

SENSESCAPES FASCILITATING LIFE QUALITY

Frans Mossberg Ph.D. Chief executive director
The Sound Environment Center at Lund University, Sweden.
email: frans.mossberg@kultur.lu.se

What can be done to raise awareness of the significance of sense- and soundscape for health, wellbeing and communication? A massive body of research is being conducted in the sound environment field today with important discoveries especially on relationship between noise and health. Outcomes of this research slowly pours up into society, raising warnings of health and environmental risks, not seldom threatening heavy economic interests and deeply rooted conventions. Some are aimed at raising the consciousness of the effects of sound on health and wellbeing and some exploring new horizons in terms of technological inventions and economical possibilities.

The Sound Environment Center at Lund University has for over ten years hosted interdisciplinary research promoting exchange of ideas through projects, symposiums and publications, aiming for holistic views of a fragmented field. Ranging from acoustics, noise abatement and soundscape understanding, to epidemiological mapping of health, biological effects, hearing and voice disorders, music and cognition, many facets of sound are covered. The center connects to national and international research networks and partners and has access to high tech labs at Lund university making use of eye-tracking technology, articulograph, VR-lab and recording facilities. Current projects focuses on health and cardiovascular issues, noise, acoustics, voice production, speech intelligibility, as well as eyetracking studies of cognitive aspects of sound exposure. Results offers information to stakeholders and community in favour of development of a quiter future. Major issues are adressed at interdisciplinary symposiums like "Health & Noise", "Sound, safety & Society" etc. The preliminary response to the centre has been positive leading to deepened network collaborations and continuously evolving new research projects.

Keywords: Soundscape, Interdisciplinary Research, Noise, Health, Psychoacoustics.

1. Introduction

This article will give a presentation of the developments of the interdisciplinary research centre, the Sound Environment Center at Lund university in Sweden from the point of view of fascilitating sensescales for life quality. Some departures in time and theory gives a background in which ideas behind the creation and the scope of the centre are developed. The article will touch upon complexities in the perception of noise and sound and how to build an interdisciplinary research construct within the framework of a large university. It will touch upon problems, but also the usefulness of connecting environmental disciplines, acoustics, audiology and artistic and cultural creative perspectives. The center at Lund University is coordinating interdisciplinary research on sound environments, promoting exchanges of ideas between researchers of different affinities through research projects, interdisciplinary symposia and publications. It aims at developing a holistic view of a field that is scientifically fragmented and scattered. Ranging from acoustics, noise abatement and soundscape understanding to issues of epidemiological health to studies of noise effects on hearing impairment

and cognition, the centre covers and tries to harmonize the many facets of sound and noise. Experience underlines the importance of a formal framework to both keep focus on the sound environment and run practical day-to-day administrative work and think tank activities.

1.1. Background

Since the infusion of the soundscape concept into acoustics, interdisciplinarity has grown to be an integrated feature of this field. General acoustics is more often than not relating to, and collaborating with other disciplines, and has done so for a long time, like environmental medicine, audiology, social sciences, musicology, construction science, design and many others. Still a holistic concept that includes the width of sound environment research in itself is difficult to find, a concept that could in terms of research offer a framework to encapsule the complexities hidden within the many issues of noise and sound and its effects on humans. In later years "Soundscape" has grown to take that place in practical use. Sound is however always part of a larger context and often it can be argued for to talk about "Sensescape" in which sound is only one part. Sonic sensations can be an immense sources of enjoyment, but today the research community have become aware of noise causing negative effects of stress and annoyance. Many times noise is causing conflicts between public health and economical interests as restrictions on noise puts restraint on economical interests such as building industry and various other agents. Therefore it is important that research on health issues can operate without direct or indirect bonds to any such interests.

