive performance, and annoyance: The MIDAS-study**

Susanne Bartels • Julia Quehl • Christian Mühl • Matthias Putzke • Daniel Aeschbach

Disturbances of sleep are the most serious effect of nocturnal traffic noise exposure. Studies on the influence of nocturnal aircraft noise on the sleep of children have hardly been carried out so far. In an ongoing field study, the German Aerospace Center (DLR) investigates the impact of aircraft noise on sleep and related psychological

reactions of 50 children aged 8 to 10 years living in the vicinity of Cologne/Bonn Airport, Germany. Children are investigated polysomnographically during four consecutive nights. In the morning, they retrospectively rate their sleep quality, problems falling asleep, acute fatigue, and short-term annoyance. Subsequently, cognitive performance is measured via age-appropriate computer-assisted tests. Long-term annoyance and disturbance, and relevant psychological moderator variables are also assessed. In parallel, a corresponding survey is administered to the parents of the participating children. Up to now, both children and parents have rated the study procedure and methodology positively. Strain due to the study protocol has been considered as small. Methods of the study are presented in detail and preliminary results regarding the adequacy of the methodology are discussed.

17:30 – 17:45

**3623 Nocturnal road traffic noise and children's sleep duration**

Kjell Vegard Weyde

What is known about the association between nocturnal road traffic noise and sleep mainly comes from studies on adults. Knowledge regarding children is scarce. In the present study, we hypothesized that increased nocturnal road traffic noise is associated with shorter sleep duration in children. The study used questionnaire data from 2,665 7-year-old children included in the Norwegian Mother and Child Cohort Study (MoBa). The main noise variable was the modelled  $L_{eq}$  for road traffic at the most exposed façade of the child's residential address. In the questionnaire, mothers were asked about their child's sleep duration, with 5 categories:  $\leq 8$ – $\geq 12$  hours. Responses were recoded into three categories: less than 10 hours, 10 hours, or more than 10 hours. It was also asked whether the children had sleep problems. Covariate information from MoBa questionnaire, Medical Birth Registry of Norway and Statistics Norway. Generalized ordered logistic regression and logistic regression analyses were conducted to investigate the association between modelled nocturnal road traffic noise and children's sleep duration and sleep problems, respectively. Results will be presented at ICEN 2017.

17:45 – 18:00

**2441 The effects of aircraft noise exposure on subjective sleep quality: the results of the DEBATS study in France**

Ali Mohamed Nassur • Marie Lefevre • Damien Leger • Bernard Laumon • Anne-Sophie Evrard

Objectives: Exposure to aircraft noise has been shown to have adverse effects on health and particularly on sleep. This study aimed to investigate the relationship between aircraft noise exposure and subjective sleep quality in the population living near airports in France. Methods: Information on their sleep was assessed through a questionnaire administered to 1,244 residents of three major French airports: Paris-CDG, Lyon-Saint-Exupéry and Toulouse-Blagnac. For each participant, aircraft noise exposure was assessed at home using noise maps. Logistic regression models were used with adjustment for potential confounders. Results: Aircraft noise exposure was associated with the risk of being a short sleeper (sleep duration  $\leq 6$ h), and with the feeling of tiredness on awakening in the morning. An increase of 10 dBA in aircraft noise level at night was respectively associated with an OR of 1.66 (95% CI: 1.16 to 2.35) and an OR of 1.24 (95% CI: 1.00 to 1.63). Conclusion: These findings contribute to the overall evidence suggesting that aircraft noise exposure at nighttime may decrease subjective quality of sleep.

17:00 – 17:30 | C44

**NOISE-INDUCED HEARING LOSS**

Chair: David Welch • Małgorzata Pawlaczyk-Łuszczynska

17:00 – 17:15

**3572 Cost-benefit analysis in occupational exposure to noise**

Paolo Lenzuni

Cost-benefit analysis in workplace acoustics has received little attention insofar. While it is usually straightforward to have an estimate of costs, this is not the case for benefits. Most of the published work appears to focus on the benefits induced by a higher productivity, despite the poor correlation of this quantity with noise levels. In this paper we present an algorithm which has been developed to predict the cost-effectiveness of noise control treatments at the workplace. This algorithm is based on the estimates of hearing threshold shifts associated to specific noise levels and exposure duration, as indicated in ISO 1999. The resulting hearing impairment is then converted into the economic compensation that the worker is entitled to. A reduced exposure will then translate into lower compensation costs. The cost-benefit ratio calculated in this paper can be used as a quality index to compare different noise abatement options in a specific workplace, and it can also be used by workers' compensation authorities to evaluate the cost effectiveness of technical actions, and support dedicated employers.

17:15 – 17:30

**4049 Adverse auditory effects associated with the combined exposure to jet fuels and noise**

Adrian Fuente

Exposure to chemicals such as organic solvents and jet fuels has been suggested to adversely affect peripheral and central auditory structures. However, no much evidence about the effects of jet fuel exposure on the human auditory system is available. The aim of this research was to determine the cumulative effects of the combined exposure to jet fuels and noise on the auditory system. Sixty male and female officers from the Royal Australian Airforce were selected. A test battery including pure-tone audiometry, distortion product otoacoustic emissions (DPOAEs), auditory brainstem response, compressed speech and a self-report questionnaire about performance in daily-life listening situations was carried. Results showed an interaction between noise and jet fuel exposure on pure-tone thresholds and DPOAEs, especially for the high frequencies. In addition, a significant effect of jet fuel exposure on ABR results was found. Finally, some factors such as job title and chronic exposure to jet fuels were significantly associated with self-report hearing difficulties. This study provides further evidence about the peripheral and central auditory dysfunction associated with exposure to jet fuels and noise.

17:30 – 18:00 IC44

**NOISE AND COMMUNICATION**

Chair: Anthony Brammer • Chantal Laroche

17:30 – 17:45

**3780 For persons with normal hearing, can speech understanding in noise be influenced by a history of temporary threshold shift?**

Anthony Brammer • Gongqiang Yu • James Grady • Kourosh Parham • Martin Cherniack • Shannon Wannagot • Kathleen Cienkowski

Recent animal experiments have found that noise-induced temporary changes in hearing threshold (TTS) unexpectedly caused persistent suprathreshold changes in auditory function, even though long-term thresholds remained normal. It was postulated that in humans the effect could influence speech communication in noise. We have studied 46 male and female students with normal hearing who completed a questionnaire concerning hearing, exposure to noise, experiencing TTS-like symptoms, and speech understanding. Subjects reported statistically significant reductions in their ability to understand speech when trying to communicate in noisy environments. However, when groups reporting TTS-like symptoms («exposed»), and »controls« (reporting no TTS-like symptoms) were formed that were matched in hearing thresholds, there was no difference in mean word scores between groups in a psychophysical test of speech intelligibility. The exposed group did exhibit a statistically significant deterioration in threshold for detecting 4Hz amplitude modulation of a 500Hz carrier, suggesting persons with normal hearing reporting TTS-like symptoms may experience subtle suprathreshold changes in hearing. Nevertheless, the reported changes in speech understanding could not be confirmed by an objective test. [Work supported by NIOSH]

17:45 – 18:00

**3603 Effects of noise type on listening effort: relationship between subjective rating and objective measures**

Chiara Visentin • Nicola Prodi

The present study investigates the relationship between the self-rated effort when listening to speech in adverse conditions, and response time, taken as a measure of the cognitive resources deployed for interpreting and responding to the auditory stimulus. Specifically, the peculiar effects of two background noises are assessed: a steady state, speech-shaped noise (SSN) and a fluctuating (ICRA) masker. Matrixed-word listening tests were proposed to a panel of young adults with normal hearing. Fourteen realistic acoustic conditions were created by varying SNR, reverberation and noise type. For each condition intelligibility scores (IS), response time (RT) and self-rating of listening effort (LE) were collected. The results were mapped by using the objective short-term metric STIr, whose run-time nature allows the tracking of non-stationary maskers, properly accounting for »listening in the gaps«. Even though the same accuracy was achieved in the two masker, the conditions with ICRA noise were always rated as more effortful; similarly, RT was significantly higher in fluctuating noise, revealing a greater engagement of cognitive resources.

	C60	C44	C6	D1	
09:00	Keynote by Christian Koch				
09:15					
09:30					
09:45	Development of the new WHO Environmental Noise Guidelines for the European Region				
10:00					
10:15					
10:30	Coffee break (Atrium)				
10:45					
11:00	Overview talk: Noise and communication		Low frequency noise and vibration		
11:15					
11:30	Overview talk: Effects of noise on cognition, performance and behavior				
11:45					
12:00	Overview talk: Community response to noise and noise annoyance				
12:15					
12:30	Lunch break (Atrium)				
12:45					
13:00					
13:15					
13:30	Poster Blitz				
13:45					
14:00					
14:15					
14:30					
14:45	Coffee break (Atrium)				
15:00					
15:15	Noise and communication	Community response to noise and noise annoyance	SiRENE Minisymposium: Short and Long Term Effects of Transportation Noise Exposure – an interdisciplinary approach		
15:30					
15:45					
16:00					
16:15	Effects of noise on cognition, performance and behavior				
16:30	Coffee break (Atrium)				
16:45	Effects of noise on cognition, performance and behavior	Noise exposure assessment in health effect studies	Low frequency noise and vibration		
17:00					
17:15					
17:30					
17:45					
18:00					
18:15					
18:30					
18:45					
19:00 – 23:00	Social evening at the Lake Side Zürichhorn				

09:00 – 09:45 | C60

**KEYNOTE BY CHRISTIAN KOCH**

**4163 Hearing behind the limit: Measurement, perception and impact of infrasound and ultrasonic noise**

Christian Koch

In our daily life many sources emit infrasound because of their function or unintended. On the other side of hearing frequency range airborne ultrasound is applied in many technical and medical processes and has also increasingly moved into daily life. There are numerous indicators that sound at these frequencies influence human beings and that sound at such frequencies can be perceived. However at present, the precise mechanisms of this perception are unknown and this lack in understanding is reflected by the unsatisfactory status of existing regulations and standards. The talk will try to briefly describe the current status of measurement capabilities, the knowledge about perception mechanisms, and the assessment of infrasound and airborne ultrasound. To contribute to the question whether these sounds can be of any risk for the hearing system the results of a study using audiological methods and neuroimaging are presented. It was implemented within an EU-funded international project in order to improve the objective rationale of the auditory perception of infrasound and airborne ultrasound in humans.

09:45 – 10:30 | C60

**DEVELOPMENT OF THE NEW WHO ENVIRONMENTAL NOISE GUIDELINES FOR THE EUROPEAN REGION**

Chair: Dorota Jarosinska • Mark Brink • Peter Lercher

The WHO environmental noise guidelines for the European Region are in the final stages of updating. The guidelines not only consider new evidence associating noise exposure with health outcomes but also new noise sources and where possible, quantify the risk of these health effects with an incremental increase in noise exposure. In addition to transport noise (aircraft, rail and road traffic), wind turbine and leisure noise are considered. The health outcomes reviewed and covered in the guidelines include annoyance, cardiovascular and metabolic effects, cognitive impairment, quality of life, mental health and well-being, hearing impairment and tinnitus, adverse birth outcomes, and effects on sleep. Moreover, the guidelines address different types of interventions and their effects. The development of WHO guidelines follows a rigorous framework to ensure unbiased systematic review of evidence and formulation of public health recommendations. The Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach was applied to assess the quality of evidence. This ICBCEN 2017 session presents the main outcomes of the systematic reviews of evidence on health outcomes and interventions. The systematic reviews will be published in a special issue of the International Journal of Environmental Research and Public Health (IJERPH).

10:30 – 11:00 | Atrium

Coffee break

11:00 – 11:30 | C60

**OVERVIEW TALK: NOISE AND COMMUNICATION**

**3779 Improving communication in noise: Some recent developments**

Anthony Brammer • Chantal Laroche

Recent research into methods for improving speech perception in environmental noise has centered on ideal time-frequency segregation (ITFS), which involves analyzing successive short intervals of a time history containing noise and speech into contiguous frequency sub-bands. The signal in each sub-band is accepted or rejected depending on the presumed dominance of noise (by a »binary mask«), and the resulting sub-band signals are then recombined. An alternative to the binary mask involves forming the intensity modulation spectrum (IMS) as a means for estimating the speech signal to noise ratios (SNRs). These form the gains of the sub-band signals, which are then recombined as before. Experiments suggest that ITFS improves speech understanding for persons with normal hearing and hearing loss while, in contrast, commercial application of IMS to hearing aids has produced conflicting results. These and related techniques for improving speech SNR are now being investigated for cochlea implants and hearing protectors. Users of the latter also benefit from techniques for improving the audibility and localization of warning sounds, which typically involve binaural listening and broadband alarm signals.

11:30 – 12:00 | C60

**OVERVIEW TALK: EFFECTS OF NOISE ON COGNITION, PERFORMANCE AND BEHAVIOR**

**4017 Review of research on the effects of noise on cognitive performance 2014 – 2017**

Andreas Liebl • Helena Jahncke

A literature review was conducted covering the years from 2014 to 2017 and searching for publications on the effects of noise on cognitive performance. Sound or noise and cognitive performance as well as several synonymous or related terms were used in the search string. The search resulted in a total of 1114 posts which were reduced by including only those publications which are work-related. This resulted in 82 articles. After skimming the abstracts 47 publications remain. Several studies aim on the effects of office noise and address only noise effects or integral effects of noise and other parameters like ventilation or odors and even extend to studies dealing with office types. In this context noise abatement measures like sound masking are also tested. Additionally positive effects of sound by means of restoration are investigated. Besides this applied research work basic research dealing with the irrelevant sound effect but also with effects on other measures of cognitive performance like mathematics, reading, word processing and writing are reported.

12:00 – 12:30 | C60

**OVERVIEW TALK: COMMUNITY RESPONSE TO NOISE AND NOISE ANNOYANCE****3983 Recent progress in the field of community response to noise**

Sabine Janssen • Jiyoun Hong

This paper aims to review the progress within the field of the community response to noise and noise annoyance based on peer-reviewed publications in the past three years (2014 to 2017). Developments include an increased focus on local or case-specific as opposed to generalized exposure-response relationships to predict noise annoyance, as well as a renewed interest in the influence of temporal and spectral characteristics on the annoyance at a given noise level. In addition, new research has been published on annoyance due to railway noise and vibration, as well as on wind turbine noise annoyance. Furthermore, some studies have investigated effects on annoyance of interventions to reduce noise, while some have focused on individual differences in noise sensitivity and annoyance. New insights from recent studies on each of these topics are discussed.

11:00 – 12:30 | C6

**LOW FREQUENCY NOISE AND VIBRATION**

Chair: Norm Broner • Geoff Leventhall

11:00 – 11:30

**3691 Burden of disease from exposure to low frequency noise: a Dutch inventory**

Irene van Kamp

The level of concern and health complaints related to low frequency noise (LFN) seem to be increasing, not only in the Netherlands, but also at international level. There is evidence suggesting an association between LFN and symptomatic effects such as annoyance and sleep disturbances. A systematic evaluation of the literature which we recently performed, focusing on epidemiological studies on residential sources of LFN in relation to various symptoms and well-being indicators confirms these findings. However, it is still hard to make a valid estimate of the burden of disease due to LFN. Therefore, based on several Dutch datasets we estimated the prevalence of health complaints due to low frequency noise or attributed to it. Limiting factor is that, although we get a feel for the »extent« of the problem, the available data only concern perceived exposure rather than actual measurements of LFN, preventing to link the exposures to these health complaints. This is one of the main research gaps in the field. In this paper we discuss the findings and propose an approach for future research to further this field.

11:30 – 12:00

**3625 Annoying Low Level Sound**

Rudolf Bütikofer • Kurt Eggenschwiler • Edith Steiner

A very specific, low level sound from an unknown source, persisting over months, may drive a person crazy, while known sounds are tolerated. Usually, a person living in a very quiet apartment is affected. Although each case is different from the other, it would be well worth to draw some scientific attention to the phenomenon. The presentation will focus on practical aspects on how to help these people. The first question to be answered is: Is there any medical indication, e.g. some sort of Tinnitus, or is the annoyance caused by real sound or vibration from a technical source? If it looks like the annoyance being caused by a technical source, the search with acoustical means is usually very time consuming. Search strategies will be discussed. If the search fails, masking of the annoying sound by some broadband noise from a loudspeaker or a well may provide some relief.

12:00 – 12:30

**3659 A new methodology for investigating IFLN complains**

Steven Cooper

The methodology employed in the Cape Bridgewater study started from resident's diaries of disturbances. The procedure used weather data, wind farm operating data and noise data (all as post-processed data) to compare the diaries and found trends where specific wind farm operations corresponded to the reported disturbances. A similar procedure occurred for investigating »noise« complaints for residents concerning a coal-fired power station and a large ventilation fan for an underground coal mine. Limitations in obtaining high quality full spectrum wave files were encountered. Typical Class 1 sound levels meters have storage limitations of 1–2½ days for such high quality samples. Using of multichannel systems such as B & K's Pulse are expensive and require very large storage capacity. Utilising the study procedure has resulted in the development of a relatively low cost, two-channel, full-spectrum data recorder for field use, coupled with simultaneous biometric monitoring. The methodology that has been successfully employed/developed and the opportunities now available for more detailed processing of this data together with linking the disturbances to the startle reflex is discussed.

12:30 – 13:30 | Atrium

**Lunch break**

13:30 – 14:45 | C60

**POSTER BLITZ**

Chair: Mathias Basner

Very brief presentations of the ICBCEN 2017 posters. Please find the poster list on page 51.

14:45 – 15:15 | Atrium

**Coffee break**

15:15 – 16:30 | C60

**NOISE AND COMMUNICATION & EFFECTS OF NOISE ON COGNITION, PERFORMANCE AND BEHAVIOR**

Chair: Anthony Brammer • Chantal Laroche

15:15 – 15:30

**3646 Communicating with low-cost hearing protectors: hear, see and believe**

Annelies Bockstael • Lies De Clercq • Dick Botteldooren

The effect of hearing protectors improve, worsen, or have no effect on oral communication is highly situational dependent. Subjectively, listening without any hearing protection is most often preferred. Specialized commu-

nication hearing protectors could improve communication, but for most common exposure conditions low-cost alternatives are needed. Generic musician earplugs (aim to) to reduce high frequency attenuation. This could not only improve music perception, but also speech perception. In this work, oral communication has been evaluated by sixty participants both quantitatively and qualitatively in six different listening conditions: with four different types of musician earplugs, one conventional foam earplug and without any hearing protection. Communication has been evaluated with and without lip-reading. Without visual information (no lip-reading), highest speech perception scores are obtained in the condition without earplugs. Speech perception scores with conventional earplugs are very similar to those with musician earplugs, despite clear differences in attenuation. Contrary, participants perceive speech perception with the conventional earplug systematically as more difficult. Lip-reading has a very strong effect on speech perception, almost equalizing scores for the six different test conditions.

15:30 – 15:45

**3975 Effect of personal safety equipment (hearing protection and helmet) on the localization of reverse alarms**

Chantal Laroche • Véronique Vaillancourt • Christian Giguère • Manuelle Bibeau •  
Veronique Carroll • Emily Gula • Flora Nassrallah • Hugues Nélisse • Jérôme Boutin

While reverse alarms are mandatory on most heavy vehicles, accidents still occur during the course of reversing manoeuvres. Recent studies have addressed the limitations of traditional reverse alarms («beep-beep») compared to broadband alarms («pschtt-pschtt»). In workplaces where reverse alarms are used, workers are often required to use personal safety equipment such as hearing protectors and helmets. The current study aimed at exploring the effect of such equipment on the ability to localize both types of alarms in 3 groups of individuals with normal hearing using earmuffs, ear plugs or double protection, with and without concomitant use of a helmet. Results revealed a significant effect of alarm type (with better results for the broadband alarm) and type of hearing protection (with a marked degradation in performance using double protection), while safety helmet use did not seem to impact localization to a great extent. These findings could help raise workplace awareness as to the potential impact of safety equipment on sound localization and identify other viable alternatives (e.g. traffic management plan) when reverse manoeuvres are performed in the vicinity of workers.

15:45 – 16:00

**2332 Disability Rights Aspects of Ambient Noise for People with Auditory Disorders**

Daniel Fink

The United States and European Union (EU) guarantee people with disabilities certain rights, with goals of full enjoyment, active inclusion, and equal participation in society. This approach is also found in the United Nations Convention on the Rights of Persons with Disabilities, adopted by EU. Noise is a disability rights issue for individuals with hearing loss. Many cannot understand speech in noisy places, with or without hearing aids. Noise worsens symptoms for those with tinnitus and hyperacusis. Noisy restaurants, stores, and other places deny full enjoyment and equal participation in public life to those with hearing loss, tinnitus, and hyperacusis. Legislative and regulatory action is needed to provide quiet environments, with established noise standards vigorously enforced. Technologies and environmental modifications to control noise are well known, readily available, and relatively inexpensive. The simplest modification is merely turning down the volume of amplified sound. Quiet facilitates communication for everyone and prevents hearing loss, tinnitus, and hyperacusis in those without auditory disorders.

16:00 – 16:15

**3675 The effect of acoustic absorbing wall panels in classrooms**

Carsten Svensson • Erling Nilsson

A wall-to-wall acoustic ceiling is a common solution in many buildings today. But this may not be enough to create good acoustics – there can be a need for more sound absorption on the vertical surfaces. Different acoustic qualities are important in different situations. In some cases the sound level is the main issue and in other cases it can be speech clarity, such as in classrooms. In this paper we discuss the results of room acoustic field measurements and calculations on how vertical absorbing wall elements affect human and acoustic qualities. Wall panels give a larger effect than expected using the Sabine formula, due handling horizontal grazing sound energy. The more vertical absorbers installed in a room with a full absorbent ceiling, the more will the speech clarity increase and the reverberation time decrease. Results also show that you only need to add a fairly small vertical absorption area to improve speech clarity and reverberation time. The sound strength was not as easy to improve. To reduce it you need to add a fairly large area of vertical absorbers.

16:15 – 16:30

**3609 When and why does a long reverberation time improve comprehension and recall?**

Staffan Hygge

In four recent experiments we have seen that a long reverberation time (RvT) may improve, rather than impair, comprehension and recall of spoken words or texts for participants who have limited language skills. A long RvT improved, rather than impaired, comprehension for Swedish pupils with a low proficiency in English reading when taking a grade 9 English listening comprehension test in their classroom. For those who were good at reading English there was a better recall with a short RvT. This crossover antagonistic interaction was replicated with Swedish college students grouped by their English proficiency reading skills. In two word list experiments with Swedish pupils in grade 4 and college students, English and Swedish words were presented with a long and short RvT and crossed with two signal-to-noise ratios. Also here there were indicators of a crossover interaction to the effects that a long reverberation time improved, rather than impaired, the recall of the words for students that were on the low side of English language proficiency. Possible explanations will be discussed in the presentation.



