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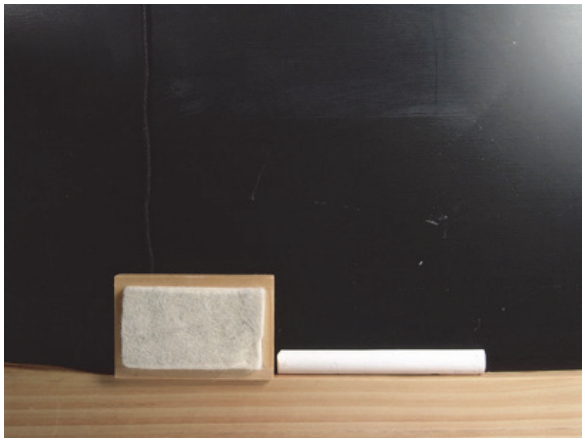
Some sounds are excruciating. Take fingernails squeaking on a chalkboard. Or the sound of a TTC subway train screeching to a halt. The noise makes many people shudder, but researchers never knew why.

A new study finds there are two factors at work: the knowledge of where the sound is coming from and the unfortunate design of our ear canals.

Previous research found the painful parts of unpleasant sounds appear to be in the middle range of audible frequencies. But scientists didn't nail down exactly which frequencies or explain why the sounds were painful.

So musicologists Michael Oehler of the Macromedia University for Media and Communication in Cologne, Germany, and Christoph Reuter of the University of Vienna asked listeners to rank sounds in a listening test. Fingernails raking against a chalkboard and chalk squeaking against slate were the most unpleasant sounds from a family of recordings, which also included Styrofoam squeaks and scraping a plate with a fork.



Back away from the chalkboard. Musicologists in Europe have found that fingernails raking against a chalkboard and chalk squeaking against slate were the most unpleasant sounds from a group of recordings.

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The researchers then modified the recordings of fingernails and chalk, removing or attenuating various frequency ranges. They also modified the sounds by selectively extracting either the tonal, musical-pitch parts or the scraping, growling, noiselike parts of the sound. Some listeners were told the true source of the sounds, whereas others were told the sounds were part of contemporary musical compositions. The same listeners then rated the pleasantness or unpleasantness of the sounds while researchers measured physical indicators of distress: the listeners' heart rate, blood pressure, and the electrical conductivity of their skin.

Oehler and Reuter found that a listener's skin conductivity changed significantly when the person heard a sound he or she later reported as unpleasant, showing that disturbing sounds do cause a measurable physical reaction. More surprisingly, they found that the frequencies responsible for making a sound unpleasant were commonly found in human speech, which ranges from 150 to 7000 hertz (Hz). The offending frequencies were in the range of 2000 to 4000 Hz.

The ratings also changed depending on what the listeners thought the sounds were. If they thought a sound came from a musical composition, they rated it as less unpleasant than if they knew it actually was fingernails on a chalkboard. But their skin conductivity changed consistently even when they thought the chalkboard sound was from music and rated it as less unpleasant.

The researchers suspect that the shape of the human ear canal may be to blame for the pain. Previous studies have shown that the ear canal amplifies certain frequencies. A loud screech on a chalkboard could be amplified within our ears to painful effect, the researchers propose.

Combining physiological measurements of pain such as skin conductance with psychological ratings of uncomfortable sounds is new and makes an important point about perception, says Reinhard Kopiez, a musicologist at the Hanover University of Music, Drama and Media in Germany, who was not involved in the study. Kopiez says the research shows how important context is in the enjoyment of music. "The audience enjoys the performance because of the knowledge about the (artistic) origins of a sound, although the physiological response remains the same as for uncomfortable sounds," Kopiez says.