In an article in Noise & Health 2011, prof. Gösta Bluhm gave an overview over Swedish research on cardiovascular effects of environmental noise that supported links between residential exposure of noise from roads as well as from aircraft traffic and hypertension, as well as increased risks of acute myocardial infarction [1]. Links also discovered, notably by researchers like Wolfgang Babisch who has published important overviews of the field [2] and was the first to really put cardiovascular health risks on the noise agenda. The Danish researcher Mette Sørensen found lately that noise have negative implications on health also in other diseases such as diabetes, stroke & cancer [3]. The common factor behind these links between noise exposure and fatal health consequences can be found in the fact that in noise exposure acts as a stressor adding to other stressors in people's life [4] [5]. Although the connections long has been controversial they are today more or less well established worldwide and this thread has been taken up in Lund in epidemiological research conducted by Maria Albin and colleagues, recently by Theo Bodin, who's dissertation 2014 focussed on cardiovascular health and traffic noise [6] His scrutinizing and further investigating those links reveals a complex picture all factors are considered.

In later years the soundscape approach has been said to have shifted the focus of environmental acoustics to a more human-focused paradigm, and this is manifested in the COST-Soundscape project (Cost td804) [7]. A shift that is positive, but problematic, because, although people have a similar perception of sound and noise, there are also apparent differences between individuals, as the human psyche is of an momentary changing character, as sensitive to cultural inheritances as to current emotional moods. It is stated in the memorandum of understanding of the COST Soundscape project [7] that environmental sound should not be treated as a waste. This opens up for a holistic perspective of a sensescape where sound is only one of many sensations, a resource for enjoyment of life quality.

The Sound Environment center wants to connect to this *rethinking* of the sound environment, support an awareness of its possibilities and dangers, and its influences on our emotional and physical status. A word may be said of *spatiality* (also discussed by Jacob Kreutzfeldt [8] in his dissertation "Acoustic Territoriality"). Sound and noise are distributed spatially, temporarily and dynamically and affect spatial orientation in a complex collaboration with other sensory inputs. This spatiality of soundscape is also noted by Dick Bottledoren when he investigates the soundscape concept in the COST Soundscape Report, where he writes: "...it always entails a sense of spaciousness. Environmental sounds intruding in private spaces result in effects following different mechanisms with control as an important factor [7]. Tjeerd C. Andringa takes psychoacoustic aspect of control likewise into account when he writes "Sound annoyed individuals are actually quite explicit about this relation by literally reporting that annoying sounds *force* them out of tranquil mind-states" [9]. Obviously the rethinking of soundscape has a lot to do with control over our environments.

1.2 Double development of Soundscape

In later years soundscape has showed a twofold 'double' development. On one hand transport noise is continuously escalating due to growing volumes of traffic. Construction noise and the continuous media flow adding to this. On the other hand many mechanical noise sources are being substituted by quieter ones and electronics, and a general awareness is growing of sound as an indicator of product quality. A quality car is less noisy than a cheap one. The same goes for washing up machines and similar. Consumers tend to get used to quieter appliances, and don't have the same acceptance of noise as the price for functionality, as thirty years ago. Many have realized that if we want quiet we have to pay for it. And we *are* willing to pay for sound comfort, and subsequently also can demand to get what we pay for. The awareness of sound is slowly creeping into the public consciousness. Sound comfort is used to heighten the attractiveness of a product. as in the case of household appliances like the Electrolux vacuum cleaners or car manufacturers like Toyota, both making use of the sound comfort to give their products a special and noticeable "identity" in their respective markets. "Buy Quiet" has become a concept used by consumers and producers alike.

There has been a number of models or 'tools' presented during the years with the aim to understand soundscape deeper, compiling typologies and mapping sounds according to various principles. Most models are more or less referring to traces of the original writings of R. Murray Schafer from the seventies in his *The Tuning of the World* [10] and concepts of keynote sounds, sound marks and sound signals [11], [12]. To a certain extent these concepts underlies tools like the 'Tranquility Rating Prediction Tool' by Greg Watts, a concept where natural features in a landscape is balanced by man-made noise resulting in an equation for prediction of tranquility. Some related models shows similarities that can be recognizable in a number of ways, as the classic cognitive model from Kuppens 2012, used and adopted by Andringa [9], also by Axelsson [13] and others. The cognitive model illustrates the human psychological perception of soundscape and operates on axes of opposites like eventful/non eventful and pleasant/unpleasant in various degrees of refinement regarding sound environmental issues and covers the interplay between dichotomies.