15:15 – 16:30 | C44

**COMMUNITY RESPONSE TO NOISE AND NOISE ANNOYANCE**

Chair: Sabine Janssen • Dirk Schreckenberg

15:15 – 15:30

**2460 Effects of noise on the wellbeing of rail staff**

Andrew Smith • Hugo Smith

The present study involved a survey of over 1,000 rail staff and the objective was to determine the effects of noise on aspects of wellbeing. One of the major problems with noise surveys has been the lack of control of confounding factors and the present study used a measuring instrument (the Smith Wellbeing Questionnaire – SWELL) that records information on demographics, lifestyle and personality, as well as job characteristics. The outcomes measured included illness caused or made worse by work, presenteeism, mental health problems, musculo-skeletal disorders, stress at work, job satisfaction, fatigue, work-life balance and life stress. Over 40% of the sample reported frequent exposure to high levels of noise and in some jobs this was much higher (e.g. train drivers 62%; engineers 82%). After controlling for possible confounders, noise was found to predict most of the negative outcomes. These findings suggest that noise is having a large effect on the wellbeing of rail staff and that further research is needed on the non-auditory effects of the frequent and loud noise exposure in this transport sector.

15:30 – 15:45

**3569 The opening of a new terminal building and its influences on community response around Hanoi Noi Bai International Airport: Comparison between Arrival and Departure sides**

Thao Linh Nguyen • Thu Lan Nguyen • Takashi Yano • Ichiro Yamada • Tetsumi Sato • Makoto Morinaga • Tsuyoshi Nishimura

To study about the change of community response in changing circumstance in Hanoi Noi Bai International Airport after a new terminal was launched, two rounds of social surveys were conducted three months prior and after the operation, and another one round was implemented nine month afterwards. The results showed a slightly increment of noise level but a considerable change in annoyance levels of the community around the airport. Moreover, the last survey's results showed an undeniable increase of respondent's annoyance level, especially in higher Lden values. Comparison between Arrival and Departure sides of the airport has also been conducted on general annoyance, activities interference and sleep disturbances. It is notable that a higher level of annoyance in Arrival side was found in all surveys, and most severe in the second survey. One of the fact that possibly be considered as a reason for this dissimilarity is a notable sleep disturbance level of respondents living under the arrival route, especially at sites A3~A6, which were farmer villages with daily routines of waking up and go to sleep early.

15:45 – 16:00

**3985 Annoyance response to helicopter noise**

Sabine Janssen • Sander J. Heblj • Theo A. Veen

Exposure-response relationships for aircraft noise may not be directly valid for specific sources such as helicopters. In addition to several non-acoustic attitudinal factors, acoustic characteristics of helicopter noise may influence its perception and the annoyance response. The present study investigates the role of helicopter noise-induced rattle (i.e. sounds of rattling objects or windows within the dwelling induced by low frequency components impacting the building) in heightening the annoyance response. This was done by asking 120 subjects to compare the annoyance due to recorded helicopter noise (either with or without rattle) with that due to fixed-wing aircraft noise in a paired comparison test. Subjects were seated in one of three dwelling types which differed substantially in their susceptibility to produce rattle or vibration. The present findings confirm earlier evidence that rattle noise and vibration increase the annoyance induced by helicopter noise.

16:00 – 16:15

**4006 Exposure, annoyance, and sensitivity to noise in informal settlements in the Western Cape province, South Africa**

Martina Ragettli • Chloé Sieber • Olaniyan Toyib • Mark Brink • Roslyn Baatjies • Nicole Probst-Hensch • Aqiel Dalvie • Martin Rössli

Little is known about the health effects of noise exposure in developing countries. We assessed the exposure, annoyance, and sensitivity to noise in adults living in informal settlements in the Western Cape Province, South Africa (SA). We developed a land use regression model for A-weighted day-evening-night equivalent sound level (Lden) using continuous 5-day outdoor noise measurements and geographic information system (GIS) variables of 134 sites to predict noise levels at 562 homes. Noise annoyance and noise sensitivity was assessed by personal interviews. The data was compared to a similar survey (n = 5,369) in Switzerland (SIRENE study). Main predictors of measured noise levels were related to road-traffic and household density. However, GIS predictors explained a small part of the measured noise (adjusted R2 = 0.13). The proportion of highly noise sensitive individuals (SA: 35% in females, 25% in males; Switzerland: 27% in females, 21% in males) and people highly annoyed from road-traffic and neighborhood noise was higher in SA than in Switzerland. This study demonstrates that noise exposure is considerably affecting the quality of life of people living in informal settings.

16:15 – 16:30

**3963 The noise pollution perception in the city of Milan: analysis of registered complains by the population**

Giovanni Zambon • Fabio Angelini • Roberto Benocci • Stefano Shumbusho Muchetti • Diego Salvi

The present study deals with the analysis of registered complains of noise pollution, reported in the city of Milan by the citizenship from 1999 to 2015. Such complains have been organized in a digital database and has been statistically analysed according to: 1) the main types of noise sources (technical facilities, music, transport

infrastructures) and activities (retail and catering businesses, production, tertiary), 2) the degree of suffering established by the limits of Italian laws, 3) the noise levels found at the complainant's and 4) conclusion of the registered complains. Further evaluations have been carried out by means of a GIS software (Geographic Information System) to represent territorial analysis of complaints according to the noise source, disturbing activities, assessments of noise suffering, analysis of nightlife impact, correlation between the perceived noise and the real estate value. This analysis includes also a geo-statistical representation by using density maps. We have, therefore, identified the most annoying sources for the population and their distribution. Such information could provide a valuable benefit for the local city administration.

15:15 – 16:30 | C6

**SiRENE Minisymposium: Short and Long Term Effects of Transportation Noise Exposure – an interdisciplinary approach**

Chair: Martin Röösl

**3894 Short and Long Term Effects of Transportation Noise Exposure (SiRENE): an interdisciplinary approach**

Martin Röösl • Danielle Vienneau • Maria Foraster • Ikenna C. Eze • Harris Héritier • Emmanuel Schaffner • Laurie Thiesse • Franziska Rudzik • Reto Pieren • Manuel Habermacher • Micha Köpfl • Mark Brink • Christian Cajochen • Jean Marc Wunderli • Nicole Probst-Hensch

This symposium presents the Swiss SiRENE study on acute, short- and long-term effects of transportation noise exposure on annoyance, sleep disturbances and cardiometabolic risks. SiRENE aims at identifying noise exposure patterns that most strongly affect individuals during sleep and thus may ultimately result in long-term health consequences. In SiRENE a nationwide assessment of road, railway and aircraft noise exposure was conducted to estimate noise levels and degree of noise intermittence for the whole Swiss population. The study includes a representative population survey on noise annoyance and sleep disturbance, an experimental study in the sleep laboratory applying contrived noise exposure scenarios, and the analysis of the SAPALDIA Biobank and Swiss National Cohort (SNC) data where cardiometabolic morbidity and cardiovascular mortality due to noise exposure and mechanistic pathways were addressed. Key findings of all aspects are presented as an example how mutual combination of human experimental and observational, epidemiological research contributes to a better understanding of the role of sleep for acute, short- and long-term noise effects on cardiometabolic outcomes and which people are most vulnerable to noise exposure in general.

16:30 – 16:45 | Atrium

Coffee break

16:45 – 18:00 | C60

**EFFECTS OF NOISE ON COGNITION, PERFORMANCE AND BEHAVIOR**

Chair: Andreas Liebl

16:45 – 17:00

**3518 The relationship between aircraft noise and reading: Mediator and moderator effects**

Jan Spilski • Kirstin Bergström • Jochen Mayerl • Ulrich Möhler • Thomas Lachmann • Maria Klatte

There is considerable evidence that chronic exposure to aircraft noise is associated with lower reading performance in children. The discussion of underlying mechanisms focuses on noise-induced impairments of verbal precursors of reading, quality of instruction, and motivation. There is, however, a lack of studies considering the impact of indirect or moderating factors on the association between noise and reading, such as migration background, urbanicity, and others. In the NORAH study (Klatte et al., 2016), reading performance, noise exposure, and a range of potential moderating and mediating variables on the individual and class levels were assessed in second-graders living in the vicinity of Frankfurt/Main airport, Germany. Here, we present a theoretically motivated secondary analysis of the NORAH data set. We calculated multilevel analyses (MLAs, mediated and moderated models), and MLAs based on a propensity score matched sample using migration background as grouping variable. We found empirical evidence for indirect and moderated effects in the relationship between noise and reading performance. Including these effects in the multilevel models resulted in a substantial increase of explained variance (R<sup>2</sup>) in children's reading.

17:00 – 17:15

**3703 Effects of noise on reading: What do we know about this topic with respect to the occupational context?**

Helga Sukowski

Reading in conditions with unwanted sounds is a common situation that many employees have to deal with in different occupational settings. There are studies investigating effects of noise on reading, but in most cases these studies are laboratory studies and only specific aspects could be implemented like in a real work system. Therefore, a direct transfer of those results to everyday working situations is limited. The studies also differ in several aspects like the reading task, the duration of testing or the study design. This contribution summarises results from several studies dealing with effects of noise on proofreading tasks. In addition to the aim to uncover similarities and differences across studies, the results are analysed in the light of the question to what extent they provide information about noise effects in the frame of an occupational context, or even the reduction of possible detrimental effects. Necessities for further studies will be pointed out, like consideration of more realistic working demands or studies with employees rather than students. Finally, an outlook on a planned BAuA-research project in this field is given.

- 17:15 – 17:30**      **2458 Effects of noise on errors, injuries and subjective health of hospital staff**  
 Andrew Smith  
 Research on mild occupational noise exposure (where there is no risk to hearing) suggests that this level of noise may be a risk factor for injuries and errors but have no effect on subjective reports of health when other job characteristics are controlled for. The present study continued this research by conducting a survey of over 800 nursing staff. The survey collected information on subjective noise exposure, job characteristics (e.g. demands, control, support, working hours, and other aspects of the physical environment), demographics, and personality. Initial univariate analyses showed that those reporting more frequent noise exposure had more injuries/cognitive failures, greater stress at work, and lower levels of general health and anxiety and depression. Subsequent multi-variate logistic regressions controlled for job and personal characteristics. These analyses showed that noise still had a significant effect on injuries/errors and stress at work. In contrast, the effects of noise on general health and mental health were no longer significant when the other factors were covaried. These results confirm findings from other occupational groups exposed to similar levels of noise.
- 17:30 – 17:45**      **3889 Impact of noise on communication and concentration during surgeries**  
 Sandra Keller • Franziska Tschan • Norbert K. Semmer • Daniel Candinas • Guido Beldi  
 Performing surgery requires both excellent coordination at the team level and high level of concentration at the individual level. We investigated the effects of noise on (1) observed communication and (2) self-assessed concentration during 109 long abdominal surgeries. Analyses of 5-min intervals showed that noise peaks (>70 dB(A)) were associated with a decrease of case-relevant, but not of case-irrelevant communication – however, only during phases when the surgery was led by the less experienced surgeon, but not by the senior surgeon. Concentration under higher noise levels also varied as a function of the experience level of the surgeon and the phase of the surgery. Only less experienced surgeons reported lower concentration under higher noise during the most complex phase of the surgery. Furthermore, anaesthesiologist's concentration was affected by higher noise levels towards the end of the surgery, the most complex phase for their specific tasks. Thus, noise distracts and affects case-relevant communication during surgeries, but these effects depend on the experience levels and the complexity of the tasks.
- 17:45 – 18:00**      **3669 How does staff perceive the sound environment in operating theaters and treatment rooms with the present standards and building regulations?**  
 Maria Quinn  
 Standards and regulations regarding the sound environment in healthcare facilities are often focused on sound insulation to avoid overhearing and disturbances from adjacent rooms and the outdoor. The aspect of room acoustics are in many European countries regulated by only one parameter, Reverberation Time (RT). The Swedish standard has set the maximum to RT >0,6 sec in Operating Theatres and in treatment rooms. The objective of this survey was to assess if this creates a comfortable sound environment where staff is confident to interpret oral ordinations and alarm signals from the technical surveillance? We conducted a survey of a total of 154 nurses and assistant nurses and the result shows that the sound environment have importance for staff possibility to conduct their work in a good manner. Also that staff often found it difficult to interpret the direction of the sound. Ability to concentrate was affected and poor sound environment was sometimes the cause of misunderstanding oral ordination. Perception of wellbeing due to the sound environment decreased when there was numerous staff in the room and the workload was stressful.
- 16:45 – 18:00 | C44**      **NOISE EXPOSURE ASSESSMENT IN HEALTH EFFECT STUDIES**  
 Chair: Jean Marc Wunderli • Peter Lercher
- 16:45 – 17:00**      **3873 The inadequacy of the A-frequency weighting for the assessment of adverse effects on human populations**  
 Bruce Rapley • Mariana Alves Pereira • Huub Bakker  
 The A-Frequency Weighting has been used for more than 50 years as the primary metric for the determination of adverse effects of exposure to sound and noise for the human population. This paper outlines why this anachronistic measurement metric is inappropriate for classification of acoustic exposure in humans. Acoustic energy impacts on human physiology in a number of different ways through significantly different neurological pathways in addition to simple hearing (audition). The long-term effects of other biological pathways have been consistently overlooked because of the health and safety focus that espouses only loud noise is dangerous. The current paradigm considers that the only adverse effects resulting from acoustic exposure is damage caused through high-level acoustic bombardment (high sound pressure level). This paper outlines some of the other mechanisms that are involved with adverse human health effects as a result of industrial noise exposure, including very low-frequency sound and waveform characteristics.
- 17:00 – 17:15**      **3670 Predicting aircraft noise annoyance: exploring noise metrics other than Lden**  
 Oscar Breugelmanns • Danny Houthuijs • Ric van Poll • Klaas Jan Hajema • Roel Hogenhuis  
 Residents living around a military airbase are concerned about the long-term health effects of their exposure to very high peak noise levels of AWACS aircraft using old and noisy engines. They argue that their exposure to high peak levels is not adequately taken into account by using Lden within the policy discourse. We investigated

the relation between reported annoyance and yearly averaged noise metrics with different characteristics in a questionnaire survey with 9365 respondents. Noise metrics were based on the highest sound level (such as L<sub>max</sub>), the duration of the noise events (T<sub>ax</sub>: Time Above level x), and the number of noise events (N<sub>ax</sub>: Number Above level x). We also adapted the calculation of L<sub>den</sub> by introducing a factor alpha that could place more emphasis on noise levels or aircraft numbers. Within the set of 28 indicators, no noise metric was identified that could improve upon L<sub>den</sub> for describing the relation between aircraft noise and annoyance.

17:15 – 17:30

**3763 A statistical model to predict sound level differences between in- and outdoors**

Barbara Locher • André Piquerez • Manuel Habermacher • Martina Ragettli • Martin Röööli • Mark Brink • Christian Cajochen • Nicole Probst-Hensch • Jean Marc Wunderli

Noise exposure prediction models for noise effect studies normally yield free field exposure levels as results. However to assess the sound exposure inside dwellings, an estimate of indoor sound levels is necessary. Typically, a constant difference between outdoor and indoor is assumed, neglecting specific conditions. This is a major cause of uncertainty in indoor noise exposure prediction. 102 interviews were carried out at home in a representative sample of swiss residents. At this occasion sound recordings were performed outdoors and indoors, in the living room and in the bedroom. Three scenarios - open, tilted and closed window – were recorded during three minutes each. For each situation additional parameters such as the orientation towards the source, floor level, room and sound in-sulation characteristics were collected. The mean outdoor-indoor sound level differences resulted in 11 dB(A) for open, 17 dB(A) for tilted and 29 dB(A) for closed windows. The most relevant parameters for the outdoor – indoor differences were determined and a statistical model was developed to predict the sound level difference as a function of dwelling and exposure characteristics.

17:30 – 17:45

**3945 Assessing the relationship of indoor and outdoor noise at residential dwellings in London**

Faridah Naim • John Gulliver • Daniela Fecht • Anna L. Hansell

Most epidemiological studies investigating the association between noise and health use outdoor noise estimates. This study aims to explore the relationship between indoor and outdoor noise at residential dwellings in London. Continuous noise measurements were made inside and outside homes for three consecutive days using an Optimus CR:171B sound level meter. Selected homes were located close to a major road, railway or under aircraft flight paths. Measurements from 18 homes in the winter period found average daytime noise levels of 44.7±7.1 dBA Leq,16h indoors and 61.7±7.3 dBA outdoors and night-time exposures of 39.1±7.8 dBA indoors and 55.9±7.6 dBA outdoors. Graphs of indoor and outdoor noise showed similar patterns with attenuation of 10–30 dB indoors, with strong correlations for night-time noise ( $r = 0.69$ ,  $p < 0.001$ ) but moderate for day-time ( $r = 0.51$ ;  $p < 0.001$ ). Significant differences were found between noise levels recorded in occupied and unoccupied rooms ( $p < 0.001$ ). This ongoing study provides information about the indoor-outdoor noise relationships. More homes will be measured and repeat measurements taken in the summer period.

17:45 – 18:00

**3949 Validation of the exposure modelling within SiRENE by long-term measurements**

Felix Schlatter • André Piquerez • Manuel Habermacher • Martina Ragettli • Martin Röööli • Mark Brink • Christian Cajochen • Nicole Probst-Hensch • Maria Foraster • Jean Marc Wunderli

In 2015 during the SiRENE (Short and Long Term Effects of Transportation Noise Exposure) project, a nationwide assessment of road, railway and aircraft noise exposure was conducted. Noise exposure was thereby modelled at façade points of all buildings in Switzerland. Based on a stratified sample, a socio-acoustic survey with 5592 respondents was performed. In the follow-up project SIAS, 102 of these participants volunteered in 2016 to temporarily equip their sleeping- and /or living room-windows with sound-level meters, resulting in 180 validation cases of the SiRENE exposure modelling. The sound-level meters were flush mounted on the outer face of the closed window and recorded A-weighted equivalent sound pressure levels in a temporal resolution of 1 s during approximately one week. With the address and the floor information of each participant, the corresponding point on the façade of the SiRENE – Database was assigned. Comparisons revealed on average 1.3 dB(A) higher calculated than measured LDEN. Possible explanations of this slight overestimation as well as general conclusions on sources of uncertainty in the process of exposure modelling are discussed.

16:45 – 17:45 | C6

**LOW FREQUENCY NOISE AND VIBRATION**

Chair: Norm Broner • Geoff Leventhall

16:45 – 17:15

**3909 Study on human reactions to vibration from blasting activities nearby dwellings**

Iiris Turunen-Rindel • Ronny Klæboe • Karin Norén-Cosgriff

Human reactions to vibration were studied in connection to preparation of Norwegian Standard, NS 8141-1. The standard concerns vibration that may cause building damage. The study started due to experience with complaints, fear, disturbances and other human reactions on vibration from construction work, especially blasting activities. Human reactions are likely to occur at much lower vibration levels than those causing building damage. The human reactions cause delays and problems at construction work that may be avoided. The aim was to provide some guidance on expected level of annoyance, and factors affecting human reactions to the blasting

activities. The study was conducted as a socio-vibrational survey on people's annoyance on vibrations from blasting. Vibration velocities were obtained for 520 respondent dwellings in seven study areas nearby construction sites. The inhabitants got a written questionnaire that could be responded through a website. Exposure-effect relationships with acceptable statistical error bands were established with weighted (frequency filter related to building damage) and unweighted peak values of vibration velocity. The resulting exposure-effect curves were included in an informative Annex in the Norwegian Standard.

17:15 – 17:45

**3653 A Citizen Science Initiative: Acoustical Characterisation of Human Environments**

Huub Bakker • Mariana Alves-Pereira • Rachel Summers

The characterisation of acoustical environments where humans are present is currently only available from acoustics experts. The investigations generally return derived measures such as 10-minute, A-weighted measurements, and sometimes 10-minute,  $\frac{1}{3}$ -octave bands and FFT Leqs, meaning that further analysis cannot be performed since the primary data, the actual sound, is no longer available. Obtaining full-spectrum IFLN data for monitoring normally involves complex, non-standard instrumentation systems. Furthermore, the cost of such detailed investigations skews the frequency of investigations towards those environments where the owners can afford them. As a component of a multi-disciplinary approach to such investigations a Citizen Science Initiative is presented to capture high quality recordings from diverse environments where humans are present. Coupling with event identification/documentation, following an established protocol permits, a cost/time effective process for assessments. A suitable recording system has been developed to support the initiative and a comprehensive protocol is available to ensure that recordings approach professional quality. A library of quality recordings will allow subsequent analysis and reanalysis by researchers in future.

## Program overview Wednesday, June 21, 2017

	C60	C44	C6	D1
09:00	Keynote by Stefan Launer			
09:15				
09:30				
09:45	Overview talk: Interactions with other agents and contextual factors		Low frequency noise and vibration	
10:00				
10:15	Overview talk: Noise policy and economics			
10:30				
10:45	Coffee break (Atrium)			
11:00				
11:15	Effects of noise on cognition, performance and behavior	Effects of noise on sleep		
11:30				
11:45				
12:00				
12:15				
12:30				
12:45	Lunch break (Atrium)			
13:00				
13:15				
13:30				
13:45	Effects of noise on cognition, performance and behavior	Non-auditory health effects of noise		
14:00				
14:15				
14:30				
14:45				
15:00	Coffee break (Atrium)			
15:15	Non-auditory health effects of noise	Noise exposure assessment in health effect studies		
15:30	Community response to noise and noise annoyance			
15:45				
16:00				
16:15				
16:30	Coffee break (Atrium)			
16:45	Effects of noise on cognition, performance and behavior	Noise policy and economics		
17:00				
17:15				
17:30				
17:45	Meeting Subject area 4	Meeting Subject area 7	Meeting Subject area 3	Meeting Subject area 6
18:00				
18:15				
18:30				ICBEN Business Meeting (on invitation only)
18:45				
19:00				
19:15				
19:30				

09:00 – 09:45 | C60

**KEYNOTE BY STEFAN LAUNER**

**4162 Noise-induced hearing loss and its impact on quality of life**

Stefan Launer

Hearing loss due to aging and noise impact is among the largest chronic health conditions in the world. The prevalence is 10–20% of the world population, strongly depending on age. Hearing loss has a very strong impact on the quality of life of people affected with hearing loss. Often times it can lead to strong changes in social life not only of the person suffering from hearing loss directly but also of the family members («third-party disability»). The occurrence of hearing loss also often strongly correlates with the occurrence of other health conditions especially in an elderly population. Strong correlations between the occurrence of hearing loss and diabetes type II, cognitive decline, risk of fall and a range of other conditions are being investigated. This talk aims to provide an overview over i) the impact of hearing loss on quality of life; ii) the benefit of using hearing instruments; iii) the state of knowledge of the correlations between hearing loss and other health conditions in elderly people.

09:45 – 10:15 | C60

**OVERVIEW TALK: INTERACTIONS WITH OTHER AGENTS AND CONTEXTUAL FACTORS**

**4052 Overview of the topic »Interactions with other agents and contextual factors«**

Adrian Fuente • Tony Leroux

The aim of this talk is to summarise the latest studies about the effects of noise with other agents in the workplace. A number of studies regarding co-exposure to noise and chemicals such as solvents, heavy metals and pesticides have been published in the period under review (2014–2017). A significant part of these studies has investigated the sensitivity of either clinical or experimental measures to identify the auditory dysfunction associated with co-exposure to noise and chemicals. Other aspects that have been investigated include the effects of co-exposures on central auditory functions as well as on pure-tone thresholds, including mid-to-low audiometric frequencies. Current research in the field proposes that permissible exposure limits for chemicals such as solvents may not be safe enough for the auditory system and that hearing conservation programmes should include chemical-exposed workers regardless of noise exposure levels. A discussion about how to translate these research findings into practice and the needs for further research will be addressed.

