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IRCA – INNOVATION RESEARCH
CLUSTER ALSION

CARIN -- Communicative Approaches to Reducing Industry Noise

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Starting point

When one starts thinking a little more about noise, it is actually surprising how this topic accompanies us and even shapes our behavior in everyday life, and how little we still know about the types of noises that are out there, how we can avoid them, and how they affect our actions, performances, and health. Admittedly, some types of noises are more prominent than others, and it is maybe for this reason that they are also better understood than others. This applies, for instance, to speech babble, music, and traffic/street noise. However, what about those types of noise that are often considered inevitable and occur behind the closed doors of factory halls or laboratories? These types of industry noise that are emitted by all kinds of machines and production processes have so far largely escaped public and scientific attention. Our research initiative outlined below aims at changing that in the future for the sake of workers and companies alike.

A problem of increasing relevance

Constantly increasing populations and population densities, especially in urban regions, as well as the ways modern technologies conquer every corner of our life at home and at work are just two important driving forces of noise. It has never been completely silent around us, and in fact humans do not feel comfortable in totally silent environments, such as sound-treated rooms, but the constant lack of silence is not good either and can cause various health problems. Noise is de facto becoming an issue of modern societies -- an issue that gains more and more attention. People protest against aircraft noise and contend successfully for noise-reducing tempo limits or sound barriers in residential areas of cities. Companies start integrating noise-cancelation techniques as a default features in everyday headphones and windows; and low noise levels are used by car as well as tire manufacturers to advertize their products.

Noise research: State-of-the-art

The increasing importance of addressing noise issues is also reflected in research. Surely, noise has been a research subject for a long time, but noise-related research has become increasingly dynamic and interdisciplinary over the last decade(s). The recently launched series of "Euronoise" conferences aims at bringing together "science and technology for a quite Europe", and linguists as well as psychologists work together with engineers and acousticians on reducing noise sources and levels, or they investigate how our cognitive, biochemical, and communicative abilities and processes are (negatively) affected by noise. For example, a team of researchers at Kiel University -- engineers and linguists -- studies how the noise inside a driving car interferes with everyday conversation patterns, and, on this basis, develops and evaluates digital enhancement systems for in-car-communication. Similarly, a research team of the Voice Biomechanics and Acoustics Laboratory at Michigan State University -- trained acousticians and linguists -- quantifies gender-

specific voice accommodation strategies used in occupational settings and acoustic environments, for example, with the aim to increase speaker comfort in adverse communication conditions.

A new focus on machine-based industry noise

The Innovation Research Cluster Alsion (IRCA) of the University of Southern Denmark is currently also advancing a line of research on noise. Our research starts from the fact that industry noise, such as the machine noise in technical laboratories or large production halls, is generally less well investigated, in particular with respect to its effects on cognition, health and speech communication. Industry noise is looked at as if it was one homogeneous type of noise, even though it is pretty obvious that the noise coming, for example, from a compressor is quite different from that of grinding and sanding machines, which, in turn, emit a different type of noise than welding and filling machines. Therefore, the first major step in our line of research is to record, analyze, disentangle, and systematize the various types of industry noise that are out there, making use of those acoustic features that also proved to be effective in classifying languages and their vowels and consonants.

In a subsequent step, we will simulate the noise in our Speech-Technology Lab (using original as well as stimuli with systematically manipulated spectral and temporal patterns) and ask people to communicate under these circumstances while we measure exponents of fluency, efficiency, expressivity, and vocal effort. We also measure stress level in terms of, for example, blood pressure, heart rate, skin conductance response, and/or pupil reactions. On this basis, we will determine if and how well these behavioral measures agree with our initial classification of subtypes of industry noise. The classification will potentially have to be revised according to our measurements in a spiral-like progression. Moreover, we will arrive at a much better understanding of how harmful each subtype of industry noise actually is for humans in terms of communication and cognition/stress, and which aspects of its temporal and frequency characteristics actually contribute to this harmfulness.

Output

The major output of our CARIN project is supposed to be a new metrics (i.e. a new parameter) that can complement the currently predominant loudness parameter. In other words, both the analyses and the treatment of noise, including machine-based industry noise, are so far mainly -- if not exclusively -- oriented towards loudness. Better noise is reduced/ softer noise. We aim at adding a harmfulness measure to this simple picture. Such an additional measure has several key advantages and opens up new perspectives in research and development:

(1) We can create 'noise maps' for factory halls and laboratories that specify harmfulness rather than loudness levels. This allows companies, amongst other things, to better designate meeting areas and investigate potential correlations between frequencies of sick/absent employees and types of machine noise.

(2) Better noise is not only softer noise. In fact, we know already that some types of noise can even create a feel-good ambience. Our research and the new harmfulness metrics will

enable us to develop innovative smarter solutions -- headphones, earplugs, sound barriers, digital filtering techniques and the like -- that (a) are tailored to specific subtypes of industry noise, and (b) focus on only their harmful time or frequency characteristics instead of suppressing the entire noise signal. Unlike the latter one-for-all solutions, our smarter solutions are to reduce the harmfulness of a noise signal while simultaneously leaving enough room for speech communication.

(3) We can offer a new way of empirically-based scientific performance testing for all kinds of noise-reducing products that are already on the market.

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Team and Partners

The IRCA team of CARIN (relevant key competences in brackets) currently consists of *Oliver Niebuhr* (phonetics and digital speech processing, IDK), *Serguei Chiriaev* (engineering, material science, MCI), *Fei Yu* (engineering, signal processing, MCI), and *Alexander Brem* (innovation strategies, innovation management, MCI). We will also work with an international scope and in close collaboration with global-player companies on both sides of the German-Danish border, the Wissenschafts- und Technologietransfer Schleswig-Holstein (WTSH, Johannes Dormann) and research teams at Kiel University, Germany (Prof. Schmidt, https://www.dss.tf.uni-kiel.de/en/research), and Michigan State University, USA (Dr. Simone Graetzer, https://researchejhunter.wordpress.com/people-2/simone-graetzer-phd/).