Theories and models aside, important as they are for the development of strategies, at the bottom line, the huge subject is how to practically deal with noise and health. Noise is becoming a high pri-

ority internationally, as a steep escalation in noise exposure has been forecast for the EU and the rest of the world in the next few decades by the World Health Organisation (WHO).

2. Activities & Research

As a response to the complexity of sound environment issues, Lund University in Sweden inaugurated an interdisciplinary academic centre for research, the Sound Environment Center in 2005. The basic functions of the centre have been financed year-to-year by the University, whereas major research projects have received funding from external foundations and donors. The centre has an interdisciplinary board, appointed by the faculty of humanities

2.1 Research symposia

The center arranges of interdisciplinary symposia, providing platforms for the exchange of information and interdisciplinary contacts within the University, as well as with the surrounding research environments and the public. The symposia engages the sound environment research community at national and Inter-Nordic levels. As these activities are widening, so are contacts with the international research community. Many well known lecturers have participated in the symposia arranged by the center over the years, notably Wolfgang Babisch, Jens Holger Rindel, Kerstin Persson Waye, Greg Watts, Tor Kihlman, Mette Sørensen, Staffan Hygge, Bridget Shield, Iren van Kamp and many more.

The symposia covers current sound environment specific topics with themes such as *Sound & Health*, *Hearing Impairment*, *Sound Design*, *Seductive Sounds*, *Sound, Silence & Recreation*, *Sound, Mind & Emotion*, *Sounds in History*, and *Wind Power Noise*. Many resulting in printed publications. At present, a growing number are available in English: “Man, Mind & Emotion” [14], “Sounds of History” [15], “Speakers’ Comfort” (Brunskog et al., 2011) [16] and the report from the “Care for Sound” symposium on health care [17] arranged together with Ecophon, Sweden.

As a reaction to the recent revision of Swedish Noise Regulations regarding traffic noise and housing, the centre arranged a major symposium in the fall of 2015 *Bo i Ro (Living in Peace)* in Stockholm, together with The department of Environmental Medicine in Lund, where many of Sweden’s most important researchers in the noise field contributed with presentations and papers on the health consequences of raised levels of traffic noise at peoples homes. A printed report with contributions by Barbro Westerholm, Kerstin Persson Waye, Dag Glebe, Mette Sørensen, Erik Skärbäck and others has recently been published [18]. A subsequent follow up to *Bo i Ro* is being planned to be held i Stockholm in collaboration with KI, when the new WHO report on noise has been published later this year.

2.2 Reports, Newsletters & Project Calls

The printed reports and downloadable pdf’s are contributions to the cross disciplinary research community together with the website www.ljudcentrum.lu.se and the quarterly newsletter with information and a Facebook site. The center has also been able to offer project calls for seed money to stimulate and fascilitate larger applications to established funders.

3. Projects & Research Environments

3.1 Overview of Research Environments connected to the Center

At SLU Alnarp (Swedish Agricultural University) a multitude of research involving sound environment assessment has been conducted during recent years (Skärbäck, Grahn, Palsdottir, Van der Bosch (Annerstedt), Cerwén) including noise and soundscape mapping, restorative environments and artistic sound installations. At The Medical faculty in Lund and the division of Environmental medicine large scale epidemiological research have investigated cardiovascular health and traffic noise exposure (Albin, Björk, Bodin). At The Department for Audiology, Speech Pathology and Phoniatry in Lund a high level of research activity is exploring relationships between the human voice, environmental noise, health and cognition, touching upon relations between indoor acoustics and learning environments. Here we also find research interest in the human voice of choir singing (Lyberg Åhlander, Brännström). Technical Acoustics is a core discipline of soundscape research and of the center as well. Through ass.prof. Jonas Brunskog collaborations with the Danish Technical University DTU, has been possible resulting in large scale fully financed research projects such as "Speakers comfort" and cognitive "Healing processes and voice damages investigated through high speed filming" (Both together with Viveka Lyberg Åhlander. At The department of Technical Acoustics at LTH in Lund, measurements of noise and vibrations in built lightweight constructions are important fields of research. The department is also involved in other interdisciplinary work within the framework of the center such as proposals for acoustic measurements of learning environments at campus and also virtual reality projects together with the humanistic laboratory, as in a recent multisensory historic VR-reconstruction of cloister environments (Bard, Shleif et.al.). At The Department of Cultural studies a number of projects have been carried out, investigating cognitive aspects, making use of eye tracking technology and Galvanic Skin Respons measurements at the high tech humanistic laboratory in Lund. A research group has been formed at the same department at the ethnology section researching psychological and emotional consequences of outsidership of hearing impaired young people resulting in a published report 2016 [19].