10:15 – 10:45 | C60

**OVERVIEW TALK: NOISE POLICY AND ECONOMICS**

**3611 Review of environmental noise policies and economics in 2014–2016**

Dietrich Schwela • Chantal Laroche

This report provides a continuation of the review of environmental noise policies and economics in 2011–2013, published in the proceedings for the ICBCEN 2014 Congress. The report addresses the international progress on noise mitigation policies and strategies, best practices and guidelines for environmental noise management. It focuses on developments in evidence and policy by international bodies and in selected countries. There is a considerable amount of new relevant documents in many countries on these topics since the last ICBCEN Congress in 2014. Much of this progress was made in the European Union, the United Kingdom and Switzerland. Developing countries, especially Costa Rica, Egypt, India, Mexico and Tanzania are increasingly committed to improve environmental noise policies. The evolving economical assessments of noise exposures are particularly important because they reflect the limits of the »polluter’s pay principle« and are crucial for governments to implement adequate and affordable noise mitigation policies.

09:45 – 10:45 | C6

**LOW FREQUENCY NOISE AND VIBRATION**

Chair: Norm Broner • Geoff Leventhall

09:45 – 10:15

**3656 Regulating low frequency noise from industry – a practical approach**

Gordon Downey • Jeffrey Parnell

The potential adverse impacts of Low Frequency Noise (LFN) from industry and wind farms are often raised in submissions to regulators as issues of concern. Whilst levels of LFN may be an occupational hazard in certain industries such as defence, aeronautics and music, it rarely constitutes an off-site hazard. It does however increase the level of annoyance and regulators must ensure controls are in place to provide adequate levels of community protection and address public concern. This paper presents a practical approach developed by the authors that could be used to assess and regulate the effects of LFN in a manner that is consistent with contemporary science. The approach was developed from a critique of existing wide band methods used to assess LFN including overall C-weighted thresholds and the C minus A delta approach currently used in New South Wales, Australia [1]. Several issues were identified from the critique including:

- The C minus A delta approach has a high potential to identify false positive results when assessed against more contemporary standards;
- There is a need for a robust, yet practical methodology;
- and • An approach based on knowledge of the noise spectrum is needed.

In summary, the critique found that LFN assessment levels need to be based on the frequency spectrum. However, such comprehensive spectral analysis is complex for compliance assessment purposes and therefore both a preliminary screening measure and industry specific simplified measures could be proposed to minimise the need to progress to full spectral analysis in all circumstances.

10:15 – 10:45

**2829 Vibration measurement as a tool to solve a murder**

David Eager • Chris Chapman

This paper will discuss a novel use of vibration measurement used to assist the NSW Police Force to solve the »pogo stick« murder. The authors were approached by the Homicide Squad regarding a suspicious death of a 7-year boy at Oatley in May 2013. The child had reportedly fallen from a pogo stick and suffered significant head injuries. The child had not been provided with medical attention after the fall and died some 24 hours later. The incident occurred inside a small unit which was used as a music recording studio. The studio is on the first level of a larger business complex. The studio consisted of a recording room, a lounge room, and a kitchenette. The child fell in the lounge room. At the time of the alleged incident the mother was in the kitchenette, and the accused was in the recording room. According to the accused, he had headphones on and was listening to loud music when he »felt« the vibration of the thud. Kodi Maybir was found guilty of murder in November 2015.

10:45 – 11:15 | Atrium

Coffee break

11:15 – 12:45 | C60

**EFFECTS OF NOISE ON COGNITION, PERFORMANCE AND BEHAVIOR**

Chair: Andreas Liebl

11:15 – 11:30

**3741 Effective open learning landscapes and the well-being of teachers and students**

Colin Campbell • Holger Brokmann • Jeroen Vugts • Esther van Oorschot-Slaat

The Importance of good acoustics is being increasingly recognised; Studies have shown that teacher and student working environments, associated behaviour and management are related to acoustic quality, especially regarding inclusion. There is also an ongoing pedagogic evolution worldwide, around innovative learning environments. Involving supporting teacher change, highlighting changes from traditional teacher lead to student centered learning activities, to encourage teacher and student collaboration and engagement. This change; traditional to diversified teaching often leads to high noise levels, which has proven to increase stress and reduction of concentration. To provide the acoustic conditions supporting effective teaching and learning requires control of sound levels, speech intelligibility, speech privacy between spaces and control of indoor ambient noise. Good practice European examples are referenced which support these evolving pedagogic approaches. Assessing specific their acoustic data and the relevant acoustic parameters and regulations. Effective open learning landscapes need to be planned with an activity based acoustic design so future learning environments make the necessary considerations to support sustainable learning outcomes, health and well-being.

11:30 – 11:45

**3665 Writing performance in open-plan study environments: a laboratory study**

Ella Braat-Eggen • Armin Kohlrausch • Maarten Hornikx

An increasing number of students work in open-plan study environments (OPSEs). OPSEs can be characterized by young users, a variable occupancy rate and a mix of individual and group activities. The occupancy rate, activities of students in an OPSE as well as the acoustic parameters of an OPSE determine the intensity and intelligibility of background speech. Especially this irrelevant speech appeared to be very disturbing in a recent OPSE field research. The aim of this study is to analyze the influence of speech characteristics in combination with reverberation time on writing performance, an important task in an OPSE. Computational modelling and auralization are used to simulate an OPSE. Four signals were composed by combining two different reverberation times with two different speech conditions. One signal was a silent control condition. Forty two subjects had to write five short essays while exposed to these acoustic sound signals via headphones. First results show the most detrimental effect on writing performance in the situation with many speakers and a high reverberation time. Full results of the research will be presented at the conference.

11:45 – 12:00

**3604 Listening efficiency in university classrooms: a comparison between native and non-native listeners**

Chiara Visentin • Nicola Prodi • Simone Torresin • Francesca Cappelletti • Andrea Gasparella

When listening to speech in one's native language a higher intelligibility is expected than when listening in a second language: perceptual and linguistic cues readily available for native listeners may be only partly accessed by non-native ones. In this study, the effects of different types of background noises on speech reception performance are compared between native and non-native listeners, while controlling for language abilities. Diagnostic Rhyme Tests (DRT) in the Italian language were proposed inside a university classroom of 198 m<sup>3</sup>, with a reverberation time in occupied conditions of 0.6 s, complying with the target value suggested by the DIN 18041 standard. A group of 26 normal-hearing young adults participated in the experiment: half of them native (Italian), the other half non-native (German) speakers. Listeners' performance was assessed in three acoustic conditions (ventilation system, stationary, and fluctuating maskers) collecting data on speech intelligibility, response time and subjective effort ratings. The interplay of perceptual and cognitive process in the speech reception process was then described by using the combined metric of listening efficiency.

12:00 – 12:15

**3760 Health effect of variation in noise absorption in open-plan office: a cross-over design field study**

Nils Rage • Frans Davidsson

The present study focuses on the evaluation of the effect of noise on occupants of an open-plan office environment. If office noise is frequently studied in controlled environments, this study investigates real conditions in two com-



parable floors of a building in use. A cross-over methodology was designed to test out hypotheses regarding the existence of a correlation between the quality of room acoustic absorption and occupant-rated noise disturbance, cognitive stress and performance. On one floor, the building sound absorption properties were changed from better to worse to better and from worse to better to worse for the other. The furniture layout was kept unaltered. The acoustical effects of these manipulations were assessed according to the ISO standard 3382-3:2012 for open-plan room acoustics. Additionally, the employees answered questionnaires after each change to rate the effect of their environment on them. The results analysis shows that, for both floors and setups, an enhanced room acoustical environment correlates with lower perceived disturbance and cognitive stress. The opposite is true for rooms with deteriorated absorption. The impact on performance was not significant.

12:15 – 12:30

**4058 Distraction distance predicts noise disturbance in open-plan offices**

Valtteri Hongisto • Annu Haapakangas

ISO 3382-3 describes four room acoustic quantities describing the room acoustic quality of open-plan offices. However, the relation between these quantities and perceived noise disturbance has not been established in field studies. Our aim was to synthesize evidence from 21 workplaces (883 respondents) and a wide range of room acoustic conditions. The data included both questionnaire surveys and the four room acoustic quantities from each office. The results showed that an increase in distraction distance predicts an increase in disturbance by noise whereas the other quantities were not associated with noise disturbance. The results support the role of room acoustic design, i.e., the simultaneous use of absorption, blocking and masking, in the attainment of good working conditions in open-plan offices. The full version of this study has been published in The Journal of the Acoustical Society of America.

12:30 – 12:45

**3570 A simple sound metric for evaluating sound annoyance in open-plan offices**

Patrick Chevret • Etienne Parizet • Krist Kostallari

Noise in open-plan offices has become a major health issue. Intelligible speech is considered as the most annoying noise sources by the occupants of such offices. Speech level fluctuations prevent people from achieving some high-demanding tasks, thus inducing annoyance and tiredness. Many studies were conducted in order to identify a sound metric closely related to this Irrelevant Speech Effect. Hongisto et al. have shown that Speech Transmission Effect is appropriate for evaluating the annoyance due to a neighbor in the office. More recently, Schlittmeier et al. suggested that the Fluctuation Strength can be used to evaluate the effect of the fluctuations of the ambient noise on task performance. This paper intends to present a new metric. It is based on the measurement of short-term temporal modulation of sound level. Results indicate that it seems to be as efficient as STI or FS, while being more suitable for in-situ experiments and usable by practitioners.

11:15 – 12:45 | C44

**EFFECTS OF NOISE ON SLEEP**

Chair: Gunn Marit Aasvang • Sarah McGuire

11:15 – 11:30

**3618 Rail traffic noise and sleep disturbances**

Tonje Veronika Antonsen • Geir Aamodt • Bente Oftedal • Norun Hjertager Krog • Jorunn Evandt • Gunn Marit Aasvang

Background: There is an ongoing increase in transportation by railway. This could impact on sleep due to more noise emission during night-time. Objectives: The aim of the study was to investigate the association between nocturnal rail traffic noise (train, tram and subway) and self-reported sleep disturbances. Methods: We used data from the population-based Health and Environment in Oslo (HELMILO) study (n = 13 019) of adults, only including individuals living within 700 meters to a railway (n = 6426). Railway noise (L<sub>night</sub>) at the most exposed façade was assessed using the Nordic Prediction Method. We used logistic regression adjusting for potential confounders. Results: Positive, however, not statistically significant associations were shown for difficulties falling asleep (odds ratio [OR] = 1.04; 95% confidence interval [CI]: 0.99–1.08), and waking up to early (OR = 1.02; 95% CI: 0.98–1.07) per 5-dB increase in noise level. Conclusions: Rail traffic noise was only weakly associated with self-reported sleep disturbances. Still, the positive effect estimates indicate that sleep may be affected by rail traffic noise to some degree in the beginning and the end of the night.

11:30 – 11:45

**3557 The effect on sleep of nocturnal exposure to noise and vibration from rail traffic**

Irene van Kamp • Uwe Müller • Elise van Kempen • Oscar Breugelmans • Franco Mendolia • Alex Hoff • Eva-Maria Elmenhorst • Arnold Koopman • Daniel Aeschbach

Freight traffic by rail during the night is increasing in Europe. Prognoses for 2020–2030 are uncertain, but public concern about the impact is growing. Scientific evidence on the health effects of rail traffic related exposures is lacking behind. It concerns the impact of noise, vibration and cumulative effects on annoyance, sleep disturbance and quality of life, performance and long-term effects on the cardiovascular system. Evidence of the negative impacts of rail traffic noise has been reasonably well documented, but the (long-term) effects of rail traffic vibration and combined effects of both are rarely studied. This paper presents recent findings on self-reported sleep disturbance in relation with modelled noise and vibration levels at night. This is done in combination with secondary analysis on data from a German study performed in 2008–2009 by DLR among 33 residents along the busy Cologne-Bonn railroad track for nine nights each. This study measured indoor noise and vibration levels

and investigated sleep indicators by means of polysomnography including awakening reactions during sleep. This allowed for better interpretation of Dutch findings on self-reported sleep disturbance.

11:45 – 12:00

**3899 On the possibility of deriving a common dose response relationship of sleep disturbance due to vibration from field and laboratory studies**

Kerstin Persson-Waye • Sabine Janssen • Michael Smith • Mikael Ögren • Laith Hussain-Alkhateeb • Arnold Koopman • James Woodcock • Calum Sharp • Eualia Peris • David Waddington

Nocturnal freight train vibrations may induce sleep disturbance, albeit little is known about the dose-response relationships. Within the European FP7 project »Cargovibes«, sleep disturbance was evaluated in field and laboratory studies. Comparisons between the study settings were possible by using similar questionnaire items for response and similar metrics and weighting for the exposure. Poland and the Netherlands contributed to one field study each making a total of 233 valid responses, and three laboratory studies in Sweden totaling 59 subjects and 350 person-nights. The odds ratio of sleep disturbance was analyzed in relation to vibration exposure (log 10 RMS) using ordinal logit regression, adjusting for moderating factors common for the settings. Outcome-specific fractions (OSF) were computed from Individually-assigned score of 11 sleep outcomes. Our findings suggest no significant difference between study settings (OR = 0.95; 95% CI 0.46 – 1.95), with increased odds of three folds by exposure (OR=3.27; 95% CI 2.44 – 4.40). Results from OSF supported the setting comparability. The plausibility of deriving common dose-response relationships is discussed in light of limitations related to exposure assessments, study populations and cultural differences.

12:00 – 12:15

**3704 Wind Turbine Noise Effects on Sleep: The WiTNES study**

Michael Smith • Mikael Ögren • Pontus Thorsson • Laith Hussain-Alkhateeb • Eja Pedersen • Julia Ageborg Morsing • Kerstin Persson-Waye

Onshore wind turbines are becoming increasingly widespread globally, with the associated net effect that a greater number of people will be exposed to wind turbine noise (WTN). Sleep disturbance by WTN has been suggested to be of particular importance with regards to a potential impact on human health. Within the Wind Turbine Noise Effects on Sleep (WiTNES) project, we have experimentally investigated the physiological effects of night-time WTN on sleep using polysomnography and self-reporting protocols. Forty-eight participants spent three nights in the sound exposure laboratory. To examine whether habituation or sensitisation occurs among populations with long-term WTN exposure, approximately half of the participants lived within 1km of at least one turbine. The remaining participants were not exposed to WTN at home. The first night served for habituation and one WTN-free night served to measure baseline sleep. Wind turbine noise (LAeq,indoor, night=33.4 dB) was introduced in one night. This exposure night included variations in filtering, corresponding to a window being fully closed or slightly open, and variations in amplitude modulation. The findings will be presented at the congress.

12:15 – 12:30

**4053 Epidemiological Study of Aircraft Noise using Sheet-Shaped Sleep Meter: Measurement of Motility, Heart Rate and Respiratory Rate**

Junta Tagusari • Masato Takakusaki • Toshihito Matsui

Night-time noise exposure may affect sleep and its physiological status, e.g. heart rate, respiratory rate and sleep stage, which could lead adverse health effects in cardiovascular system. However, existing techniques to measure sleep status in field settings have methodological disadvantages: PSG is invasive, requires highly professionals and costs a lot, actimetry is less invasive but records limited information of sleep. In this study, we applied a non-invasive and inexpensive sheet-shaped sleep meter which was set under a mattress and recorded the vibration during sleep. We obtained quantitative physiological data from the vibration recording and carried out epidemiological analyses. Around the Kadena US airfield, 30 subjects were recruited. Sleep measurement were carried out by themselves consecutive 26 nights. Noise levels were measured at a monitoring point near their home every second. From the vibration recordings of the subjects, we distinguished motility, heart and respiratory rate using signal-processing techniques. Statistical analysis was made on the relationship between noise exposure and changes of the physiological measures.

12:30 – 12:45

**3583 On the application of two statistical approaches to establish noise exposure-response relationships from repeated binary observations**

Beat Schäffer • Reto Pieren • Franco Mendolia • Mathias Basner • Mark Brink

Noise exposure-response relationships for binary variables such as high annoyance or sleep disturbance are used to estimate the effects of noise on individuals or a population. Such relationships may be established from repeated binary observations with different statistical approaches. As the statistical approaches are inherently different and yield disparate results, it is crucial to decide which modelling approach to use. This aspect, however, was not always sufficiently considered in the past in noise effect studies. This paper gives an overview on two existing statistical approaches to establish noise exposure-response relationships from repeated binary observations, namely, a subject-specific vs. population-averaged logistic regression analysis. With an example of a recent noise effect study, the potential magnitude of differences in results between the two approaches is estimated, reasons for the differences are disclosed, and possible implications for future studies are discussed.

12:45 – 13:45 | Atrium

Lunch break

13:45 – 15:00 | C60

**EFFECTS OF NOISE ON COGNITION, PERFORMANCE AND BEHAVIOR**

Chair: Andreas Liebl

13:45 – 14:00

**3647 Why are Background Telephone Conversations Distracting?**

John Everett Marsh • Robert Ljung • Helena Jahncke • François Vachon

Telephone conversation is ubiquitous within the office setting. Overhearing a telephone conversation – whereby only one of the two speakers is heard – is subjectively more annoying and objectively more distracting than overhearing a full conversation. However, it is unknown whether this »halfalogue« effect is attributable to unexpected offsets and onsets within the background speech (acoustic unexpectedness), or is due to the tendency to predict the unheard part of the conversation (semantic [un]predictability). Using a realistic office-related task as the context, we attempted to tease apart the acoustic unexpectedness and semantic (un)predictability accounts of the halfalogue effect. In this study, we compared halfalogue and dialogue background speech against a quiet control. Half of the participants were presented with conversational speech in the participant's first language – meaningful speech – whereas the remainder were presented with spectrally-rotated speech – a match to the meaningful speech in terms of acoustic and temporal complexity. The halfalogue effect was only present for the meaningful speech condition. The halfalogue effect is thus attributable to the semantic (un)predictability, not the acoustic unexpectedness, of background telephone conversation.

14:00 – 14:15

**4019 Improving both cognitive performance and subjective evaluations in open-plan offices by combining partial maskers**

Sabine Schlittmeier

Office noise has been shown to impair cognitive performance and subjective evaluations in many studies. To reduce such disturbance effects, continuous noise is played in open-plan offices as a partial masker. Yet, whether other sounds, like music or nature sounds, can be used instead is questionable. Although findings suggest the subjective preference for certain alternative sounds, these sounds did not reduce negative performance effects, unlike continuous noise [e.g. Haapakangas et al., 2011; Schlittmeier & Hellbrück, 2008]. The reported experiments investigated whether the beneficial performance effects of continuous noise and the positive preference ratings of background music can be unified into one partial masker combining these two sounds. In Experiment 1, short-term memory performance (n = 40) was tested during silence, office noise and three masker conditions: office noise plus combined masker, continuous noise or music. In Experiment 2, subjective evaluations were collected from 72 students who did academic homework during one of the masker conditions for 1 h. Both performance data and subject ratings favour the combined masker. The potential of combined maskers are discussed from cognitive psychological and applied perspectives.

14:15 – 14:30

**4024 Evaluation of measures for the reduction of impairment by background speech at office workplaces: Comparison of measurements and listening tests**

Andreas Liebl • Maria Zaglauer • Noemi Martin

Speech is the most disturbing source of noise in open space offices. The interference can be reduced by room acoustic measures such as sound absorption, sound insulation and sound masking. A variety of products advertise with their ability to reduce annoying speech. However, there is still no standardized method to quantify the reduction of speech sound by such products. A procedure was proposed in 2016 and applied here. The question arises as to how much speech sound has to be reduced so that the user can profit from it or at least notice a perceptible difference. The proposed method has been used to evaluate office furniture. In addition, recordings of speech sounds were made with different furnishing and listening tests were conducted. It was examined whether the extent of the reduction of speech sound by the furniture is sufficient to demonstrate improvements with regard to cognitive performance. As it was shown that the reduction of speech sound by the furniture in the tested design at a near distance is insufficient, scenarios were investigated in which the background noise was varied.

14:30 – 14:45

**4057 The effect of acoustic design on performance in office rooms**

Valtteri Hongisto • David Oliva • Jukka Hyönä

Our purpose was to determine the acoustic conditions where private office rooms can provide sufficient work performance and protection towards office noise. 32 students participated in a laboratory experiment which simulated two adjacent office rooms. Speaker and listener were located in rooms 1 and 2, respectively. Four conditions were investigated. Condition A corresponded with the typical situation where the weighted sound reduction index was 35 dB R<sub>w</sub> and background noise level from building services was 33 dB LAeq. Conditions B and D had a 10 dB greater sound insulation than condition A. Conditions C and D had 9 dB larger background noise level in room 2 than condition A. As expected, cognitive performance was the worst in condition A. Acoustic satisfaction and several other subjective measures indicated that conditions B–D were superior to condition A. The results give clear guidelines for the necessary sound insulation and/or sound masking levels to be used in private office rooms. The full version of this study has been published in Building and Environment.

14:45 – 15:00

**3798 Psychoacoustics Survey Results: Psychological Factors affecting Noise Distraction in the Workplace**

Nigel Oseland • Paige Hodsman

This research addresses psychoacoustics in office environments, with an emphasis on personality factors and perceptions of noise and noise distractions in the office. Results will be presented from an on-line survey conducted

to test the hypotheses from the literature review conducted by Oseland and Hodsmans<sup>3</sup>. The primary objective was to test whether personality types, in particular extroversion, affect noise perception and distraction. The survey explored the relationship between noise distraction metrics and key variables such as personality, work activities, primary workplace, acoustic design, the ability to screen noise and demographics. We received 516 valid responses, providing a valid sample size for analysis. The survey included 44 sub-questions used to determine the respondents' personality profile on the Big Five Inventory (BFI), also known as OCEAN, as it determines the strength of five personality factors: Openness, Conscientiousness, Extroversion, Agreeableness and Neuroticism. The respondents were sub-grouped into three categories, on each personality factor, to represent those with low, medium and high scores relative to other respondents. Three-quarters of our respondents reported that they are negatively affected by the noise in their workplace.

13:45 – 15:00 | C44

#### NON-AUDITORY HEALTH EFFECTS OF NOISE

Chair: Yvonne de Kluizenaar • Toshihito Matsui

13:45 – 14:00

#### 3816 Long-term exposure to traffic noise in relation to development of obesity – A cohort study

Göran Pershagen • Charlotta Eriksson • Andrei Pyko • Alva Wallas • Mikael Ögren

Some studies have shown associations between exposure to road traffic noise and obesity markers but only one study focusing on adults was longitudinal and this was based on self-reported outcome data, which are prone to bias. We assessed individual long-term exposure to noise from road traffic, railways and aircraft based on residential histories in a cohort of 5151 men and women from Stockholm County. Noise levels were estimated at the most exposed façade of each dwelling based on a modification of the Nordic prediction method. Waist circumference, weight and height were measured by trained nurses at recruitment and after an average of 8.9 years of follow-up. Extensive information on potential confounders was available from repeated questionnaires and registers. There were clear trends in waist circumference increase as well as in incidence of central obesity in relation to exposure to noise from road traffic or aircraft ( $p < 0.001$ ) but not from railways. Risks appeared particularly high in those with elevated exposure to all three traffic noise sources. Our results provide further evidence linking noise exposure to development of central obesity.

