## Focus

# IN SEARCH OF THE BEST SOUND

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Carolin Feldmann in her laboratory.

**Sleep seems a million miles away. The night feels like a furnace, without even the slightest breeze. An air conditioning system could provide some relief, if only it didn't make such horrible noise. Making the sounds of such devices more agreeable is the current research interest of junior researcher Carolin Feldmann.**

By Katrin Pudenz

At the psychoacoustic hearing lab of the University of Siegen, which is part of the Chair for Fluid Mechanics and Turbomachinery, researchers are currently exploring how we perceive the sounds made by kitchen hoods, air conditioning systems, heat pumps, air purifiers and residential ventilation systems. The mechanical engineers specialized in psychoacoustics aim to make household appliances and related devices sound more pleasant.

### Sound engineering for household appliances

"Psychoacoustics is all about the perception of sounds. We explore issues relating to subjective description and perception of sound, or how an impulse, i.e. sound, translates into emotions," says the 29-year-old mechanical engineer Carolin Feldmann, explaining her area of expertise. So the focus is on soft and pleasant sounds. "However, it is often not enough for noise to be as low as possible. Buzzing, humming or fizzing sounds emitted by devices may well drive you mad, regardless of the volume." Since air conditioning systems, kitchen hoods and heat pumps are needed, they cannot simply be turned off. But their sound can be optimized to make it more agreeable for the users' ears. This relatively new special field goes by the name "sound engineering for household appliances".

At the department, Feldmann analyzes the sound of various household appliances as part of her PhD thesis. "Sounds are created by the movement of air, which is why I analyze the sounds generated by flow devices with fans."

### The goal: A sound label for devices

After Feldmann completed her master's program in mechanical engineering at the University of Siegen in 2014, she plunged right into the next task - her PhD thesis. Since fall 2014, she has been working on the development of a sound label as part of her PhD thesis, which is funded by ebm-papst. "The idea is to develop a label that is similar to the energy labels used on refrigerators and dishwashers," explains Feldmann. "This new sound label is intended to inform customers about whether the device was tested as good or agreeable in terms of noise."

### Tested in the hearing lab

A psychoacoustic hearing lab was established specifically for the study, where testers can participate in hearing tests. At six work stations equipped with high-tech headphones, participants listen to various sounds, such as those produced by kitchen hoods and air conditioning and ventilation systems. In front of each of them sits a tablet computer, on which 37 pairs of adjectives are displayed. These adjectives are to be used to evaluate the individual sounds. The sound of an air conditioning system, for example, can range from "not droning at all" to "loudly droning", or from "dull" to "sharp". Other pairs of adjectives include "low-priced" and "high-quality", "deep" and "bright", "coarse" and "smooth". These pairs are arranged at the ends of a seven

point scale on which the participants rank the sound.

Feldmann explains that the sounds are all similar, yet different. “The devices all hum, buzz and whir in very different ways and each has a different pitch, thus evoking feelings associated with words such as loud, heavy, rough, fast or slow.”

“The test requires the participants to be highly concentrated,” says Carolin Feldmann. One test series for one type of device takes about forty minutes to an hour. 330 volunteers have visited the hearing lab to participate in the test since Carolin Feldmann began working on her PhD thesis, and just as many are still to come until the end of the study. “Our goal is to be able to clearly identify the most agreeable sounds of kitchen hoods and air conditioning systems - and this is the essential prerequisite for improving their sound,” explains the PhD student.

### First results

The 29-year-old researcher has already identified some initial tendencies. For example, the experiments have shown that low-frequency sounds are more agreeable than sounds with higher frequencies. Too low frequencies, on the other hand, were described by the participants as buzzing and disagreeable noises. Other unpleasant sounds include droning and rattling. “Such sounds evoke the feeling that something is wrong,” explains Feldmann. “As a result, the sound is not as easy to ignore as a monotonous hum.” For Carolin Feldmann herself, the loud rattling of computer hard drives ranks among the most unpleasant sounds, and she also thinks that air conditioning systems should not be too loud. “The pitch is only of secondary importance to me. Of course, I prefer sounds that are neither buzzing nor whistling. But all in all, a monotonous, steady sound is more important to me than the pitch of a device.”

The results of Feldmann’s study are also of great interest to the industry. “Automotive manufacturers have long been working on the sound of engines and closing car doors,” explains Professor Dr. Thomas Carolus, head of the Chair for Fluid Mechanics and Feldmann’s PhD supervisor. In the field of household appliances, sound engineering is a relatively new concept. “But its importance is growing,” adds Carolin Feldmann.

### The expert Dr. Marc Schneider, Group Leader, ES-VA, Pre-Development Fluid Mechanics - Acoustics, at ebm-papst says:

“Here at ebm-papst, we hope to gain a competitive edge by investigating the psychoacoustics of fans. Specifically, we think that the psychoacoustic parameters developed by Carolin Feldmann will help us to better assess the acoustic properties of our products as they are used in customer devices. This will enable us to ensure improved psychoacoustic properties that are in line with our customers’ (and the end consumers’) subjective perception.
In many of these applications, the sound a device produces is just as important as its efficiency values - and in some cases, it is even more essential. The conventional methods for assessing sounds are based on A-weighted sound pressure levels, which often fail to accurately reflect subjective perception.
Using the calculation methods that are currently being developed, we benefit from an advanced method for assessing the sound of fans that corresponds to what the users actually hear - allowing for a substantially improved assessment compared to the technical/physical parameters used up to now.”

### Further Information

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