3.2 Major Interdisciplinary Projects

3.2.1 *Speakers Comfort, Acoustics and Voice Health*

The "Speakers' Comfort" project (funded by AFA) was led by Associate Professor Jonas Brunskog of the Technical University of Denmark, DTU. It deals with teachers' voices in different acoustic conditions with regard to health aspects and room acoustics [16]. The project has produced two dissertations: one in logopedics at Lund University, [20] "Voice use in teaching environments, Speakers' comfort" by Viveka Lyberg Åhlander, (2011), and one by David Pelegrín García, "The role of classroom acoustics on vocal intensity regulation and speakers' comfort" (2011) [21].

3.2.2 *Damage and healing processes for voice health; High Speed Camera and biomechanic models*

The aim of this second project lead by Jonas Brunskog in collaboration with the department of audiology and logopedy is to generate objective clinical methods to analyze high speed movies of vocal

vibrations in order to distinguish subjects with normal voice health from those with functional voice problems. This is achieved by means of biomechanical models of vocal vibrations, including models of degradation and recovery of tissues, together with voice studies in the field. These results provide a much firmer foundation for finding, diagnosing and helping individuals in voice-loaded occupations, such as teachers.

3.2.3 Health Hazards of Noise Exposure: Cardiovascular Disease

Interdisciplinary studies conducted by Theo Bodin [5], [6], under supervision of Professor Maria Albin, confirm that the evidence is growing. A survey published in 2009 combined Swedish epidemiological GIS data on people dwellings, self-reported prevalence of hypertension and traffic noise exposure. The study, covering a large group of over 24,000 inhabitants, showed significant effects in many age groups. Most conspicuously, those aged 40–59 exposed to 60–64dB had about a 27% higher risk compared to the control groups (Odds Ratio 1.27) with the risk rising rapidly at higher noise levels > 64 dB (Odds Ratio 1.91) [22].

3.2.4 Particles and Noise – Combination Effects of Noise and Airborne Particles

A joint project between environmental medicine, acoustics and aerosol technology that is investigating combined noise and particle exposure in chamber experiments. Epidemiological studies have shown that noise and diesel exhaust are important environmental risk factors for cardiovascular disease and premature death. The main goal of the study is to determine effects on the cardiovascular system from simultaneous exposure. [23].

3.3 Pilot Projects

“Urban Green Environments and Wellbeing” Project, executed at the Swedish Agricultural University, SLU, that compared GIS data on sound exposure with a survey of how people relate their wellbeing to a number of green environmental qualities [24]. Complementary cross-sectional studies showed physical activity, general health and neighborhood satisfaction were associated with a presence of the three perceived green qualities: 1) historical sites (Culture), 2) silence, enabling sounds of nature to be heard (Serene) and 3) richness in animal and plant species (Lush) [25], [24].

“Stress Recovery in Multi Sensory Perception of VR Environment” Project hosted in Lund by SLU researcher Matilda Annerstedt together with staff from the humanistic laboratory and a fully sized Virtual Reality environment that investigated the impact of different soundscapes on stress recovery, making use of laboratory experiments in digitally mastered, VR simulated environments [26].

“Cognitive Effects in Children’s Comprehension Caused by Teachers’ Dysphonic Voices and Acoustics” In collaboration with audiology and phoniatrics, Jonas Brännström, Viveka Lyberg_Åhlander together with colleagues study how the comprehension of school children is affected by the mix of noise, acoustic conditions and the quality of the teachers voice. [27].