14:00 – 14:15

#### 3824 Long-term exposure to road, railway, and aircraft noise levels and their association with incidence of obesity and different obesity parameters

Maria Foraster • Ikenna C. Eze • Danielle Vienneau • Mark Brink • Christian Cajochen • Harris Héritier • Medea Imboden • Ayoung Jeong • Franziska Rudzik • Laurie Thiesse • Reto Pieren • Emmanuel Schaffner • Jean Marc Wunderli • Martin Röösli • Nicole Probst-Hensch

The contribution of different transportation noise sources to obesity and its subphenotypes remains understudied. We evaluated the associations of long-term exposure to road, railway and aircraft noise levels with measures of general, central obesity and incidence of overweight and obesity in an adult Swiss cohort using cross-sectional and longitudinal designs. We assessed 4678 SAPALDIA cohort participants visited in 2001 and 2010/2011. We measured body mass index (BMI, kilograms/metre<sup>2</sup>), waist circumference (WC, centimetres), and Kyle body Fat Index (BF, %) and derived incidence by severity: overweight only (iOW, BMI: 25–29.9) or obesity only (iOB, BMI:  $\geq 30$ ). We assigned annual average aircraft, railway, and road traffic noise levels at the most exposed dwelling façade ( $L_{den,source}$ , dB) using Swiss noise models for 2001 and 2011. Associations were evaluated with multivariable linear and Poisson regression models. We observed positive associations between  $L_{den,road}$  and BMI, WC, %BF and iOB.  $L_{den,rail}$  and  $L_{den,air}$  were related to iOW. Associations were independent of the other noise sources and air pollution. Long-term exposure to road traffic noise levels may be more obesogenic than railway or aircraft noise.

14:15 – 14:30

#### 3810 Association between night-time road traffic noise and perturbations in glucose control may be modified by sleep-related parameters

Ikenna C. Eze • Medea Imboden • Maria Foraster • Emmanuel Schaffner • Ashish Kumar • Danielle Vienneau • Harris Héritier • Franziska Rudzik • Laurie Thiesse • Reto Pieren • Arnold von Eckardstein • Christian Schindler • Mark Brink • Jean Marc Wunderli • Christian Cajochen • Martin Röösli • Nicole Probst-Hensch

Given the limited understanding of the glycaemic effects of noise, we assessed the modifying effects of sleep-related parameters [genetic risk for melatonin dysregulation (GRMD) and self-reported sleep problems (SRSP)] on the association between night-time road traffic noise (RTN) and subsequent change in glycosylated haemoglobin ( $\Delta HbA1c$ ). We prospectively assessed 2142 participants of the Swiss SAPALDIA study who did not change their residence between two study time-points in 2001 and 2010/2011. For 2001, annual RTN ( $L_{night}$ ; 23–07 hours) was calculated by validated Swiss noise models and assigned to participants based on the most-exposed façade of their residential floors. GRMD was computed as a score of six common MTNR1B variants. Participants reported on sleep problems and diabetes status.  $\Delta HbA1c$  was computed as the difference between HbA1c measured in 2010/2011 and 2001. Using linear mixed models, we investigated the association between  $L_{night}$  and  $\Delta HbA1c$ , and modification by sleep-related parameters. RTN  $L_{night}$  exposure increased mean HbA1c regardless of diabetes status. This increase was significantly modified by GRMD and SRSP in diabetic participants where noise may impact on glucose control through sleep-related pathways.

- 14:30 – 14:45**      **2476 Residential traffic noise exposure and colorectal cancer incidence – a cohort study**  
 Nina Roswall • Ole Raaschou-Nielsen • Matthias Ketzel • Kim Overvad • Jytte Halkjær • Mette Sørensen  
 Purpose Traffic noise has become an increasing public health concern, associated with pervasive negative health effects, most likely through pathways of sleep disruption and stress. Both sleep disruption and stress have been associated with colorectal cancer. This study investigated the association between residential traffic noise and colorectal cancer incidence. Methods: Traffic noise was calculated for residential addresses from 1987–2012 for 51,286 Danes. We used Cox Proportional Hazard Models to calculate crude and adjusted Incidence Rate Ratios (IRR) between residential traffic noise 5 and 10 years before diagnosis, and colorectal cancer incidence, as well as sub-types (rectal, proximal colon, distal colon). Results: During follow-up, 1,134 colorectal cancers developed. There was no association between residential road traffic noise and rectal cancer. We observed an association with distal: IRR 1.15 (0.98–1.34), but not proximal colon cancer: IRR 1.02 (0.87–1.21), per 10 dB, 10 years preceding diagnosis. Railway noise was not associated with colorectal cancer, or any sub-type. Conclusion: This study suggested that long-term exposure to residential road traffic noise might increase the risk for colon cancer, especially distal colon cancer.
- 14:45 – 15:00**      **2505 Exposure to traffic noise and risk for febrile seizure: a cohort study**  
 Mette Sørensen • Dorrit Hjortebjerg • Anne-Marie Andersen  
 Traffic noise stresses and disturbs sleep, which are mechanisms that may affect risk of febrile seizures. We aimed to investigate whether road traffic noise increased risk for febrile seizures in children. In a population of 57,282 children from the Danish National Birth Cohort we identified 2,175 children diagnosed with incident febrile seizure before 6 years of age. Residential address history from conception to 6 years of age was found in national registers, and road traffic noise (Lden) and air pollution (NO<sub>2</sub>) were modeled for all addresses. Analyses were done using Cox proportional hazard model. An interquartile range increase in childhood road traffic noise exposure (9.5 dB) was associated with an incidence rate ratio (IRR) of 1.11 (1.04–1.19) higher risk of febrile seizures after adjustment for gender, maternal lifestyle and socioeconomic status. After further adjustment for air pollution, the IRR was 1.08 (1.00–1.16). In these mutually adjusted models air pollution also seemed associated with febrile seizures (IRR: 1.03 (0.99–1.06)). In conclusion, road traffic noise increased risk of febrile seizures in children, both before and after air pollution adjustment.
- 15:00 – 15:15 | Atrium**      **Coffee break**
- 15:15 – 16:30 | C60**      **NON-AUDITORY HEALTH EFFECTS OF NOISE & COMMUNITY RESPONSE TO NOISE AND NOISE ANNOYANCE**  
 Chair: Sabine Janssen • Dirk Schreckenberg
- 15:15 – 15:30**      **3614 Burden of disease from road traffic noise and air pollution in Oslo, Norway**  
 Gunn Marit Aasvag • Marit Låg • Per Schwarze  
 Environmental noise is increasing and estimated as the second largest contributor to health burden due to environmental exposures, after air pollution. The aim of this project was to estimate the burden of disease from road traffic noise and air pollution in Oslo, Norway. The burden of disease from noise and air pollution was estimated as Disability Adjusted Life Years (DALY). These estimations were conducted using standard environmental burden of disease methodology. For each exposure-outcome pair Population Attributable Fraction (PAF) was derived based on population exposure (Lden, Ln and annual mean of PM<sub>2.5</sub>) and scientifically based risk estimates. Data on deaths, causes of deaths and data on life expectancy were further used to estimate years of life lost (YLL) and years lived with disease (YLD), which sums up to DALYs attributable to environmental noise and air pollution. Preliminary results suggest that sleep disturbances due to noise contribute considerably to the environmental health burden estimates for Oslo. The method, the estimated DALYs for air pollution and noise and the uncertainties will be presented and discussed at the conference.
- 15:30 – 15:45**      **3577 Bias due to Nonresponse in Noise Annoyance Surveys?**  
 Heidi Bruderer Enzler  
 Most studies on noise annoyance are based on surveys. However, typical survey response rates range between 15 and 35%. This leads to the question how this affects the results. Is there self-selection of participants that is correlated to noise exposure? At the time of writing, we are preparing a data set that will allow looking into such questions in more detail: We are running a study on environmental justice in two major Swiss cities. The core of the study is a paper-and-pencil survey that has been sent to 4,000 randomly selected persons from the cities' population registers. We will geocode their residential addresses and link them to both spatial data on road traffic noise and to data from the official register of buildings and dwellings. Doing so will allow comparing those who responded to the survey and those who did not with regards to actual noise levels, properties of the buildings and apartments they live in as well as nationality, country of birth, age, gender and duration of their residency.
- 15:45 – 16:00**      **3792 Secondary analysis of social survey on community response to transportation vibration in Japan**  
 Shigenori Yokoshima • Takashi Morihara • Yasuyuki Sano • Yasunao Matsumoto  
 Vibration Regulation Law in Japan has controlled vertical ground vibration caused by factory, construction work and road traffic. In addition, countermeasures for ground vibration from Shinkansen super-express railway was recommended. In the law and recommendation, regulatory and guideline values are established, respectively.

Enforcement of the law and recommendation has brought about reduction in ground vibrations; however, most of recent complaints due to vibrations are generated at sites below the values. This suggests that the values don't work as criterion for preserving living environment. For the purpose of providing fundamental data for the revision of vibration policy, we made secondary analysis and showed the relationship between maximum-based vibration level and annoyance associated with transportation vibration at ICBEN2014. In this paper, energy-based vibration level as vibration exposure and perception and rattling as community response are added into the analysis. One purpose of this study is to clarify whether maximum-based or energy-based index is better to measure consistent dose-response relationship associated with transportation vibration. The second is to examine the degree of effect of noise on community response to transportation vibration.

16:00 – 16:15

**3809 A review of the human exposure-response to amplitude-modulated wind turbine noise: health effects, influences on community annoyance, methods of control and mitigation**

Michael Loting • Richard Perkins • Bernard Berry • Colin Grimwood • Stephen Stansfeld

WSP | Parsons Brinckerhoff led a research project on behalf of the UK Government, reviewing the human exposure-response to amplitude-modulated (AM) wind turbine noise (WTN). The review included identifying the potential effects on health, and recommendation of a scheme for use in development planning to control the potential impact of AM WTN on communities situated near to wind farms. This paper focuses on the findings of the review, including effects on community annoyance and health, with reference to the results of recent field studies. The control scheme for AM is described, and emerging measures for mitigation are discussed. Also examined is the range of non-acoustic factors that influence responses to WTN, and potential future approaches to addressing these complex issues are considered.

16:15 – 16:30

**4059 Noise annoyance caused by large wind turbines – a dose-response relationship**

Valtteri Hongisto • David Oliva

The purpose was to determine a dose-response-relationship of large wind turbines with nominal power of 3–5 MW. A cross-sectional survey was conducted around three wind farms in Finland. The sample involved all households within 2 km from the nearest turbine. Altogether 429 households out of 753 responded to the questionnaire or participated in the interview. The dose-response relationship was determined between the predicted noise exposure level LAeq outdoors and the perceived noise annoyance indoors. The dose-response relationship was in rather good agreement with previous studies obtained for significantly smaller turbines (0.15–3.0 MW). It seems that the size of wind turbines is not affecting the annoyance of wind turbine noise.

15:15 – 16:30 | C44

**NOISE EXPOSURE ASSESSMENT IN HEALTH EFFECT STUDIES**

Chair: Jean Marc Wunderli • Peter Lercher

15:15 – 15:30

**3937 Towards an uncertainty analysis for parametric aircraft system noise prediction**

Lothar Bertsch • Beat Schäffer • Sebastien Guerin

Parametric noise assessment in the context of low-noise aircraft design and flight procedure optimization has been around for more than 15 years. Continuous improvement of the models and the interconnection to other simulation tools allow today's models to capture the major noise sources and relevant interactions along arbitrary flights. Yet, reliable and comprehensive uncertainty analysis of the overall aircraft noise prediction process has not been available for parametric tools in the past. This paper will present ongoing work to assess the overall uncertainty of DLR's in-house aircraft noise simulation with PANAM, i.e. definition of a general approach to specify uncertainties on the ground noise predictions. This will allow to discuss the temporal and the spacial distribution of the uncertainties. Certain areas along a flight path are afflicted with different uncertainties than others. The impact on exposure-response relationships due to the variation in uncertainty will be discussed, i.e. the influence of varying noise source dominance along the simulated flights. Initial results of uncertainties along typical flight procedures and their impact on selected metrics are presented in this contribution.

15:30 – 15:45

**3970 Uncertainty of calculated noise levels and its influence on exposure-response-relationship in the NORAH-project**

Manfred Liepert • Maximilian Mühlbacher • Ulrich Möhler • Georg Thomann • Dirk Schreckenber

At the end of 2015 the multidisciplinary research project NORAH was published. In this study the noise impact by air, rail and road traffic had to be determined for nearly 1,000,000 residents in order to gain dose-response-relationships. Due to the number of participants (order: respondents) calculations of noise levels instead of measurements were conducted. In the discussion of the relation between exposure and response it is usual to show the scattering of the response variables whereas the uncertainty of the noise levels usually is neglected. In the NORAH-project the uncertainties of the calculated noise levels were estimated for each noise source in order to show its influence on the exposure-response-relationship. The uncertainty of the relevant calculation parameters were estimated for the noise source, the transmissions path and the receiver point for each traffic noise source considering three different distance classes between source and receiver. The resulting uncertainties were then summarized for each noise source. In a second step, for aircraft noise, the influence of both uncertainties (exposure and response) on the exposure-response-relationship were examined for annoyance and reading performance.

15:45 – 16:00

**3841 Addressing confounding by air pollution in studies of noise and health: the relationship of measured noise and ultra-fine particles**

John Gulliver • Gerard Hoek • Erik van Nunen • Paolo Vineis • David Morley

There is a need in studies of traffic noise pollution and health to evaluate the robustness of associations in order to distinguish the effects from other factors such as air pollution. Little is known to this end about the relationship of noise and novel pollutants such as ultra-fine particles (UFP). We contemporaneously measured noise levels (Optimus CR:171B), UFP (TSI-3007 condensation particle counter), and manually counted vehicles, for 30 minutes on 3 occasions, at 161 sites [55 major roads, 92 background residential; 4 rural, 10 urban green space] during 2014/15, in the city of Norwich, UK. Overall, UFP (mean = 8522) and noise (mean = 64.5 dB(A)) were moderately correlated ( $r = .48$ ;  $p = .000$ ). Overall correlations were not substantially different than at major roads ( $r = .39$ ;  $p = .004$ ; mean UFP = 11426 ; mean LAeq = 70.0 dB(A)) and in background areas ( $r = .32$ ;  $p = .001$ ; mean UFP = 7015; mean LAeq = 61.6 dB(A)). Vehicle counts were highly correlated with LAeq ( $r = .71$ ;  $p = .000$ ) and moderately correlated with UFP ( $r = .48$ ;  $p = .000$ ).

16:00 – 16:15

**3935 Uncorrelated components of Noise and PM exposure give opportunities to disentangle health effects of noise and air pollution**

Luc Dekoninck • Dick Botteldooren

Traffic emits noise and air pollution simultaneously but the emission dynamics of noise and air pollution differ significantly. Even within the mixture of air pollutants, important differences occur. Gaseous emissions relate to fuel consumption while particulate matter emissions relate to incomplete combustion. The dispersion and propagation dynamics of noise and PM differ as well. Especially the life-time and accumulation of Ultrafine particles is, due to many removal mechanisms, very short (coagulation and wind speed). The differences in the distance to source relation for different road types (with specific dynamics) influence the spatial impact of noise, gaseous components and traffic related PM (BC/UFP). Dwellings at moderate distance of highways are highly exposed to noise but relatively less exposed to BC/UFP. The highest exposure to BC/UFP is found near dwellings close to in-city roads with high traffic dynamics while night-time noise exposure is lower compared to dwellings near highways. A pilot experiment will illustrate these interesting features. A population based impact assessment estimates the size of these uncorrelated sub-populations.

16:15 – 16:30

**4055 Development of a national job exposure matrix for occupational noise in the US**

Richard Neitzel • Benjamin Roberts • Wenting Cheng • Bhramar Mukherjee

The assessment of occupational noise exposure in the United States is challenging. While a substantial number of noise measurements is made each year through government and industry efforts, these data are not easily available to epidemiologists or occupational health researchers and practitioners. We requested and compiled measurements from government and industrial sources, as well as from the peer-reviewed literature, to create a national job exposure matrix for noise for the United States and Canada. This job exposure matrix is based on over 1.1 million noise measurements spanning 1979–2015. Using this extensive dataset, we have estimated occupational noise exposures for thousands of job titles and hundreds of industries. The tool is now accessible through a searchable website, and the entire job exposure matrix can also be downloaded. The creation of this job exposure matrix has yielded a valuable new tool for researchers and practitioners to easily and efficiently estimate noise exposures for research subjects or workers in a wide array of jobs and industries.

16:30 – 16:45 | Atrium

Coffee break

16:45 – 17:30 | C60

**EFFECTS OF NOISE ON COGNITION, PERFORMANCE AND BEHAVIOR**

Chair: Andreas Liebl

16:45 – 17:00

**3947 Effects of Noise on Risky Decision Making and Decision Confidence**

Marc Syndicus • Bettina S. Wiese

Nearly half of the European workforce is working in an office or office-like environment. While the detrimental influence of some workplace stressors (e.g., time pressure) on our decision making behavior has repeatedly been shown, it remains unclear whether noise impairs decision making, too. Study 1 (N = 97) employed a lottery task, the Balloon Analogue Risk Task and two risk scenario questionnaires (Choice Dilemma Questionnaire and Risk Scenario Questionnaire). The tasks were performed while being exposed to one of three noise stressors presented at 60dB(A) or in a quiet condition. Compared to the other conditions, a radio podcast sound-file caused a significant increase in risk aversion in the CDQ task. Study 2 (ongoing) involves three tasks. In the first two tasks, participants answer trivia questions and are required to state the confidence they place in their decisions. The third task surveys the probabilities participants assign to various negative events like accidents or risk of illnesses, incorporating a confidence judgment after each question. Participants complete these tasks either in a noise condition (office noise) or a quiet control condition.

17:00 – 17:15

**3862 Context specific analysis of the sound environment at the workplace and its meaning for a task**

Jikke Reinten • Helianthe Kort • Maarten Hornikx • Armin Kohlrausch

A method to analyze the sound environment and its relation with typical professional tasks is described in which structured non participant observations are combined with audio recordings. First results of a field study are reported, directed towards hospital nurses' tasks, working a day shift at an orthopedic or trauma ward. With this method we want to extract context specific outcomes which we consider a prerequisite for the design of dedicated laboratory experiments which can reveal insights transferable to natural work settings. In

our reading of the literature we see many studies on task-sound interaction with one or more of the following shortcomings: 1. The sound conditions used in the experiment are not representative of the dedicated environment. 2. The experimental task is not representative of tasks performed in the dedicated environment. 3. The task-sound interaction is such that subjects are instructed to ignore environmental sounds, while in real life meaning needs to be attached to each sound to decide whether it is (ir)relevant. It is our expectation that the proposed method helps designing experiments that overcome these shortcomings.

17:15 – 17:30

**3626 An Attempt to Predict ISE by a Spectral Estimator**

Toros Ufuk Senan • Sam Jelfs • Armin Kohlrausch

The distractive effect of background sounds on cognitive performance is investigated under the paradigm of irrelevant sound and the effect is called irrelevant sound effect (ISE). The effect is quantified by comparing the cognitive test scores under different acoustic conditions. Even though the acoustic properties are well established and three predictors were proposed in literature, a single metric that relates the cognitive distortion to an acoustic feature is not successfully developed yet. The present work investigates one of these estimators, a spectral parameter, which was proposed to be an ideal metric to predict ISE: frequency domain correlation coefficient (FDCC). The parameter measures the spectral variation between perceptually distinguishable segments of distracting sounds. In order to evaluate FDCC, alternating noise pulses and noise-vocoding speech stimuli are generated in a way that the spectrum of the adjacent segments of the sound varies systematically. Finally, the stimuli are employed in short-term memory tasks and the parameter is evaluated under the light of the test scores.

16:45 – 17:30 | C44

**NOISE POLICY AND ECONOMICS**

Chair: Truls Gjestland • Abigail Bristow

16:45 – 17:00

**3679 Review of the effect of transport noise interventions on human health: policy implications and future research**

Alan Lex Brown • Irene van Kamp

A systematic literature review [1980–2014] of evidence on the effects of transport noise interventions on human health was performed in the framework of preparation of the WHO Environmental noise guidelines for the European Region. Sources considered were roadways, railways, and air traffic; health outcomes were sleep disturbance, annoyance, cognitive impairment of children and cardiovascular diseases. While evidence was thinly spread across different sources, outcomes and intervention types, the results of 43 individual transport source studies showed that interventions invariably lead to a measurable change in health outcomes. For road traffic noise (and some aircraft noise) studies, the changes in annoyance outcomes were either in line with those derived from relevant exposure-response functions, or exhibited excess response. This paper will discuss the implications of these findings for noise policy and management. It will also raise system-wide issues that need to be considered in evaluations of transport noise interventions. It will also provide guidance for future studies of interventions with a suggested protocol for their conduct, including repeat measures of outcomes and confounders, not merely of change in noise levels.

17:00 – 17:15

**4054 Economic impacts of noise and hearing loss in America**

Richard Neitzel • Tracy Swinburn • Monica Hammer • Daniel Eisenberg

Evaluations of noise exposures and the economic impacts of noise-related health effects have not been conducted in the United States for several decades. As a result, the prevalence of potentially harmful noise exposures to the American public, as well as the economic burden associated with auditory and non-auditory effects of noise, have not been sufficiently characterized. We created updated estimates of US noise exposures based on data from the 1980s, and used these estimated exposures to model the cost savings that could be achieved through the prevention of hypertension and myocardial infarction as a result of a hypothetical 5 dB reduction in noise exposures in America. We used similar exposure estimates to model the potential US wage losses that could be avoided through the prevention of noise-induced hearing loss. While our estimates of the economic impacts of auditory and non-auditory impacts of noise exposure contain substantial uncertainty, they nevertheless suggest that annual costs in the US could exceed \$125 billion when avoidable healthcare costs from cardiovascular disease and avoidable wage and employment losses from noise-induced hearing loss are considered.

17:15 – 17:30

**3732 Best practice for cost/benefit based decisions on abatement of traffic noise**

Bert Peeters • Gijsjan van Blokland

Noise from road, rail and air traffic is a major source of annoyance, causing serious health issues in Europe. Noise abatement measures exist at all levels, such as noise barriers, rerouting or investments in silent vehicles. Decision makers implementing these measures need to balance the costs of the measures and the benefits for society. The EPA Network Interest Group on Traffic Noise Abatement (IGNA) has investigated several methods for decision making, based on cost/benefit analysis. A survey shows that well-defined, sophisticated methods exist in some countries, while other countries have no regulations for noise abatement decisions. The key elements from existing systems are explained. We show what costs are included and how to calculate these. We demonstrate how to quantify the benefits in terms of annoyance and public health, and recommend values to be used. We present how costs and benefits are balanced, including other criteria that may influence the decisions. From these investigations, we propose a best practice which could be a guideline for countries and organizations that wish to increase transparency and fairness in noise abatement policy.



	C60	C44	C6	D1
09:00	Keynote by Rainer Guski			
09:15				
09:30				
09:45	Non-auditory health effects of noise	Community response to noise and noise annoyance		
10:00				
10:15				
10:30	Coffee break (Atrium)			
10:45				
11:00	Non-auditory health effects of noise	Community response to noise and noise annoyance	Noise policy and economics	
11:15				
11:30				
11:45				
12:00				
12:15				
12:30	Lunch break (Atrium)			
12:45				
13:00				
13:15				
13:30	Non-auditory health effects of noise	Special topics related to noise effects	Noise policy and economics	
13:45				
14:00				
14:15				
14:30				
14:45	Coffee break (Atrium)			
15:00	Closing Ceremony			
15:15				
15:30				
15:45	Farewell Drinks			
16:00				
16:15				
16:30				
16:45				

09:00 – 09:45 | C60

**KEYNOTE BY RAINER GUSKI**

**4164 The increase of aircraft noise annoyance in communities near airports: Causes and consequences**

Rainer Guski

Field research data indicate an ongoing increase of aircraft noise annoyance in communities at given LpAeq levels. We discuss several potential causes of this process: 1. Methodological changes in the studies, 2. Contextual changes reflected in the studies, 3. General increase of the number of aircraft movements, 4. Changes in the composition of aircraft fleets, and 5. Attitudinal changes in the residents. At present, several consequences can be drawn: 1. Recommendations with respect to intolerable levels of continuous noise for aircraft and railway traffic should be adjusted. Within this process, it seems recommendable to distinguish between low rate and high rate change airports. 2. Since the increase of the number of flight movements, as well as the change in fleet mix seem to be systematically related to the annoyance increase, assumptions of the energy-equivalent long-term continuous sound pressure should be re-evaluated and amended or supplemented by additional acoustic variables. 3. We should keep an eye on the development of socially shared values and attitudes related to personal autonomy, as well as to the evaluation of airports, and their noise policy.

09:45 – 10:30 | C60

**NON-AUDITORY HEALTH EFFECTS OF NOISE**

Chair: Yvonne de Kluizenaar • Toshihito Matsui

09:45 – 10:00

**3819 Long-term exposure to source-specific transportation noise levels and temporal noise characteristics in association with arterial stiffness**

Maria Foraster • Ikenna C. Eze • Emmanuel Schaffner • Danielle Vienneau • Harris Héritier • Simon Endes • Franziska Rudzik • Laurie Thiesse • Reto Pieren • Christian Schindler • Schmidt Trucksäss Arno • Mark Brink • Christian Cajochen • Jean Marc Wunderli • Martin Rööslü • Nicole Probst-Hensch

Transportation noise levels and characteristics may impact arterial stiffness, a predictor of cardiovascular disease. We evaluated the association of long-term road, railway, and aircraft noise levels (Lden), total noise intermittency (IR), and total number of noise events (NE) with brachial-ankle pulse wave velocity (baPWV) using a cross-sectional design. We measured baPWV in 2775 adults from a Swiss cohort in 2010/2011. We assigned Ldensource, and total day- and night-time Netime and IRtime (IR: 0%: constant, 100%: highly intermittent noise) at the most exposed dwelling façade, using 2011 Swiss noise models. Associations were analyzed with multivariable linear mixed regression. Medians (interquartile ranges) were baPWV: 13.4 (3.1) m/s, Ldenroad: 54.2 (10.6) dB, Ldenrail: 30.0 (8.1) dB, and Ldenair: 32.8 (8.0) dB. Both Ldenrail and NEnight were associated with baPWV, independently of other noise sources and air pollution. The association with Ldenrail was greater with IRnight > 80% and with reported daytime sleepiness. Long-term exposure to railway noise levels, particularly in intermittent night-time noise environments, and night-time noise events, mainly related to road noise, may impair arterial stiffness more than other noise characteristics.

10:00 – 10:15

**3910 Road traffic noise and incident cardiovascular disease: a joint analysis of HUNT, EPIC-Oxford and UK Biobank**

Yutong Cai • Susan Hodgson • Marta Blangiardo • John Gulliver • David Morley • Danielle Vienneau • Kees de Hoogh • Tim Key • Kristian Hveem • Paul Elliott • Anna L Hansell

Aims: This study aimed to investigate the effects of long-term exposure to road traffic noise on incident CVD in three large cohorts: HUNT, EPIC-Oxford and UK Biobank. Methods: In a complete-case sample (N = 361,699), 4,014 IHD and 2,109 cerebrovascular incident cases were ascertained between baseline (1993–2010) and end of follow-up (2008–2015) through medical record linkage. Annual mean road traffic noise exposure was modelled at baseline address. Individual-level covariate data were harmonised and data were pooled. Analyses used Cox proportional hazards model with adjustments for confounders, including air pollution. Results: For an interquartile range (IQR) (3.9 dBA) higher daytime noise, a non-significant association with incident IHD was seen (Hazard ratio (HR): 1.015, 95% Confidence Interval (CI): 0.989–1.042), fully adjusted. Statistically significant associations and interaction terms were seen in obese individuals (HR: 1.099, 95% CI: 1.029–1.174), and current-smokers (HR: 1.054, 95% CI: 1.007–1.103). No associations were found for ischemic or hemorrhagic stroke. Conclusions: Our study strengthens the evidence base for an effect of road traffic noise on incident IHD, whilst the association with incident stroke remains unclear.

10:15 – 10:30

**2500 Long-term exposure to road traffic noise and risk of heart failure: a cohort study**

Mette Sørensen • Olav Nielsen • Ahmad Sajadieh • Matthias Ketzler • Anne Tjønneland • Kim Overvad • Ole Raaschou-Nielsen

We aimed to investigate associations between road traffic noise and incident heart failure, which is an area receiving only little attention. In a cohort of 57,053 people aged 50–64 years at enrolment in 1993–1997, we identified 2,550 incident heart failure cases during a mean follow-up of 13.4 years. Residential address history from 1987–2011 was found in national registers, and road traffic noise (Lden) and air pollution (NO2) were modeled for all addresses. Analyses were done using Cox proportional hazard model. An interquartile range increase in 10-years mean road traffic noise exposure (9.9 dB) was associated with an incidence rate ratio (IRR) of 1.14 (1.08–1.21) after adjustment for gender, lifestyle and socioeconomic status. After further adjustment for air

pollution the IRR was 1.08 [1.00–1.16]. In these mutually adjusted models air pollution was also associated with heart failure [IRR: 1.07 (1.01–1.14)]. The association between noise and heart failure seemed strongest among men (1.19), hypertensive (1.17) and diabetics (1.20). In conclusion, road traffic noise increased risk of heart failure, both before and after air pollution adjustment.

09:45 – 10:30 | C44

**COMMUNITY RESPONSE TO NOISE AND NOISE ANNOYANCE**

Chair: Sabine Janssen • Dirk Schreckenber

09:45 – 10:00

**2449 Standardized questions and scales for social surveys**

Truls Gjestland • Rainer Guski

In 2001 IC BEN Team 6 presented an important article on community noise surveys. Following the initial study by T Schultz in 1978, several authors had tried to compare the results from community surveys on noise annoyance. However, due to differences in study design, different questionnaires, different use of noise indices, etc. these comparisons left a number of unsolved problems. In order to facilitate cross-study comparisons the IC BEN team presented two standardized questions and a verbal scale to be used for noise reaction studies. The response to these two questions would permit valid international comparison of survey results within and between languages. The original article comprised standardized questions and scales in nine different languages, but the IC BEN team also presented a protocol for constructing questions and scales in other languages. So far eight new languages have been added to the list. The »IC BEN survey method« has also been adopted as an international standard, ISO 15666. The paper will present an overview of existing survey questions and scales together with a recommendation and method for constructing questions and scales in new languages.

10:00 – 10:15

**3634 First results of the development of a multiple-item annoyance scale (MIAS)**

Dirk Schreckenber • Christin Belke • Jan Spilski • Rainer Guski

The international standardized questions and response scales recommended for the assessment of noise annoyance by IC BEN in 2001 have been widely accepted in the scientific community allowing for comparisons between studies. However, summarising concepts of annoyance as studied in surveys, annoyance can be seen as a multi-dimensional construct, including past experiences with a noise source and comprising at least three elements: (1) Experience of an often repeated noise-related disturbance and the behavioral response to cope with it, (2) an emotional/attitudinal response to the sound and its disturbing impact, (3) the perception of control of the noise situation. We followed the concept of annoyance as a multidimensional judgment. The psychometric properties of items reflecting the above mentioned three elements of noise annoyance have been explored. Analyses were conducted using data of the NORA H-Study (Noise-Related Annoyance, Cognition, and Health) and a multi-item annoyance scale has been developed by using a stepwise process (exploratory and confirmatory factor analyses). The validity of the scale was tested by a total sample (N = 13491) collected at four German airports (Frankfurt, Berlin, Cologne/Bonn, Stuttgart).

10:15 – 10:30

**3992 Comparison of annoyance response measured with IC BEN 5-point verbal and 11-point numerical scales in Japanese and Vietnamese**

Thulan Nguyen • Takashi Yano • Takashi Morihara • Shigenori Yokoshima • Makoto Morinaga

For the discussion on global noise policies, it is important to define representative exposure-response relationship for each noise sources. IC BEN proposed 5-point verbal and 11-point numerical scales in socio-acoustic surveys. Though the top 27–29% of annoyance scale (3/11 or 2/7) is usually defined as %Highly Annoyed (%HA), the top 40% (2/5) is often used as %HA. In this study annoyance response measured with the 5-point verbal and 11-point numerical scales are compared. Thus a total of 15 data sets including seven Japanese surveys and eight Vietnamese surveys are used for the analysis. The Japanese data sets are those of aircraft, road traffic, railroad and Shinkansen noises, and the Vietnamese are those of aircraft and road traffic noises. It was found that the correspondence between the two scales is various depending on the intensity of each modifier in difference languages. In both Japan and Vietnam surveys, the difference in exposure-response relationship obtained by the two calculation methods is quite small.

10:30 – 11:00 | Atrium

Coffee break

11:00 – 12:30 | C60

**NON-AUDITORY HEALTH EFFECTS OF NOISE**

Chair: Yvonne de Kluzenaar • Toshihito Matsui

11:00 – 11:15

**3851 WHO evidence review of the cardiovascular and metabolic effects of environmental noise: blood pressure in children**

Elise van Kempen • Maribel Casas • Göran Pershagen • Maria Foraster

In 1999 and 2009, WHO had published reviews dealing with the scientific evidence on noise and health and made recommendations for protecting human health from environmental noise exposure. In addition, recommendations were included, aiming to reduce environmental noise exposure in settings where most children spend part of their time. However, none of these guidelines dealt with the cardiovascular effects of noise in children. This is remarkable, since children are considered as a vulnerable group to the effects of noise. Moreover, it could be possible when people are exposed to high levels of noise from an early age on, they might be at higher risk for cardiovascular problems in later life. Furthermore, the number of studies investigating the impact of noise on children's blood pressure has increased substantially. For these reasons, it was decided to include the effects of noise on

children's blood pressure in the WHO evidence review dealing with the cardiovascular and metabolic effects of noise. This paper presents the results of the review dealing with the impact of noise on children's blood pressure.

11:15 – 11:30

**3600 Noise at school independently raises the odds for hypertension in children and adolescents**

Goran Belojevic • Jelena Ilic Zivojinovic • Katarina Paunovic

Community noise is a strong stressor that might affect the regulatory mechanisms of blood pressure in children. The aim of this study was to investigate the prevalence of hypertension among schoolchildren and adolescents and its possible relationship with exposure to community noise. A cross-sectional study was performed on 632 schoolchildren and adolescents (278 boys; 44%), aged 11–15 years from the center of Belgrade. Noise (Leq) was measured in front of schools in two daily intervals and on the streets where children lived in one evening period and in two night intervals. Children's resting blood pressure was measured with sphygmomanometer in a school setting. Hypertension was defined as systolic and/or diastolic pressure that is at or above the 95th percentile in relation to child's gender, age and height. The prevalence of hypertension was 4.6% (29 cases). In a multiple regression analysis body mass index percentile and noise at school (per dB Leq) were significant predictors of children's hypertension (odds ratio/95% confidence interval/= 1.067/1.038–1.097/ $p < 0.001$  and 1.072/1.001–1.149/ $p = 0.048$ , respectively).

11:30 – 11:45

**4075 Are environmental noise and air pollution in middle-sized cities risk factors for preterm delivery?**

Frédéric Mauny • Marie Barba-Vasseur • Sophie Pujol • Paul Sagot • Didier Riethmuller • Gérard Thiriez • Hélène Houot • Jérôme Defrance • Anne-Sophie Mariet • Vinh-Phuc Luu • Eric Benzenine • Catherine Quantin • Nadine Bernard

The aim of this study was to analyze the relationship between preterm birth and environmental multi-exposure to noise and air pollution, in middle sized cities. A case-control study was conducted on single pregnancies without associated pathologies (303 cases and 1208 controls). The mothers lived in the urban community of Dijon or in the city of Besançon (France). The delivery occurred in one of the two university hospitals between 2005 and 2009. Four controls were matched to each case on the mother's age and city of delivery. Different noise and nitrogen dioxide (NO<sub>2</sub>) exposure assessments were modeled at the mother's home. No significant differences in pollutant exposure levels were found between cases and controls. The adjusted odds ratios were very close to 1. The correlations between noise assessments and between NO<sub>2</sub> assessments were very high. Sensitivity analysis conducted using different temporal and spatial exposure windows lead to the same results. The results are in line with of a lack of association between preterm delivery and multi exposure to noise and air pollution in moderately polluted cities, in pregnant women without underlying diseases.

11:45 – 12:00

**3844 Road traffic noise and air pollution exposures and birth outcomes in London**

Rachel B. Smith • Daniela Fecht • John Gulliver • Sean Beevers • David Dajnak • Marta Blangiardo • Rebecca Ghosh • Anna L. Hansell • Frank Kelly • Ross Anderson • Mireille B. Toledano

Research on noise and birth outcomes is limited, but suggests an association with low birthweight. This study investigates road traffic noise and air pollution exposures in relation to birth outcomes, in a registry-based population of 887,664 singleton live and stillbirths in the Greater London area (2003–2010). We estimated road traffic noise at birth address for 2007 using the TRAffic Noise EXposure (TRANEX) model, and also prenatal exposure to traffic-related air pollutants. We are analysing the relationship between noise and air pollutant exposures and birth outcomes, including term birth weight, preterm birth, and stillbirth. Mean day (LAeq,16hr) and night-time (Lnight) road traffic noise exposures were 58dB and 53dB respectively, and were moderately correlated with traffic-related air pollutant exposures (0.29–0.50). Preliminary results suggest that increasing road traffic noise is associated with decreasing mean term birth weight, but that this is not robust to adjustment for traffic-related air pollution. Analyses for other birth outcomes are ongoing. This will be the largest study to date examining joint noise and air pollution exposures in relation to birth outcomes.

12:00 – 12:15

**3701 Association between road traffic noise exposure and cortisol metabolites in newborns**

Manuella Lech Cantuarua • Jakob Usemann • Elena Proietti • Victoria Blanes-Vidal • Harris Héritier • Jean Marc Wunderli • Philipp Latzin • Urs Frey • Martin Rösli • Danielle Vienneau

Several epidemiological studies in adults and children provide strong evidence for non-auditory health effects of noise, which may be mediated by a noise-induced release of stress hormones. However, information regarding effects on newborns is scarce. We investigated the association between modelled residential road traffic noise exposure and cortisol metabolite concentrations in urine of 166 one-month-old infants, from a prospective birth cohort in Bern, Switzerland. Multivariable linear regression models adjusted for anthropometric data, family and pregnancy history and exposure to NO<sub>2</sub> were used to estimate the associations. Noise exposure (Lden in dB(A)) was categorized into tertiles, i.e. low (reference category), medium and high exposure. Positive associations were found between high traffic noise and cortisone (22.57% [-1.78–52.95%]) and β-cortolone (51.51% [-0.86–131.54%]). On the other hand, exposure to higher noise levels reduced the concentration of tetrahydrocortisol (-23.68% [-42.82–1.87%]) and β-cortolone (-18.28% [-33.62–0.61%]). This study suggests a potential effect of noise on cortisol metabolism in early postnatal life. The physiological meaning of this finding in regard to the onset of health disorders during infancy needs to be determined.

12:15 – 12:30

**3592 Traffic noise and determinants of saliva cortisol levels in adolescents**Alva Wallas • Charlotta Eriksson • Olena Gruzieva • Tomas Lind • Andrei Pyko • Mikael Ögren •  
Mattias Sjöström • Göran Pershagen

Only few studies have investigated the role of exposure to transportation noise for annoyance and saliva cortisol levels in adolescents. We evaluated the relation between residential road traffic noise exposure with saliva cortisol levels and annoyance among 1751 16-year olds in a birth cohort from Stockholm. Noise levels were estimated at the most exposed façade of each dwelling based on a modification of the Nordic prediction method. Morning and evening saliva cortisol levels were measured with radioimmunoassay and information on annoyance as well as potential confounders was obtained via questionnaires. Increased morning saliva cortisol levels were seen in females as well as in those with allergic diseases, high physical activity or not using nicotine products (cigarettes or snuff). We did not observe a clear relation between estimated noise exposure and saliva cortisol levels. However, there were statistically significant trends in saliva cortisol levels in relation to annoyance by road traffic noise at the residence and by other people at school/work. These results point to the complexity of using saliva cortisol as a marker of noise exposure in adolescents.

11:00 – 12:30 | C44

**COMMUNITY RESPONSE TO NOISE AND NOISE ANNOYANCE**

Chair: Sabine Janssen • Dirk Schreckenberg

11:00 – 11:15

**3566 How to test noise annoyance models based on psychoacoustic indices using socio-acoustic survey data? The case of aircraft noise annoyance models**

Catherine Marquis-Favre • Laure-Anne Gille

Noise annoyance affects health and well-being of residents in urban areas. For European cities of more than 100,000 inhabitants, strategic noise maps characterize noise exposure using the index Lden. This index was also used to propose dose-effect relationships. However, different studies showed that Lden insufficiently characterizes noise annoyance. Indeed, noise annoyance is influenced by various acoustical features (e.g. spectral distribution of energy) and non-acoustical factors (e.g. noise sensitivity). Noise annoyance models based on noise sensitivity and different psychoacoustic indices were proposed in literature. The psychoacoustic indices account for auditory sensations. It will be interesting to test such models using in situ noise annoyance and noise sensitivity data. The difficulty lies in the lack of the values of psychoacoustic indices in database built from socio-acoustic survey. Thus a methodology is proposed in this paper to estimate the values of different psychoacoustic indices. Therefore models proposed for aircraft noise annoyance are tested. Their predictive power is assessed using survey data. Results show that the models led to an improvement in comparison with model only based on Lden.

11:15 – 11:30

**3694 Annoyance due to railway noise and vibrations: A comparison of two methods of collecting annoyance scores**

Philéas Maigrot • Catherine Marquis-Favre • Etienne Parizet

An experiment has been conducted in order to determine if the method of collecting partial and overall annoyance scores – during separated sessions or during the same session – has an influence on the participants' answers. The experiment used controlled noise and vibration stimuli corresponding to a train pass-by, recorded inside a house in the vicinity of a railway track. 32 participants attended 4 sessions A, B, C and D during each of which they were presented with 16 combinations of noise and vibrations. They had to evaluate partial annoyance due to noise in the presence of vibration (session A), partial annoyance due to vibrations in the presence of noise (session B) or overall annoyance (session C). Lastly, they were asked to rate partial and overall annoyances in a same session (session D). Results show that partial and overall annoyance scores, simultaneously collected during session D, were quite similar to the ones respectively collected during dedicated sessions. Furthermore, this method is convenient as a reduced number of stimuli is presented to each participant.

11:30 – 11:45

**3958 Community response to mixed traffic noise sources: assessing the overall effects of a soundscape**

Peter Lercher

Sufficient data refer to the public health relevance of mixed traffic sound exposure. Furthermore, the consideration of combined sound exposure is required in legal procedures (e.g. environmental health impact assessments). Nevertheless, current practice still uses single exposure response functions. It is silently assumed that standard exposure-response curves accommodate also for mixed exposures – although some evidence from experimental and field studies casts doubt on this assumption. In this paper we use own data to apply several approaches to study deviations from standard exposure-response curves and its determinants in the case of mixed traffic exposure. The results show several limitations of the current approaches. Even facing the two inherent methodological limitations (energy equivalent summation of sound, rating of overall annoyance) the consideration of main contextual factors jointly occurring with the sources (such as vibration, air pollution) or the coping options (associated with building structure, topography) increase the variance explanation considerably. However, the additional contributions vary significantly depending on the source combination. Especially in the case of a three source exposure situation the overall annoyance is already high at lower levels.

11:45 – 12:00

**2453 Effects of floor impact noise on people – annoyance and physiological responses**

Sang Hee Park • Pyoung Jik Lee

This paper discusses the effects of floor impact noise, which is one of the important issues in multi-family residential buildings. First, semi-structured interviews were carried out and a conceptual model was developed to show the relationships between non-acoustic factors and perception of floor impact noise. Secondly, a social survey (N = 487) was conducted to validate the conceptual model and significant relationships between noise disturbance, annoyance, coping and health concerns were found. Thirdly, two laboratory experiments were performed to investigate psycho-physiological responses (e.g., annoyance, heart rate and electrodermal activity) to floor impact noise. Sound pressure level (SPL) had significant impacts on changes in psycho-physiological responses; for instance, heart rate decreased with increasing SPL. Noise sensitivity significantly affected noise annoyance and heart rate when noise levels were greater than 50 dBA, and electrodermal activity and respiration rate at above 60 dBA. Lastly, adjectives representing emotion and feelings induced by floor impact noise were collected and classified into four groups. Perception of noise was assessed using adjectives at different noise levels and the noise annoyance was then explained using emotional words.

12:00 – 12:15

**3813 Dose-response curves for satisfactory sound insulation between dwellings**

Jens Holger Rindel • Anders Løvstad • Ronny Klæboe

A socio-acoustic survey in Norway included field measurements of sound insulation in 600 dwellings, whose residents received a survey to evaluate of the sound quality subjectively. 97% of the dwellings were apartments in multi-unit houses. The questionnaire followed ISO/TS 15666 using a five-step verbal evaluation of the degree of annoyance. By means of logit analysis, dose-response curves were derived for airborne and impact sound insulation between dwellings. Both the normal frequency range down to 100 Hz and the extended frequency range down to 50 Hz were evaluated. For airborne sound insulation, the inclusion of low frequencies did improve the correlation in relation to music with bass and drums, but not in relation to speech sounds. For impact sound, the results were strongly in favour of including the low frequencies. The findings in this investigation confirm results from the literature pointing at a slope of 4 percentage points per dB in the middle range of the curves. On this basis, generalised dose-response curves for airborne and impact sound insulation are presented.

12:15 – 12:30

**3814 Perceived sound quality in dwellings in Norway**

Anders Løvstad • Jens Holger Rindel • Clas Ola Høsoien • Ingunn Milford • Ronny Klæboe

An extensive socio-acoustic survey assessing the perceived sound and noise quality in multi-unit, residential buildings in Norway has been done. The buildings are all supposed to comply with the present building code and requirements. Based on field measurements of sound insulation in 600 dwellings, a questionnaire survey was sent to nearly 4000 residents from which 702 responses were obtained. Thus, the questionnaire responses could be evaluated based on the actual measured sound quality in the respective buildings. The quantity and range in the measurement results allowed for the establishment of exposure-effect relationships for annoyance caused by both airborne and impact sound insulation. Additionally, annoyance due to different sound sources and levels were assessed, as well as effects of using light or heavy building structures, frequency range required in the evaluation of sound insulation, willingness to pay for improved sound quality, and whether people limit themselves to ensure that neighbours are not annoyed.