“Social and Cultural Aspects of Hearing Impairment. Identity and Sound Environments of Leisure” Researchers from ethnology and cultural sciences, explore “sound environments of leisure” from the perspective of hearing-impaired adolescents and the cultural implications in terms of social initiation or exclusion [19].

"Effects of Sound and Noise as Observed in Eye Movement and Cognitive Measures" Project conducted in the state-of-the-art Humanities lab at Lund University, using eye-tracking equipment, galvanic skin response measurement and other advanced technologies. A joint project involving cognitive science, audiology, musicology, linguistics and acoustics. Data from eye-tracking and GSR was collected and stress and cognition measures analyzed [28].

"Evaluation of the reception of "Silent Area" in Swedish Communities" Investigation of the reception of soundscape policies in local communities, involving a survey gathering information on how the soundscape concept has been received by different stakeholders.

4. Discussion

The *Sensescape* affects us in the form of simultaneous effects at sensorial, biological/physiological, psychological and cultural levels. This calls for coordination of research efforts to develop and deepen our understanding. The Sound Environment plays a big role in the sensescape, a role that the Center tries to highlight and promote with the aim the develop scientific foundations for a better quality of life, through maintaining a broad perspective with open channels between different disciplines and schools of thought.

This interdisciplinary approach has been shown to provide a fruitful scientific platform to synchronise soundscape studies. Interdisciplinary soundscape study can also act as a prism reflecting awareness and knowledge in many directions. An academic framework offers opportunities for designing applications for funding of joint research projects. Through "seed money" the center is capable of economic support to promote arranging of seminars, something that our case has proved successful and has resulted in a number of arrangements and project applications.

The response to the work of the centre so far has been overwhelmingly positive to this day. It was awarded the Swedish Acoustic Society's Major Sound Prize in 2008 for "the innovative mobilization of power the centre constitutes with an aim to coordinate and initiate interdisciplinary sound environmental projects with the human being in focus". The preliminary outcome of the interdisciplinary design provides a creative research environment that is both positive and fruitful, leading to continuously deepened network collaborations and new research projects.

REFERENCES

- 1 Bluhm, G. and Eriksson, C. "Cardiovascular effects of environmental noise: Research in Sweden," *Noise Health*, vol. 13, no. 52, p. 212, 2011.
- 2 Babisch, W. E. A. "Exposure modifiers of the relationships between road traffic noise and aircraft noise with high blood pressure (HYENA study)," presented at the Internoise 2012, 2012. pp. 1–10.
- 3 Sörensen, M. "Road traffic noise and risk for stroke and myocardial infarction," presented at the Internoise 2012, 2012, pp. 1–8.
- 4 Albin, M. Skärbäck, E. Ardo, J. Björk, J. and Kihlman, T. "Buller och Hälsa," Ljudmiljöcentrum vid Lunds universitet, 2006.
- 5 Bodin, T. et al., "Annoyance, Sleep and Concentration Problems due to Combined Traffic Noise and the Benefit of Quiet Side," *IJERPH*, vol. 12, no. 2, pp. 1612–1628, Feb. 2015.
- 6 Bodin, T. "Road Traffic Noise", Faculty of medicine dissertation series 2014:75, 2014.
- 7 Kang, J. Chourmouziadou, K. Sakantamis, K. Wang, B. and Hao, Y. Cost_td804_ebook_2013a Soundscapes of European cities and landscapes," COST office, Jan. 2013.
- 8 Kreutzfeldt, J. *Akustisk territorialitet*. Diss., Copenhagen university, 2009.

- 9 Andringa, T. C. and Lanser, J. "How Pleasant Sounds Promote and Annoying Sounds Impede Health: A Cognitive Approach," ... *of environmental research and public health*, 2013.
- 10 Schafer, R. M. *The Tuning of the World*. Alfred A. Knopf, 1977.
- 11 Hedfors, P. *Site Soundscapes*. 2003.
- 12 Grahn, P. and Stigsdotter, U. K. "The relation between perceived sensory dimensions of urban green space and stress," *Landscape and Urban Planning*, vol. 94, no. 3, pp. 264–275, Mar. 2010.
- 13 Axelsson, Ö. Nilsson, M. E. and Berglund, B. "The Swedish soundscape-quality protocol," *Journal of the Acoustical Society of America*, vol. 131, no. 4, pp. 3476–3476, Mar. 2012.
- 14 Juslin, P. Rosenhall, U. Nielzén, S. et al, "Sound, Mind & Emotion," Lund, 8, May 2009.
- 15 Lund, C. S. Rindel, J. H. Hagström, C. and Brunskog, J. "Sounds of History," 6, May 2008.
- 16 Brunskog, J. Rydell, R. Åhlander, V. L. García, D. P. and Lövgren, A. "Speakers Comfort" Sound Environment Center at Lund university, Sweden, Lund, Sweden, May 2011.
- 17 Grahn, P. Berg van der, J. Persson Waye, K. Theorell, T. Thoorgaard, P. and Quinn, M. "Care for Sound," Sound Environment Center at Lund University, Sweden, Lund, 12, Apr. 2014.
- 18 Albin, M. Persson Waye, K. Glebe, D. Lindqvist, M. Skärbäck, E. Sörensen, M. and Westerholm, B. "Bo i ro", Rapport nr 15, Ljudmiljöcentrum vid Lunds universitet, Apr. 2016.
- 19 Alftberg, Å. Apelmo, E. Hansson, K. Malmö University. Faculty of Health & Society, *Ljud tar plats : funktionshinderperspektiv på ljudmiljöer*. Dep. of Arts and Cultural Sciences, Lund University, 2016.
- 20 Lyberg Åhlander, V. "Voice use in teaching environments: Speakers' comfort," *Lund University, Faculty of Medicine Doctoral Dissertation Series*, vol. 2011, 2011.
- 21 García, D. P. "The role of classroom acoustics on vocal intensity regulation and speakers' comfort," *hearingthewords.com*, , May 2011.
- 22 Bodin, T. Albin, M. Ardo, J. Strohm, E. Östergren, P.-O. and Björk, J. "Road traffic noise and hypertension: results from a cross-sectional public health survey in southern Sweden," *Environ Health*, vol. 8, no. 1, p. 38, 2009.
- 23 Xu, Y. Barregard, L. Nielsen, J. Gudmundsson, A. Wierzbicka, A. Axmon, A. Jönsson, B. A. G. Kåredal, M. and Albin, M. "Effects of diesel exposure on lung function and inflammation biomarkers from airway and peripheral blood of healthy volunteers in a chamber study," *Part Fibre Toxicol*, vol. 10, no. 1, pp. 60–60, 2013.
- 24 Skärbäck, E. Björk, J. Grahn, P. and Stoltz, J. "Evidence-based landscape analysis for wellbeing with objectively park and city data ," presented at the ICRCSSHS 2012, publisher: Information Engineering Research Institute, USA, 2012.
- 25 Annerstedt, M. Östergren, P.-O. Björk, J. Grahn, P. Skärbäck, E. and Währborg, P. "Green qualities in the neighbourhood and mental health – results from a longitudinal cohort study in Southern Sweden," *BMC Public Health*, vol. 12, no. 1, pp. 337–337, Dec. 2011.
- 26 Annerstedt, M. Jönsson, P. Wallergård, M. Johansson, G. Karlson, B. Grahn, P. Hansen, Å. M. and Währborg, P. "Physiology & Behavior," *Physiology & Behavior*, vol. 118, pp. 1–11, Mar. 2010.
- 27 Åhlander, V. L. Haake, M. and Brännström, J. *How does the teacher's voice and background noise in the classroom affect children's comprehension and learning*, Clinical Phonetics, 2014.
- 28 Johansson, R. Holmqvist, K. Mossberg, F. and Lindgren, M. "Eye Movements and Reading Comprehension While Listening to Preferred and Non-preferred Study Music," *Psychology of Music*, vol. 40, p. 339-356, 2012.