11:00 – 12:30 | C6

**NOISE POLICY AND ECONOMICS**

Chair: Truls Gjestland • Abigail Bristow

11:00 – 11:15

**3509 Managing »kaman« (noise) impacts and expectations in a changing city centre, Wollongong, Australia**

Suri Mora • Jeffrey Parnell

Wollongong is a city located 80 km from Sydney, Australia with a population of 211,000. Consistent with other centres close to the major state capitals of Sydney, Melbourne and Brisbane, Wollongong has experienced significant population increases in its central business district. This population shift combined with a government desire to make these city centres more vibrant and liveable has a high potential to result in land use conflicts between outdoor restaurants, bars and music venues located in proximity to high rise residential developments. »Kaman« means noise to the local indigenous peoples and the present paper examines historical background noise levels, entertainment licencing and hours of operation, changes in population demographics and expectations, along with the measures that the local government authority is taking to assess and minimise noise conflict. The positive results of these measures include architectural requirements to reduce the ingress of noise to residential apartments, and limits on noise generation by commercial premises are presented in this paper.

11:15 – 11:30

**3730 Application of noise mapping in an Indian opencast mine for effective noise management**

Veena Manwar • Bibhuti Bhusan Mandal • Asim Kumar Pal

Noise is recognized as a major pollutant of the environment. So far as mining industry is concerned, noise pollution is not new. It is generated from operation of equipment and plants for excavation and transport of minerals which affects mine employees as well as population residing nearby areas. Although in the Recommendations of Tenth Conference on Safety in Mines, noise mapping has been made mandatory in Indian mines, still mining industry are not giving proper importance on producing noise maps of mines. Noise mapping is preferred for visualization and its propagation in the form of noise contours so that preventive measures are planned and implemented. Study

was conducted in an opencast mine in Central India. Sound sources were identified and noise measurements were carried out according to international standards. Considering source locations along with noise levels and other meteorological, geographical factors as inputs, noise maps were generated by Predictor LimA software. Results were evaluated in the light of Central Pollution Control Board norms as to whether noise exposure in the residential and industrial area were within prescribed limits or not.

11:30 – 11:45

**4063 Road traffic noise exposure scenarios 2015 – 2035 for Gothenburg, Sweden**

Mikael Ögren • Peter Molnar • Lars Barregard

Exposure to high levels of road traffic noise at the most exposed building facade is increasing, both due to urbanization and due to overall traffic increase. This study investigated how different noise reduction measures would influence the noise exposure on a city-wide scale in Gothenburg, a city in Sweden with approximately 550 000 inhabitants. The scenarios include business as usual, traffic flow reductions, increased proportion of electrically powered vehicles, introduction of low noise pavements and tires. The noise exposure was estimated for the period 2015–2035 using the standardized Nordic noise prediction method together with traffic flow measurements and population statistics. In the business as usual scenario the number of inhabitants exposed above 55 dB equivalent level increases by 23% from 2015 to 2035. The best reduction was achieved with the low noise tires scenario, where the number of exposed instead decreased by 23%.

11:45 – 12:00

**3579 Willingness to pay in the Rhine-Main region according to aircraft noise, railway noise, road traffic noise**

Kerstin Giering • Rainer Guski • Tobias Klein • Ulrich Möhler • Dirk Schreckenber

A study on willingness to pay for noise abatement has been carried out in the Rhine-Main region using survey data from 9,244 participants of the NORAH project (Noise-Related Annoyance, Cognition, and Health), workpackage 1 »Annoyance and health-related quality of life«. The willingness to pay was analyzed by the question »What would you be willing to pay in the next five years for noise reduction in addition to monthly housing costs?«. In the analysis 6,700 valid responses were considered. For each respondent, the willingness to pay was related to individual levels of aircraft, railway, and road traffic noise exposure and to their energetic summation; no linear dependency between WTP and sound level could be observed. The relative payment (related to income) shows an increase (linear tendency) with noise level. The strongest effect can be seen by aircraft noise. Furthermore, the association between willingness to pay and annoyance (highly annoyed - %HA) was examined. Here a linear dependency of the WTP becomes apparent: Except for railway noise the WTP increases strictly with an increase in annoyance.

12:00 – 12:15

**3936 Respite from Aircraft Noise**

Nicole Porter • Richard Norman

The concept of providing respite from aircraft noise has been moving up the agenda in recent years, as a useful and effective strategy for providing a break from aviation noise. However, there are no specific guidelines to explain what respite from aircraft noise means and how it should be implemented. Following recommendations from the UK's Respite Working Group (RWG), a research project has been carried out to address the key objectives identified by the RWG. This paper describes the work of the RWG and its recommendations, the aims and objectives of the follow on research work, its methodology and headline findings.

12:15 – 12:30

**4355 The Noise Landscape: understanding the spatial impacts of noise in European airport peripheries**

Eirini Kasioumi • Benedikt Boucsein • Christian Salewski • Kees Christiaanse

In Europe, it is estimated that 5 million people are regularly exposed to airplane noise levels above 55 dB(A) Lden, with many more experiencing annoyance irregularly. Noise mapping is a common practice to capture noise impact in the areas around major airports where most of this population resides. The resulting contours delineate the impact space of noise: a space defined by noise both as experience and as metric, since contours are the basis for compensation schemes and urban development restrictions. But what spatial reality corresponds to noise contours? Our research approaches this question by focusing on the »Noise Landscapes« of eight major European airports (Amsterdam, Zurich, London-Heathrow, Frankfurt, Munich, Madrid, Paris-Charles de Gaulle and Paris-Orly): expansive areas affected by noise, infrastructure, and transient architecture. Juxtaposition of the socio-geographic characteristics, extent of noise impact, regulatory frameworks, and noise abatement measures in the eight areas is complemented by case analysis of the spatial impacts of noise and related policy conflicts. We present here some of the results of the upcoming volume »The Noise Landscape: A Spatial Exploration of Airports and Cities«.

12:30 – 13:30 | Atrium

Lunch break

13:30 – 14:45 | C60

**NON-AUDITORY HEALTH EFFECTS OF NOISE**

Chair: Yvonne de Kluizenaar • Toshihito Matsui

13:30 – 13:45

**3818 Possible long-term implications of being in a preschool noise environment, from a child and personnel perspective**

Kerstin Persson-Waye • Sofie Fredriksson • Irene van Kamp

Early exposure to noise may have long-term health implications, of which we today have little knowledge. Mechanisms such as alterations in biological stress regulatory responses, adoption of behavioural strategies resulting in manifest coping patterns and susceptible hearing systems, may be of importance. In Sweden 83% of children between the ages of 1 to 5, attend preschool. The noise exposure is intermittent and irregular and the noise levels

reach up to 85LAeq (time indoors). To increase the overall understanding of the possible implications of being in a preschool noise environment, the paper will describe the child perspective obtained through qualitative and quantitative measures. The personnel's perspectives of how noise affected children's behaviour and health were derived by qualitative content and quantitative analyses. Finally, the risks of long-term implications for hearing and health will be discussed.

13:45 – 14:00

**3617 A questionnaire survey on health effects of aircraft noise for residents living in the vicinity of Narita International Airport: The results of physical and mental health effects**

Masaaki Hiroe • Koichi Makino • Saburo Ogata • Shôsuke Suzuki

A questionnaire survey on health effects of aircraft noise was performed by the Narita International Airport Corporation (NAA) for residents living in the vicinity of Narita International Airport. The survey was implemented to investigate psychological effects like noise annoyance, night-time insomnia, mental effects like emotional instability and depressive tendency, and physical effects like high-blood pressure. In this paper, we particularly focused on the results of physical and mental effect of aircraft noise. The questionnaire was consisted of both Total Health Index (THI) questionnaire constructed from about 130 self-rating questions asking perceived health and a general questionnaire asking about systolic/diastolic blood pressure and noise sensitivity. The survey was carried by postal mail and the total of valid responses collected from the mail survey was 3,659. In order to analyze health effects of aircraft noise, we applied logistic regression model to the responses of this questionnaire survey. From these results, we concluded that some of mental effects might be suspected to associate with aircraft noise exposure however the associations between physical effects and aircraft noise exposure were not found.

14:00 – 14:15

**2444 The effects of aircraft noise exposure on psychological distress: the results of the DEBATS study in France**

Clémence Baudin • Marie Lefevre • Bernard Laumon • Anne-Sophie Evrard

Background: 18% of the French population suffer from mental disorders. Some studies suggested that aircraft noise exposure may increase psychological distress, but the number of these studies is limited and no one exists in France. We investigated associations between aircraft noise exposure and psychological distress for people living near airports in France. Methods: The DEBATS longitudinal study included 1,244 residents around three French airports: Paris-Charles-de-Gaulle, Toulouse-Blagnac, and Lyon-Saint-Exupéry. Information about psychological distress was assessed by a face-to-face questionnaire, including the 12-version of the General Health Questionnaire. Aircraft noise exposure was evaluated for each participant's home address using the integrated noise model. Associations with psychological distress were investigated using logistic and linear regressions including relevant confounders. Results: 13% of the participants reported depression and 22% were considered to have psychological distress according the GHQ-score. No association was found between exposure to aircraft noise and depression or psychological distress. Discussion: In the present study, no association was observed between aircraft noise exposure and psychological distress. This result partly confirms the findings of the few studies investigating this association.

14:15 – 14:30

**3635 The relationship between aircraft sound levels, noise annoyance and mental well-being: An analysis of moderated mediation**

Dirk Schreckenber • Sarah Benz • Christin Belke • Ulrich Möhler • Rainer Guski

The evidence of a direct relationship between environmental noise exposure and mental health is inconsistent. However, several studies have shown an association between noise annoyance and mental health. This has been interpreted in terms of a mediation effect of annoyance on mental well-being. The reversed hypothesis that individuals with poor mental health have low resources to cope with noise and thus are more annoyed is also discussed. For aircraft noise, both hypotheses that noise annoyance mediates the impact of noise exposure on mental well-being (Model 1) and that mental well-being contributes to the prediction of annoyance (Model 2) were analysed using longitudinal data of the NORAH study (Noise-related annoyance, cognition, and health). Mediation analyses were done by means of OLS regression and SEM. Results indicate that aircraft noise annoyance (ICBEN-5-point scale) mediates the effect of LpAeq,24h for aircraft on the SF8 score for mental health-related quality of life (MCS). This mediation effect is stronger for higher aircraft sound levels [»moderated mediation«]. The analysis of the reversed Model 2 reveals lower effect sizes as compared to Model 1.

14:30 – 14:45

**3892 Health impact assessment of noise in Rome, Italy**

Francesca Mattei • Chiara Badaloni • Elena Ascari • Paolo Gagliardi • Gaetano Licitra • Giulia Cesaroni • Massimo Stafoggia • Francesco Forastiere • Carla Ancona

The study aim was to estimate the health impact of vehicular traffic noise on residents in Rome. Road traffic noise indicators (LAeq16h, Lden, Lnighth) were estimated for all the residential addresses in Rome using the acoustic model Sound-Plan7.4 (2009 traffic-flow data). We estimated attributable cases of hypertension, coronary events incidence, and sleep disorders. Available exposure-response functions were extrapolated from published meta-analyses. The counterfactual levels were 55dB(A) for LAeq16h and Lden, 40dB(A) for Lnighth. Rome citizens (2,617,165 residents) are exposed to relatively high mean annual-levels of noise, 62.6 dB(A) LAeq16h, 60.5 dB(A) Lden, and 51.3 dB(A) Lnighth. We estimated 15,458 [CI 95% 5,277–24,491] hypertension cases, 247 [CI 95% 129–383] incident coronary events, and 146,744 [CI 95% 62,763–299,250] sleep disorders attributable to traffic noise. The HIA indicates an important negative impact of noise in Rome. Although a certain overlap between



the impact of air pollutants and noise must be clarified, results call for the adoption of structural interventions to reduce traffic in the city and prevent large health effects among residents.

13:30 – 14:45 | C44

### SPECIAL TOPICS RELATED TO NOISE EFFECTS

Chair: Adrian Fuente • Tony Leroux

13:30 – 13:45

#### 3805 Consciousness of Individual Noise Pollution Behavior of the German Population

Jördis Wothge

The German study of environmental consciousness is a representative biannual survey of the German Environment Agency. It investigates the attitudes, beliefs and behavior of the German population with regard to various environmental issues. Noise is an integral part of this study. Until 2014, noise was only included with respect to annoyance by traffic noise, industrial noise and neighborhood noise. The latest version of the survey also introduced a section on the populations' consciousness of their own noise polluting behavior («noise consciousness»). A 10-item questionnaire was implemented to investigate the factual knowledge of the German population about health impacts of environmental noise, as well as attitudes, awareness and behavior towards and about the individual noise emission. This contribution introduces and describes the methods of the survey and presents and discusses first results of the section on «noise consciousness» in the current study about the environmental consciousness of the German population by the German Environment Agency.

13:45 – 14:00

#### 3838 The influence of audio-visual aptitude on audio-visual interaction in appraisal of the environment

Dick Botteldooren • Kang Sun • Gemma Maria Echevarria Sanchez • Bert De Coensel • Timothy Van Renterghem

Perception and appraisal of the living environment are multi-sensory processes. People are able only to some extent to isolate one particular sensory input and appraise it separately. Hence, in a more holistic soundscape design, combined stimuli should be included. Of particular interest for appraising the sonic environment, is the role of attention. Attention and gating partly determine whether sound interferes with or promotes instantaneous activities that the listener is engaged in. As it has become clear that a considerable part of the brain governing auditory perception has a high plasticity, large differences can be expected between persons. Hence we redesigned a classical experiment for an ecologically valid setting to assess one of these personal factors: audio-visual aptitude. Both the ability of a person to distinguish small changes in the sonic environment and its resilience to visual distraction are assessed by the test. Using a noise annoyance experiment with visual context in a mock-up living room, it could be shown that there is an effect of being easily visually distracted, in particular in combination with visibility of natural green elements.

14:00 – 14:15

#### 3898 Good acoustic architecture for streetscapes

Inès Neuhaus • Fabian Neuhaus

In urban areas around the world, people and animals have to cope with noise, and living environments are becoming increasingly dense and scarce because of it. This is especially true in the neighbourhood of traffic routes. With all the advantages around-the-clock mobility and means of transport offer us, the noise they cause is currently one of the biggest problems in urban areas. To create attractive, popular places requires up-to-date solutions that in terms of acoustics lead well beyond what was achieved before and at the same time are in tune with broader urban design goals. In a design guide developed for the Swiss Canton of Zurich, the authors present a new approach to building design along traffic routes that is both architecturally holistic and acoustically sustainable. It focuses on the way spaces completely or partially enclosed by buildings act as sound boxes and strongly define the acoustic situation. Presenting ready-to-use architectural design principles, the authors show a path to creating satisfying acoustic conditions for people in and around streets and other traffic routes.

14:15 – 14:30

#### 3926 Effects of anthropogenic sound on terrestrial ecosystems: a review of recent evidence

Guillaume Dutilleul

Since the beginning of the 1980s a large body of scientific and technical literature regarding the effects of anthropogenic noise on terrestrial wildlife has developed. These effects are mostly documented for birds and anurans. They range from behavioral modifications like signalling louder, increasing the signalling rate or redundancy, signalling at a higher pitch, signalling outside noisy periods, but also to alterations of intraspecific or interspecific interactions. Moreover it is now proven that man-made noise may lead to reduced reproductive success, reduced species richness or reduced density. This paper reviews the published literature on the topic since the beginning of the 2010s. The careful design of experiments helps avoid methodological biases some more ancient studies in this field may suffer from. The paper highlights the progress of knowledge among the different taxa including invertebrates and also on the effects of anthropogenic noise relating to the operation of an ecosystem.

14:30 – 14:45

#### 3585 Ears II – Development of an ultrasound measurement technique for use in occupational safety

Christian Ullisch-Nelken • Robert Schöneweiß • Andrea Wolff

During the past several years ultrasound has gained importance in the field of occupational safety, since the dissemination of ultrasound technology in industrial applications has increased. While several studies on airborne ultrasound and its effects on human health exist, no major research has been carried out in this area approximately since the seventies of the last century. Thus, airborne ultrasound still poses a potential risk to employees and the general population alike. To address this problem, among others, the EU-project »Ears II« was initiated. For

occupational safety, measuring airborne ultrasound in-situ is vital. However, current measurement techniques apply to measuring audible sound only and do not cover ultrasound for several reasons. The ultrasound fields emitted by today's industrial appliances are mostly unknown and likely to be complex. Additionally, no weighting for a comparable assessment of the exposure to ultrasonic noise is defined. We iteratively develop a measurement procedure by evaluating current laboratory and conventional in-situ techniques as well as existing data and by performing in-situ measurements. We will present the current progress of the development and discuss possible caveats.

13:30 – 14:15 IC6

#### **NOISE POLICY AND ECONOMICS**

Chair: Truls Gjestland • Abigail Bristow

13:30 – 13:45

#### **3649 One Justice for All? Noise Pollution and Different Notions of Distributive Justice**

Heidi Bruderer Enzler • Andreas Diekmann • Ulf Liebe

How are noise annoyance, noise exposure at one's home and perceptions of distributive justice of noise pollution related? In an environmental justice survey, we are currently running in two major Swiss cities (n≈ 3,500), respondents are presented with a fictitious municipal project to reduce road traffic noise immissions. They are asked to choose among four options of how the project should affect noise exposure of the cities' residents. These options correspond to different justice theories: Bentham's utilitarianism (i.e. maximization of aggregate net benefits), Rawls' contractarianism (i.e. maximization of benefits to the least advantaged), and two aspects of egalitarianism (i.e. »equal benefits to all« or minimization of existing inequalities). To analyze the relationship between distributive-justice perceptions and one's own perceived and objective noise exposure, we will geocode the respondents' residential addresses and link the survey to spatial data on road traffic noise exposure. This allows analyzing how differences in the perception of justice are related to both individual characteristics – e.g. noise annoyance, subjective noise exposure, environmental attitudes, education, income and further sociodemographic variables – and actual noise exposure.

13:45 – 14:00

#### **3934 Socioeconomic and ethnic inequalities in transport-related outdoor noise at residence in London**

Daniela Fecht • Carles Mila • Mar Álvarez Pedrerol • John Gulliver • Cathryn Tonne

Transport-related noise varies within cities but little is known about differential exposure across vulnerable sub-populations. We characterised inequalities in residential exposure to traffic-noise from roads, railways and aircraft in relation to individual- and area-level socioeconomic status (SES) and ethnicity in Greater London. We assigned road-traffic noise (LNight, LAeq,16hr, LDen) to ~45,000 individuals, using the TRAffic Noise EXposure model and identified those within 50dB noise contours of over-ground railways and Heathrow and City airport. We used household income as an individual-level and the Index of Multiple Deprivation as an area-level marker of SES. Road-traffic noise increased slightly with decreasing area-level SES for all metrics. We observed a strongly increasing trend in exposure from railways and City airport with deprivation (individual- and area-level); 10% and 0.3% of individuals in the highest tenth of household income were exposed to noise from railways and City airport, respectively, compared to 15% and 0.9% in the lowest tenth. For Heathrow airport the trend was opposite; 18% in the highest tenth of household income and 10% in the lowest. Differences by ethnicity were marginal.

14:00 – 14:15

#### **3612 Environmental noise challenges and policies in low and middle income countries**

Dietrich Schwela

Information on environmental noise challenges was gathered for 139 countries, identified by the World Bank as of low income (31), lower middle income (52), and upper middle income (56). Data on noise levels were found in urban agglomerations of two low income, 13 lower middle income, and 20 upper middle income countries. Environmental noise pollution continues to grow in all studied cities due to increase in motor vehicle fleets, airport operations and industries. The main driving forces are population growth, urbanization, motorization and to a large extent technological development. In this paper the major noise sources in two low income countries, 13 lower middle income countries and 13 upper middle income countries (excluding Member States of and countries on the road to the European Union) are identified and observed environmental noise levels reviewed. The paper also compiles the adverse health effects of extensive noise exposures in urban agglomerations that have already been observed in some of these countries. The key laws and by-laws and other regulations on noise pollution in these countries and the level of their enforcement are discussed.

14:45 – 15:00 | Atrium

**Coffee break**

15:00 – 15:45 IC60

#### **CLOSING CEREMONY**

Chair: Mark Brink • Mathias Basner • Sabine Janssen

The closing ceremony of IC BEN 2017 is devoted to a brief review of the congress, presented by the IC BEN secretary, the awarding of the best presentation and best poster, gratifications, the presentation of new IC BEN executive committee members and a brief teaser for the next IC BEN congress.

The posters will be exhibited throughout the conference in the Atrium.  
The Poster Blitz Session is on Tuesday, June 20 from 13:30 – 14:45 in Room C60.

- 01**                    **3773 Sustainable hearing loss prevention**  
Judith Sobel • William Martin • Susan Griest • Thomas Becker  
Community-based interventions offer the possibility of producing effective, self-sustaining health promotion programs in communities with common values, culture, recreational activities, occupations, and geography, as is the case among many Native American tribal groups. Therefore, an intervention was conducted to determine the sustainability of a community-based noise induced hearing loss and tinnitus prevention program in three different types of American Indian settings, where tribal members have 2–4 times the rate of moderate to severe hearing loss as compared with others in the United States. The target population was elementary school students, but components of the intervention included their families, tribal council members, local media professionals, school principals and teachers, medical staff, and the Northwest Portland Area Indian Health Board. This 5-year study determined that it is possible to develop a self-sustaining health promotion strategy to insure program activities continue. It requires flexibility, patience and a sincere commitment by at least one or two individuals from the community to carry on the work. Program sustainability should be central to any health promotion activity that targets health issues in a community.
- 03**                    **3692 Looking at Non-Occupational Noise-Induced Hearing Loss**  
Neil Di Sarno  
Although many countries have programs in place to reduce the risk of work-related hearing loss, noise-induced hearing loss (NIHL) continues to rank among the most prevalent conditions worldwide. The World Health Organization estimates 60% of hearing losses are preventable. Noise exposure from non-occupational or recreational sources contribute to the continuing burden on NIHL across the world. In fact, the social acceptability of noise in the general makes it difficult to raise concern about the health impact of high levels of noise. This poster will present a »picture« of the problem of non-occupational hearing loss and a path forward towards prevention. Key points for consumer education will be presented visually as an infographic. The poster will summarize this public health issue – including the prevalence of non-occupational NIHL and tinnitus, the effects of noise exposure on the hearing mechanism, common sources the non-occupational noise exposure, the social and economic impact of NIHL, and how to preserve hearing and avoid tinnitus and other noise related effects. This infographic poster will be available as a free download via a QR code and link.
- 04**                    **2330 What is a safe noise level for the public?**  
Daniel Fink  
What is a safe noise exposure level for the public? This question underlies regulatory efforts to control public noise exposure. It cannot be an unadjusted occupational standard. Unlike other occupational exposures, noise exposure continues outside the workplace. Occupational limits must be adjusted for increased exposure time, from 8 to 24 hours daily, 240 work days to 365 days annually, and from 40 work years to the entire lifespan. Recommended safe exposure levels depend on which adverse noise effect is being considered. To prevent hearing loss, the U.S. Environmental Protection Agency (EPA) adjusted the U.S. occupational recommended exposure level of 85 dBA for additional exposure time to calculate a 24-hour 70 dB time weighted average (Leq = 70). EPA did not adjust for lifespan years so the correct safe exposure level is likely lower. The World Health Organization (WHO) also recommends 70 dB to prevent hearing loss. EPA and WHO determined that non-auditory health impacts of noise occur at 55 dB average exposure, with annoyance starting at 45 dB. These are the safe noise exposure levels for the public.
- 05**                    **3616 The »Hearwig« as hearing protector for musicians – a practical investigation**  
Andrea Wolff  
The »Hearwig« is a new approach to hearing protection for orchestral musicians. The standing device is placed behind the sitting musician. By leaning backwards into the sound absorbing shell of the »Hearwig«, the musician's ears and the back of the head are covered. Thus, the device can predominantly be used inbetween entries. The musician can remove the head quickly and easily from the shell in order to play the instrument unhindered. So far, very few investigations on the sound absorbing properties of the »Hearwig« exist. We present results of our own measurements in the laboratory and in the field. In the laboratory measurements the angle-dependent sound attenuation was measured with the help of an artificial head. Additionally, sound attenuation was determined using trained test persons and the experimental setup for testing of hearing protection following ISO 4869-1. Afterwards, field measurements during rehearsals of a classical orchestra were performed in a concert hall. We discuss the results of our investigation and the consequences for the usability of the »Hearwig« in the field.
- 06**                    **3793 A building code on indoor noise environment for the hearing impaired senior's aging at home**  
Yang Ki Oh • Jong Kwan Ryu  
Hearing impairment in one's senior age is a part of natural aging process like wrinkles on the face. It is important to provide acoustically well concerned housing facilities for a better life quality of hearing impaired seniors. Discomforts from the hearing impairment mainly due to noise and reverberant environments. An acoustic design guideline is studied for hearing impaired seniors aging at home.

- 07**      **4034 The localization of the sound sources: a new approach based on the divergence of the sound pressure level**  
 Valentin Buzduga  
 This paper presents a new approach for explaining how the human hearing system is able to localize the sound sources. The theory of the head related transfer functions known from literature shows that the position of a sound source is determined from monaural and binaural cues, by using the time differences of arrival and the intensity differences of the sound at the two ears. The approach described in this paper uses the divergence of the sound pressure between certain points in the field of the acoustic source. The paper proves that sensing the difference of the sound pressure levels between four adequately chosen points in the field of a source allows determining the position of that source. The paper argues that certain elements in the structure of the human ear confirm the new approach for the localization of sound sources. The paper proposes further research for clarifying the topics in this domain.
- 08**      **3587 An Ecological Study to assess relationship between noise pollution and cardiovascular disease in India**  
 Charu Kohli • Saurav Basu • Bratati Banerjee • Suneela Garg  
 Background: The noise pollution is a serious public health problem. Objective: To determine any correlation between noise pollution and cardiovascular disease. Methods: An ecological study was conducted by collecting secondary data on noise pollution and cardiovascular disease in Delhi over a period of 2010–2015. Data on noise pollution was taken from Delhi Pollution Control Board. Total and month wise distribution of number of cases of cardiovascular disease reported from a period of year 2010–2015 in a secondary level hospital in Delhi was collected. Data was analyzed to find any correlation between the average noise pollution levels over the years and proportion of cases of cardiovascular diseases out of total number of patients reported. Results: The average level of noise pollution was 79 dB which was higher than permissible levels of 55 dB in India. However, the average noise pollution level was decreasing from 2010–2015. The proportion of cardiovascular cases of total disease cases reported was 2.2% in 2010 which decreased to 1.9% in 2015. Conclusion: There is a correlation between noise pollution levels and cardiovascular disease.
- 09**      **3677 Cardiometabolic risks of exposure to different environmental noise sources in vulnerable population**  
 Lubica Argalasova • Ludmila Sevcikova • Diana Vondrova • Zuzana Stefanikova • Jana Babjakova • Alexandra Filova • Martin Samohýl • Katartina Hirosova • Jana Jurkovičová  
 The recent advances in research have pointed out a possible relationship between traffic noise, type 2 diabetes, and obesity. The study aims to examine the association between exposure to environmental noise sources and markers of obesity (BMI (body mass index), WHR (waist hip ratio), WC (waist circumference), body fat percentage) in the sample of university students in Slovakia. The sample comprised of 484 university students (mean age 22.9±2 years, 25.6% males); 188 living in the dormitory exposed to road traffic noise and 296 living in the control area, for more than 4 years. Students from the exposed group are more annoyed by road traffic, tramway and social noise. The bivariate analysis showed higher, but not significant levels of all obesity markers in the group exposed to traffic and social noise. The results were significant only for body fat percentage assessed by NIR method in the categorical analysis in men (OR = 2.19 [95% CI 1.1–4.75], p=0.048), after adjustment for possible confounding factors. Future research is necessary in this new field to extend its inferences to the general population.
- 10**      **2340 Stress and cardiovascular reactions to temporary noise experiences in healthy males**  
 Shkurti Enkelejda • Shtiza Diamant  
 Background: Although earlier epidemiological surveys demonstrate difficult consequences of long-term noise experience on cardiovascular health, the devices responsible for these results are indistinct. Methods: Healthy male (n=15) contributors were observed on visits through no noise, low- or high-frequency noise experience situation lasting 45 min. Contributors did an ambulatory electrocardiogram (ECG) and blood pressure assessment and saliva tests were made before, through and after noise experiences. ECGs were processed for evaluations of heart rate variability (HRV): high-frequency power (HF), low-frequency power (LF). Results: It was investigated an overall of 672, 198, and 156, HRV, saliva, and blood pressure measurements over 50 days. Declines in HRV (LF and RMSSD) were detected during noise experience (a diminution of 17% [-32,-3.1]). After adjusting for noise occurrence, during low occurrence noise experience, HF, LF, and SDNN were diminished (a decline of 29% [-54,-6.7], 31% [-49,-17], and 13% [-22,-5.8]), correspondingly. Conclusions: These outcomes recommend that revelation to noise, and to low-frequency noise, harmfully influences HRV. The occurrence of noise should be reflected on when appraising the cardiovascular health of revelation.
- 12**      **2443 Reported general health and aircraft noise exposure: the results of the débats study in France**  
 Clémence Baudin • Marie Lefevre • Bernard Laumon • Anne-Sophie Evrard  
 Background: The impact of exposure to aircraft noise on health is of growing concern because of a steady rise in flights. While many studies address the annoyance associated with aircraft noise, few studies consider the health status perceived by the population itself. We investigated associations between aircraft noise exposure and perceived health for people living near airports in France. Methods: The DEBATS longitudinal

study included 1,244 residents around three French airports: Paris-Charles-de-Gaulle, Toulouse-Blagnac, and Lyon-Saint-Exupéry. Information about perceived health was assessed by a face-to-face questionnaire. Aircraft noise exposure was evaluated for each participant's home address. Associations with perceived health were investigated using logistic regressions including relevant confounders. Results: No association was found between aircraft noise exposure and perceived health. After stratification on gender and occupational activity, significant associations were observed mainly for men without occupational activity: OR = 2.28 (95% CI = 1.05 – 4.98) per 10-dB(A) Lden-increase. Discussion: The associations observed in this study could be due to residual confounding or to declaration bias which cannot be excluded. Further studies are necessary in order to better understand these associations.

**13 3931 Health risk assessment for large industrial cities population under the noise exposure**

Dmitrii Koshurnikov

The impact of noise on health is proved in many epidemiological studies. However, the topic of the health risk evolution in the areas of acoustic discomfort is not fully understood. Study purpose – evaluation of chronic noise exposure in areas of acoustic discomfort and health risk using modeling and instrumental measurements. Study object – Russian city with intensive road transport and a high level of aircraft noise. Methods: acoustic calculations in the places of residence were carried out. A city noise map with the use of 1,300 noise sources was made. Noise levels were compared with population health data according to geographical areas using GIS technology. Noise exposure scenarios, mathematical models to assess the risk evolution were prepared. Zones with different noise levels were identified. Risk assessment showed that noise level of 59.9 dB forms a moderate risk of cardiovascular disorders, the risk will be formed by the age of 68; 61.5 dB noise level creates a risk by the age of 45, in the maximum noise load (66,6 dB) zone – by 20 years.

**14 2448 Occupational noise exposure and the risk for work-related injuries: A systematic review and meta-analysis**

Angel Dzhambov • Donka Dimitrova

Occupational noise has been linked to occupational injuries, with the underlying mechanisms being cognitive impairment, poor information processing, disturbed intelligibility of sounds and communication, etc. Strategies to control occupational hazards often rely on dose-response relationships needed to inform policy, but, to our knowledge, quantitative synthesis of the relevant literature has not been done so far. This study aimed to systematically review the epidemiological literature and to perform a meta-analysis of the risk for work-related injuries due to occupational noise exposure. PRISMA and MOOSE guidelines were followed. PubMed, ScienceDirect, and Google Scholar were searched up until December 15th 2016 in English, Russian, and Spanish. Reference lists, grey literature, and expert archives were searched as well. Overall, 19 studies were included. Their methodological quality was evaluated and incorporated into the meta-analysis weights, using the quality effects model. Preliminary results showed RR per 5 dB = 1.22 (95% CI: 1.15, 1.29) and RR highest vs. lowest group = 2.18 (95% CI: 1.62, 2.93). The systematic review will be updated regularly and final results will be presented at the ICBCN Congress.

**16 2823 The Bigger the Better and the More the Merrier? Realistic Office Reverberation Levels Abolish Cognitive Distraction by Multiple-Voice Speech**

François Vachon • Elizabeth Winder • Mathieu Lavandier • Robert W. Hughes

Background speech is consistently rated as the most objectionable noise in open-plan offices. There is ample evidence that acoustic variation in the speech is a key determinant of its disruption of cognitive performance. Theoretically, any means of attenuating sound variability such as increasing room reverberation should help counter the negative impact of irrelevant speech. To date, such benefits have been reported only with reverberation times uncharacteristic of office environments. Based on the observation that multiple voices are less disruptive than a single voice, we sought to test the joint impact of number of voices and reverberation on the disruptive effects of speech. The effects on a (visually-presented) short-term serial recall task of adding realistic reverberation times (0.4 or 1 s) to irrelevant speech composed of either 3 or 15 superimposed voices was compared to a quiet control condition. Disruption diminished with both an increase in number of voices and with increasing reverberation and disappeared in the 15-voice + long-reverberation condition, suggesting that realistic room reverberation levels may ameliorate the damaging effects of background speech in relatively large multiple-occupancy offices.

**17 3896 Interrelations between noise and patients' critical states during surgeries**

Sandra Keller • Franziska Tschan • Daniel Candinas • Guido Beldi • Katharina Seidl

In modern operating rooms (OR), anaesthesiologists rely on acoustic signals in addition to visual information on the patient monitor to identify critical patients' states, which trigger specific actions (e.g. application of additional medicine). Higher noise levels in the OR can be an interference to the perception of such signals and impair concentration. This may complicate the correct handling of the patient and impact the patients' state. However, anaesthesiologists who react to a critical patient state also generate noise, because handling of materials is one of the main sources of noise in the OR. Aim of the study was to model the interrelations between noise in the OR and patients' critical phases throughout the surgery. Method: We measured noise per 10-minute intervals during 65 abdominal surgeries with a noise measuring device placed on the main lamp in the OR. In parallel we identified moments of critical patient states during anaesthesia (if patient values exceeded

a critical threshold that required the anesthetist to react). Results: Analyses are ongoing and results will be available at the time of the conference.

**18 3508 Dental equipment noise on dental anxiety and its noise reduction**

Cheuk Ming Mak • Hai Ming Wong • Yijing Chu

The dental office environment subjects both patients and dental professionals to the noises associated with dental equipment. The sound of the dental drill, for example, usually causes some discomfort and anxiety. Fear and anxiety due to these noises are among the major reasons why patients avoid dental visits. It is important that these fears are addressed and patients are encouraged to seek the oral healthcare treatment they need. Long-term exposure to these noises also puts dental professionals themselves at high risk of hearing loss. It is unclear about the psychological influence of the sound of dental equipment on dental anxiety. This paper presents a work conducted by the authors to study the effects of the sound of dental equipment on people's perceptions and dental anxiety levels and suggests a possible solution to address problem.

**19 3948 Cross-country comparison of aircraft noise-induced sleep disturbance**

Sarah Mc Guire • Uwe Müller • Eva-Maria Elmenhorst • Franco Mendolia • Daniel Aeschbach • Mathias Basner

To inform policy exposure-response relationships for aircraft noise-induced sleep disturbance are needed. Due to different nighttime airport operational patterns it is unknown whether data from one airport generalize to other airports. In addition, there may be intercultural differences that affect an individual's sensitivity to awakening. To examine whether there are cross-country differences in aircraft noise-induced awakenings, results from 3 studies that obtained objective sleep and noise measurements were compared. Two of the studies were conducted in Germany and include the STRAIN study conducted near Cologne/Bonn airport (N = 64) and data from three years of the NORAH study conducted near Frankfurt airport (year 1 N = 49; year 2 N = 83; year 3 N = 187). The third study was conducted in the United States near Philadelphia International airport (N = 39). Awakenings were identified based on ECG and actigraphy measurements using an automatic algorithm, enabling consistency in scoring across the three studies. Models relating awakenings to the indoor maximum noise level of single aircraft events were derived. Similarities and differences in the exposure-response functions of the 3 studies are discussed.

**20 3558 FAA studies on the effects of aircraft noise on sleep**

Natalia Sizov

Aircraft noise is disturbing to some people living near airports and can also affect sleep. Past field studies on the effects on aircraft noise on sleep often either lacked sufficient sample size or adequate physiological or behavioral endpoints. In order to inform future policy and procedural considerations, it is important to obtain exposure-response relationships between aircraft noise exposure and objective sleep disturbance data in ecologically valid field conditions. Recent advances in ease of use and miniaturization of physiological measurement technology, along with new data analysis techniques allow for the investigation of large subject samples at a low methodological expense in field settings. The Federal Aviation Administration (FAA) is actively conducting research to advance our knowledge in this area. This paper will discuss objectives, long – term goals and current work.

**24 3559 Higher noise tolerance may be associated with more refreshing sleep**

Daniel Fong • Janet Wong • Huang Lixi

Studies have shown indication of an association between noise tolerance and non-restorative sleep. However, most of them had inadequate sample size and residual confounding which may obscure the association. Therefore, we aimed to assess the association between noise tolerance and non-restorative sleep. We recruited 202 Chinese adolescents and adults from a representative household survey. Their noise tolerance was assessed by an audiometric test and non-restorative sleep was assessed by self-report on a 0 – 10 scale. The mean age was 32 years. After adjusting confounding effects, people who can tolerate one more decibel would be associated with 0.1 unit increase (p = 0.001) in feeling refreshed after sleep. Hence noise tolerance was associated with non-restorative sleep. Clinical consultations may involve the assessment of noise tolerance in people with sleep complaints.

**25 3739 Living environment survey along Hokuriku Shinkansen railway: Social survey conducted one year after opening**

Takashi Morihara • Shigenori Yokoshima • Yasunao Matsumoto

We report the results of a social survey along the Hokuriku Shinkansen (high-speed) railway. This survey was conducted in November 2016, one year after the opening of the Hokuriku Shinkansen Line. Questionnaires were distributed to the inhabitants of 20s and the older living in detached houses along the railway in Ishikawa and Toyama prefectures by mailing method. We selected 1,980 households for survey cooperation and got about 1,000 responses. The main question items were as follows: housing and living environments, transportation facilities (including noise and vibration), lifestyle habits and individual factors. Since noise and vibration exposures for each house have not yet been estimated, we examine the relationship between the distance from the railway to each house and community response to each of noise and vibration. Furthermore, we conducted a social survey with similar questionnaires in 2007, the year before the opening of the Shinkansen Line. We also overview the changes in the evaluation of living environment including noise before and after the opening.

- 26**                    **3876 Community Tolerance Level for transportation noises derived from Socio-Acoustic Survey Data Archive, SASDA**  
 Makoto Morinaga • Shigenori Yokoshima • Takashi Morihara • Keiji Kawai • Takashi Yano  
 Socio-Acoustic Survey Data Archive (SASDA), established in 2011 under the Institute of Noise Control Engineering/ Japan, is a data archive that accumulates social survey data on community responses to transportation noises in Japan. At the present, SASDA possesses more than 20,000 samples from more than 20 surveys conducted in Japan for the noise sources of road traffic, conventional and high-speed railway, civil and military aircraft. Using these data, exposure-response relationships and Community Tolerance Level (CTL), it is shown in the latest version of ISO 1996-1, are calculated for each dataset derived from the SASDA. In the present paper, distributions of CTL in each noise sources are examined and mean CTL values are compared between noise sources. Furthermore, mean CTL values in each noise sources are compared with the results in the previous studies based on social surveys conducted in western countries. It is suggested that the values of CTL derived from the SASDA are smaller than that in the previous studies.
- 27**                    **3874 Annoyance due to railway noise before and after the elevation of the conventional railway**  
 Tsubasa Shimokawatoko • Takashi Yano • Yasuhiro Murakami  
 The Kyushu Shinkansen Line was opened in 2011, the conventional railway line was moved under the Shinkansen Line (the second temporary line) in 2012, and a part of the conventional railway was elevated in 2015. The noise and vibration exposures are usually changed by opening a new line or elevating lines. The purpose of this study is to compare community response to railway noise and vibration between before and after the elevation of the conventional railway. A social survey on noise and vibration from the Shinkansen and the conventional railway was conducted along the railway where the Shinkansen and conventional railway lines ran close and parallel to each other. In this study, the annoyance responses obtained before and after the elevation was compared by applying multiple logistic regression analysis with highly annoyed/annoyed as the response variable and day-evening-night sound level, sex, age, and a dummy variable of before and after as explanatory variables. The results shows that both noise exposure and annoyance decreased significantly after elevation than before, but the exposure-response relationship was significantly higher than before elevation.
- 28**                    **3636 Attitudes towards authorities and aircraft noise annoyance. Sensitivity analyses on the relationship between non-acoustical factors and annoyance**  
 Dirk Schreckenber • Sarah Benz • Julia Kuhlmann • Max Conrady • Ute Felscher-Suhr  
 Numerous studies have shown that non-acoustical factors correlate with noise annoyance. In particular, attitudes towards the source and authorities have been identified as important modifiers of annoyance. Some authors have discussed non-acoustical factors not just in terms of confounding variables need for adjustment in exposure-response models but as variables that might help to relief residents from adverse noise effects. In order to clarify the potential of non-acoustical factors to reduce annoyance sensitivity analyses of attitudinal and annoyance data from the NORAH study were carried out. Considerable differences in exposure-response curves for aircraft noise annoyance were found in dependency of trust in authorities and perceived fairness of decision-making concerning air traffic and noise management and with participation in programs of sound insulation and compensation and satisfaction with sound insulation at home. However, two models of moderated mediation were tested with trust/fairness as modifiers of annoyance and vice versa. None of the models could be ruled out. Intervention studies are needed to get more insight into the causal direction of the relationship between non-acoustical variables and annoyance.
- 29**                    **3608 Community response to environmental noise: A preliminary soundscape assessment of highland environment**  
 Nazli Che Din • Engku Mastura Engku Mohd Anuar • Hazreena Hussein  
 Highland rich in natural resources encourages economic and development growth, hence, altered the sound and landscape of the highland environment. Noise pollution in developing highland area could intrude the ability to comprehend of natural and environmental sounds. In accordance with the previous research conducted on physical noise assessment and psychological assessment of audio and visual lab-test, this paper presented the soundscape assessment of in-situ using questionnaire at selected green area. As preliminary, the main objective of this research is to identify respondents' preferences that characterise the soundscape on highland environment. At the first stage of survey, 53 respondents were participated to evaluate the existing soundscape condition. Next, the existing soundscape environment with additional sound intervention was created to examine the preference and perception of acoustic comfort in selected green area. The questionnaire is based on the people's preference towards the perceived sound and landscape. In general, people preferred nature sound, therefore, the dominance of the perceived nature sound along with the congruence aspects of landscape and context at selected green area influence the preference level.
- 30**                    **2489 Prior and current noise exposure: effects on university students' wellbeing and attainment**  
 Andrew Smith  
 Extensive research shows that noise influences the cognitive performance of school children. This is especially true for aircraft noise exposure. In contrast, effects of noise on childrens' wellbeing appear to be less robust.

There is also extensive research that a child's exposure to negative events can influence their later wellbeing and attainment. The present study is part of a programme of research examining factors which influence university students' wellbeing and attainment. In the present study 200 undergraduate students will complete a survey measuring noise exposure when they were at primary and secondary school and also their current exposure to different types of noise. Wellbeing is being assessed using the student wellbeing process questionnaire. Academic attainment is measured using results from coursework and exams, as well as perceptions of efficiency of working. Preliminary analyses (N = 50) based on the survey responses only show that both current and past exposure to aircraft noise are correlated with reduced performance efficiency. None of the noise measures appeared to be associated with wellbeing and only aircraft noise was associated with reduced performance.

32 **2517 Noise pollution in Dhaka city of Bangladesh**

Mohammed Abul Kalamh

Background: Like many other mega cities of developing countries, noise pollution in Dhaka city of Bangladesh is a big concern. Here noise is produced from different sources like traffic, loud-speaker, people gathering etc. Exposure to high level noise may cause severe stress on the auditory and nervous system of the city dwellers. Methods: This study reports the level of noise pollution in Dhaka city. For this purpose noise levels have been measured at ten major locations of the city from 8 a.m to 10 p.m during the working days. The data have been analyzed to calculate various noise parameters such as Leq, and Lnp. Results: It is observed that at all the locations, the level of noise remains far above the acceptable limit for all the time. Comparison of present results with the existing previous results shows that noise level in the Dhaka city is increasing day by day. Conclusion: The study suggests that urgent measures should be taken into consideration to control the level of noise pollution in the city.

33 **3678 Problems of noise annoyance in the newly built apartment buildings in Slovakia**

Lubica Argalasova • Ladislav Mihalcik • Jan Simonovic • Jana Jurkovičová

The paper presents results of a pilot cross-sectional study on subjective traffic noise annoyance and sleep disturbance among the population groups in selected new apartment houses situated close to major inner city corridors in Slovakian capital Bratislava. The noisy facades of these buildings have noise exposure above the limit during the day and the night (LAeq, day = 72 dB, LAeq, night = 60 dB). Statistical outcomes of the questionnaire survey on the pilot sample of 176 respondents (57 % females, average age 41,7±9,3 years, living in houses in the average for four years), are presented comparing the exposed and control group of inhabitants with bedrooms windows facing noisy streets or quite streets. Road traffic noise annoys significantly more daily and night activities in the exposed group (OR = 2.86, 95 % CI = 1.27 – 6.44 for sleep disturbance), who are unable to adapt to it neither by day nor by night. After completion of the results, we plan to propose interim measures to noisy facades of the apartment buildings as well as intervention procedures in the prevention of adverse effects of traffic noise.

34 **3761 Soundscape pleasantness in urban places: dimensions and relation with health aspects**

Karmele Herranz-Pascual • Igone Garcia • Itziar Aspuru

The overall aim of this paper is to present results in terms of effects on perceived health obtained in a research about soundscape pleasantness. Our main conceptual framework has been the Environmental Experience Model and the ISO of Soundscape. This work has been undertaken as part of the CITI-SENSE project. 55 people were engaged to provide 120 observations in the city of Vitoria-Gasteiz using environmental sensors connected to a smartphone in four public urban places. The soundscape was evaluated using a Semantic Differential scale of five points. Results indicated that the capacity for relaxation and tranquillity of acoustic environment is the most relevant dimension to understand its pleasantness. Other important aspects are the ability of sound environment to be fun and informative, as well as the natural content of the sounds. Soundscape pleasantness is related to positive emotional states (happiness) and inversely with negative emotional states (sadness and anger) and sleep problems. The limitations of the findings are also discussed, as are suggestions for further research.

35 **3699 Association between different indices of greenspace »exposure« and noise annoyance in youth**

Angel Dzhambov • Donka Dimitrova • Iana Markevych • Boris Tilov

This study aimed to explore the association between greenspace »exposure« and road traffic noise annoyance. We sampled 652 participants (15–25 years of age) at two randomly selected high schools and three universities in the city of Plovdiv, Bulgaria. Data on sociodemographic factors, road traffic noise annoyance (0–10 scale), noise sensitivity, orientation of rooms, and indices of access, availability, usage, and quality of neighborhood greenspace were obtained by a self-administered questionnaire. In addition, 399 participants reported their address, allowing the calculation of Lden and several vegetation indices (e.g., NDVI, tree canopy density, %UGS) within several buffers around the address. Mixed linear models showed lower noise annoyance among participants living in greener environment, having better access to greenspace, and having available greenspace of higher quality. Objectively-measured vegetation did not have substantive effect on noise annoyance. In conclusion, perceived »exposure« to neighborhood greenspace is beneficial for road traffic noise perception among Bulgarian youth, but the lack of a dose-response relationship with remotely-sensed/land use vegetation indices might be a hindrance for evidence-based urban planning.



- 36**                    **3922 A Case Study on Perception of Noise Policy and Relation to Noise Complaints**  
 Nilgün Akbulut Çoban • Mustafa Çoban  
 With increase of population and rapid urbanization, environmental noise and its impacts on health have also been increasing. In this study, the focus is mainly on community response to noise and perception of environmental noise policy by owner of workplaces as a case study in Antalya City of Turkey. In the scope of this study, the public noise complaints appealed to local authority up to 2017 has been evaluated. According to the preliminary analysis of data, it has been increasing as 34% in three years although intensive audits by local authority. Moreover, the most annoying noise source was determined as entertainment places. Due to this fact, how environmental noise regulation and its applications are perceived by owner of entertainment places has been trying to understand through the questionnaires. The statistical analysis has been just completed. With this study, the suggestions for solutions to entertainment noise pollution which is determined as the most annoying noise source in Antalya have been designed under the light of questionnaire results and this is aimed to be taken into account by local authorities in future noise policy applications.
- 39**                    **3799 How to establish a better information disclosure system on noise and environment – Concept proposals of information disclosure and a noise experience tool –**  
 Mari Ueda • Takashi Nishikubo • Takahiro Miura • Takashi Morihara • Yoshio Tsuchida • Masaaki Hiroe • Yasuhiro Hiraguri  
 This paper discusses information disclosure on airport noise and environment at airports in Japan by considering the way to develop a road map to a more successful system. We investigated the situation of information disclosure on airport noise at a few airports in Japan from several different viewpoints as follows: 1) Aim and process to introduce the system of information disclosure, contents and the way of opening to the public, 2) Accessibility, familiarity, 3) Guidelines like existing regulation agreements with residents.
- 40**                    **3654 An Affordable Recording Instrument for the Acoustical Characterisation of Human Environments**  
 Huub Bakker • Bruce Rapley • Rachel Summers • Mariana Alves-Pereira • Philip Dickinson  
 Characterising acoustical environments where humans may be sleeping requires hi-fidelity recordings of the entire soundscape, which allows relevant post-processing of the data. The ongoing Citizen Science Initiative for the Acoustical Characterisation of Human Environments (CSI-ACHE) is dedicated to capturing quality recordings of such human acoustical environments. This paper introduces the recording system created to capture such soundscapes. It provides the specifications for the device, as well as the implementation and the tests used to characterise the performance and calibrate against a Class 1 instrument. This system has been marketed as SAM Scribe and fundamentally consists of a two-channel device that can measure at sampling rates up to 44.1 kHz, and that delivers the data streams via USB to a Windows notebook computer to store as uncompressed wav files to hard disk. GPS information is stored as metadata in the files, which also include a digital signature. Storage of several months of continuous recordings can be achieved using an external USB 3.0 hard drive. The system can accurately record from 0.1 Hz to 20 kHz and is simple to operate.
- 42**                    **2382 The different evaluation-methods of the wind farm noise in Switzerland – Computer models/ IN-SITU measurements**  
 Victor Desarnaulds • Dimitri Magnin  
 The different evaluation-methods of the wind farm noise in Switzerland – computer models (project of new wind farms) or in-situ measurements (as for existing wind farms) are often discussed by the concerned authorities and organizations (federal and cantonal public authorities, Suisse Eole...). For modeling the FOEN (Federal Office for the Environment) recommends the method based on the EMPA report »Lärermittlung und Massnahmen zur Emissionsbegrenzung bei Windkraftanlagen« (2010). There is no official measuring method in Switzerland for the evaluation of the wind farms noise. In order to improve the evaluation of the wind farm noise, this research project aims to compare the current Swiss calculation method with the results of in-situ measurements of a wind park. The comparison between the results of the measurement and the modeling shows that the average global sound level (annual averaged LAeq by day) obtained from the measurements is 6 to 8 dB(A) higher than the values obtained by the modeling. If one takes into account the index L90, the difference is between 4 and 6 dB(A).
- 45**                    **3722 Exploring perception of vibrations from rail: an interview study**  
 Laura Maclachlan • Eja Pedersen • Kerstin Persson-Waye  
 The European Commission's 2011 Transport White Paper indicates that railway forms a core component of the move to achieving more sustainable modes of transport. Transportation of freight and high-speed passenger trains is expected to increase by approximately 22% between 2011 and 2020. This shift to rail will reduce greenhouse gas emissions, which contribute towards global warming, and is therefore an environmentally responsible approach. There are, however, valid concerns regarding the consequences for the health of populations living in close proximity of railways. There is good understanding of annoyance and disturbance to rail noise, however, very little is known about the way in which people report, describe and perceive vibrations. This project is a qualitative research study based on a Grounded Theory approach. Its aim is to interview 12–14 individuals and examine the way which vibrations and noise are perceived by residents living in close proximity to railways in Sweden. The results of the study will be reported at the conference.

- 46**                    **3797 Laboratory measurement of vibration and secondary noise transmission loss for rubber elastomer mats**  
 Hui Li • Xiang Yan • Jianguhua Wang  
 Beijing Subway Line 6 West Extension and Beijing Shijingshan District Performance Center are both under construction. Line 6 will go through beneath the performance center. In order to lower the impact from the train to the performance center, it has been decided that the subway will conduct steel spring floating slab as its vibration control method, and the performance center will add a layer of rubber elastomer mats under the raft foundation of the building. For the purpose of predicting the vibration and secondary noise transmission loss of the rubber elastomer mats, Acoustic lab of Tsinghua University conducted a measurement according to the real load of this project with the standard tapping machine as the sound and vibration source on a vibration isolation platform. By comparing the environmental vibration deviation on the platform with and without the rubber elastomer mats, the vibration and secondary noise transmission loss for each octave band can be easily calculated.
- 47**                    **3601 Experiences of a Polyurethane-Manufacturer with the Elastic Decoupling of Machines**  
 Thomas Schönherr  
 Getzner Werkstoffe as a manufacturer of polyurethane-material is involved in a broad variety of projects for elastic decoupling of machines. Aim of the presentation is to give a real-life overview to the material itself, to the constructional execution of the decoupling and to the success of the reduction measure. In a first thematic block the distinctive features of polyurethane-material for elastic decoupling will be discussed. Non-linear behavior will be explained as well as recommendations for handling and processability. Procedures for dimensioning and calculation of elastic bearings will be illustrated as well as different ways of constructional execution. As a conclusion the challenges and implemented solutions of realized projects will be elaborated. For this purpose projects with discrete bearings (point bearings) and full-surface-bearings (machine-foundations) will be presented.
- 48**                    **3631 An investigation on the interaction analysis of beam – active isolator with low suspension frequency**  
 Khairiah Turahim • Kamal Djidjeli • Jing Tang Xing  
 The application of vibration isolation with a particular low or high supporting stiffness is widely being used in the field of science and engineering. These particular supporting stiffness can be provided by using active vibration isolation. The supported structure is connected to the active isolation unit, therefore creating an interaction between the structure vibration behaviour and the isolation unit dynamic characteristics. This work investigates the interaction between a structure and an active isolator for a low stiffness support to design an accurate practical isolation system. It is found that the structure provides additional mass, stiffness and force to the active isolator. This shows that the interaction give some effects on the active isolator and this must be considered when designing a practical isolation unit.
- 49**                    **2411 Reducing playground injuries by increasing HIC sampling rate from 8 kHz to 20 kHz**  
 David Eager • Chris Chapman • Emily White  
 Impact attenuating surface (IAS) materials are used in children's playgrounds to limit the potential impact hazard presented to a child when falling from playground equipment; the largest hazard being head impact injuries. The head injury criterion (HIC) is used to measure the IAS around the world. Australia adopted a sampling rate of 8 kHz for playground IAS testing in 1996 from automotive industry testing for measurement of the HIC. Data acquisition has improved since 1996 and it is important that the performance of the IAS is measured accurately. An investigation into the effects of sampling rate on the HIC value was undertaken. A variety of IAS samples were impact tested at sampling rates ranging from 8 kHz to 80 kHz using a calibrated hemispherical headform fitted with a tri-axial accelerometer. The results of this testing will be presented. The testing confirmed that a sampling rate of 8 kHz under reported the HIC particularly at the critical fall height of IAS. Australia adopted a sampling rate of 20 kHz on the 23 November 2016 when they published AS 4422:2016.
- 50**                    **2410 Double bounce vibration on trampolines and associated injuries**  
 David Eager • Chris Chapman • Alan Matotek  
 By observing usage and reviewing accident data it is clear that multiple-user trampoline double-bouncing creates highly dangerous situations. An understanding of this phenomenon's characteristics has not been fully researched. Observation indicate that under certain circumstances there is the potential for a high transfer of energy from one user to another, leading to surprisingly higher launch heights, which result in landing and compression injuries. Medicine balls of various weights, heights and impact location were released from above a trampoline mat to simulate user impact. The quick release mechanisms were controlled by electronic triggers to eliminate any undesired variances in impact timing between tests, allowing for reliable, repeatable testing. A calibrated video analysis is the primary means of data collection. Due to the unpredictable nature of double-bouncing, users are often unable to anticipate the occurrence of a double-bounce, meaning they are physically unprepared or braced for the immense acceleration forces generated by the transfer of energy. This paper presents the experimental findings of trampoline double-bouncing and quantifies the conditions which allow the high energy-transfer rates that lead to multi-user injuries.

All congress attendees who want to be involved in one or several ICBEN topical »teams« are invited to attend one or more Subject area meetings (»Team meetings«). These in total 8 group meetings take place on Monday and Tuesday after the regular congress program is finished and are open to everyone interested in the respective subject area or team. Any member of a team becomes a member of ICBEN itself. The primary purpose of the subject area/team meetings is to elect the team chair and co-chair, who should take care for a vivid communication among the members of the team and are expected to helping design the program of the next congress. The team chairs and co-chairs will also be part of the ICBEN Executive Committee for the next 3-year term.

### **THE TEAM MEETINGS ON MONDAY, 18:00–18:30**

Subject area 1	Noise-induced hearing loss (Room C6)
Subject area 2	Noise and communication (Room C44)
Subject area 5	Effects of noise on sleep (Room C60)
Subject areas 8 & 9	Noise exposure assessment in health effect studies Special topics related to noise effects (Room D1)

### **THE TEAM MEETINGS ON WEDNESDAY, 17:45–18:15**

Subject area 3	Non-auditory health effects of noise (Room C60)
Subject area 4	Effects of noise on cognition, performance and behaviour (Room C44)
Subject area 6	Community response to noise and noise annoyance (Room C6)
Subject area 7	Noise policy and economics (Room D1)

### **BUSINESS MEETING ON WEDNESDAY, 18:15–19:30 (ROOM D1)**

All ICBEN officers and executive committee members of ICBEN gather at the ICBEN business meeting. Its purpose is announcing the appointment of new officers, nominating team chairpersons, and for any other business that might arise, like planning future congresses or changing the team structure of ICBEN et cetera.

Please note that the business meeting is on invitation only.

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### ADDRESS OF THE CONGRESS VENUE:

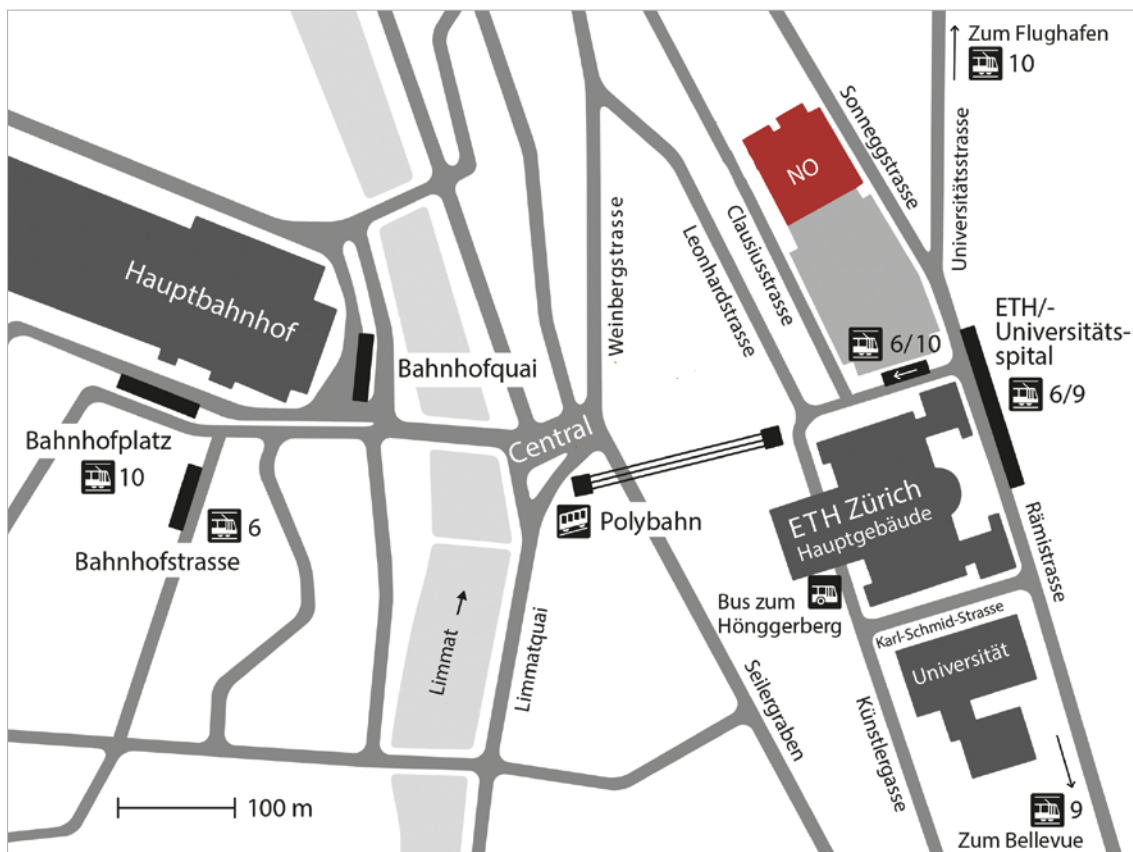
ETH Zürich, NO-Gebäude • Clausiusstrasse 26 • CH-8006 Zürich

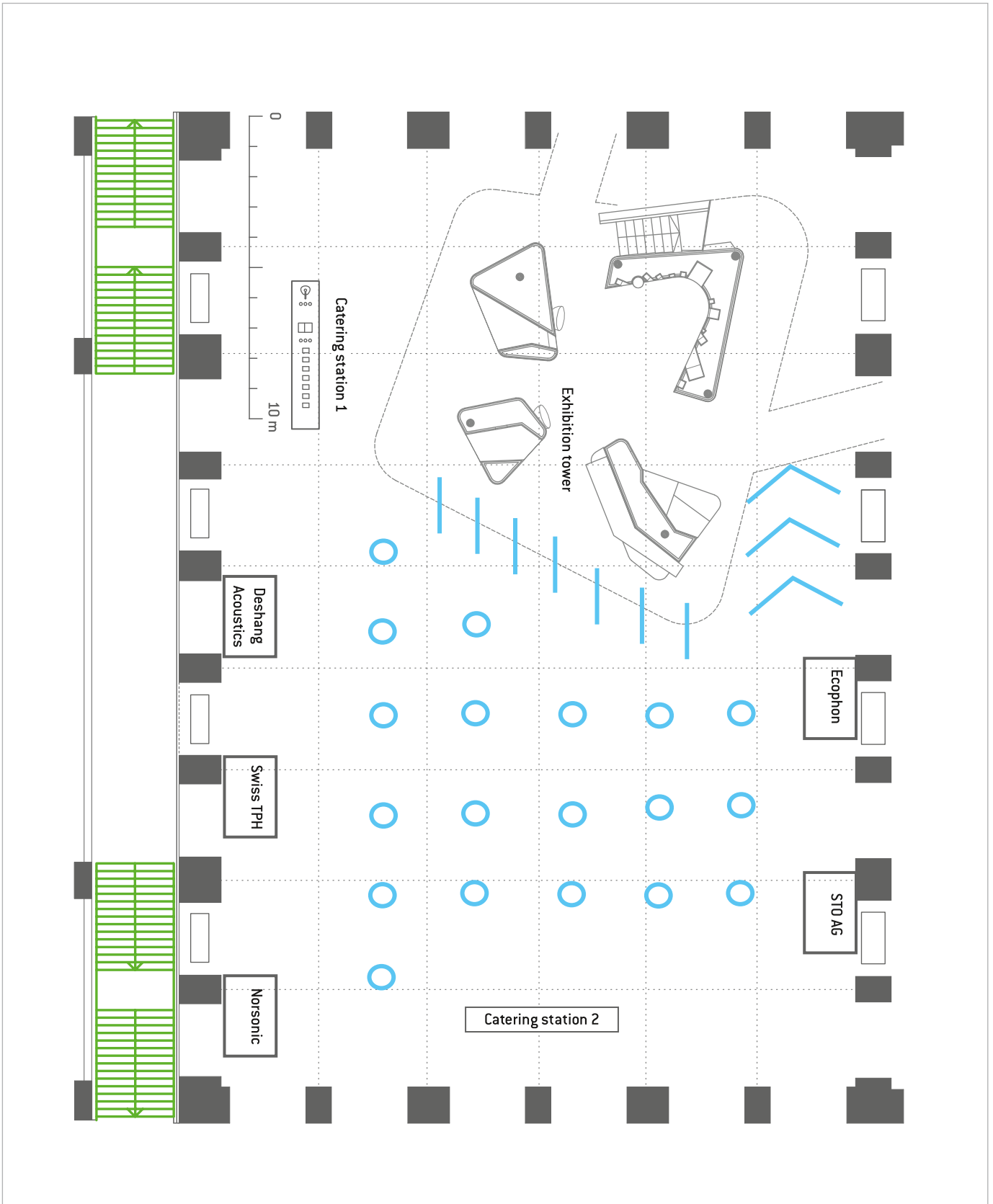
### Getting to the main railway station (Zürich HB) and congress venue from Zürich Airport

- By train: In the arrival hall, follow the signs to the airport underground railway station and take the next train to or stopping at »Zürich HB«, get off at the main station. Trains depart about every 5–10 minutes. The train ride to the main station is about 10 minutes.
- By tram: In the arrival hall, follow the signs to the airport tram station just outside of the airport center building. Take tram Number 10 in direction »Zürich, Bahnhofplatz/ HB«, get off at the »ETH/Universitätsspital« stop after about 30 minutes of tram ride. The congress entrance is on Clausiusstrasse 26, 100 m from the tram stop. The train ride is quicker, but you will have to take a short walk to the congress site from the main station or change to a tram. The airport Tram 10 is slower (22 stops), but gets you directly to the congress site.

### Getting to the congress venue from the main railway station (Zürich HB)

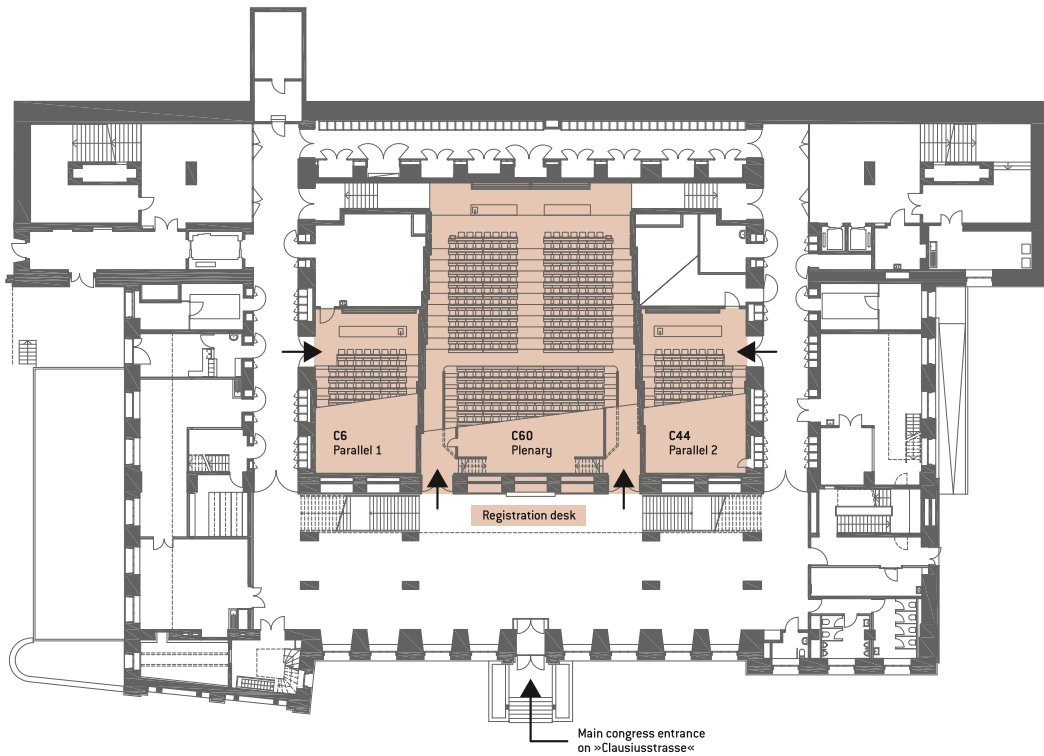
- From the main station, the congress venue can be reached by foot in 10–15 minutes. At the main station, follow the signs towards »Bahnhofquai/Central« exits. Pass the bridge over the Limmat river to get to the »Central« square and walk up to the congress venue on the small alley »Auf der Mauer« or
- On »Central« square, jump on the small funicular (the Polybahn) which will bring you up to the ETH Main building in the midst of the campus area in 1 minute.
- or
- From the main station, take tram Number 6 (Direction »Zoo«) or Number 10 (Direction »Zürich Flughafen«) and get off at the third stop »ETH/Universitätsspital«.





# Floor plans

Floor plan Level C:



Floor plan Level D:

