Why 'singing' sand dunes hum certain notes

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"Singing" sand dunes, such as these in Al-Askharah, Oman, often hum at multiple frequencies simultaneously. By sieving sand from the Omani dunes, scientists managed to narrow down the frequencies at which the sands sing. Credit: Simon Dagois-Bohy, Université Paris Diderot

What does Elvis Presley have in common with a sand dune? No, it's not that people sometimes spot both in the vicinity of Las Vegas. Instead, some sand dunes, like The King, can sing. And new research looking for clues to how streams of sand can sing may explain why some dunes croon in more than one pitch at the same time.

Sand dunes only sing in a few areas across the globe, and their songs – always a low, droning sound—have been an object of curiosity for centuries. Marco Polo encountered their haunting drone during his travels and Charles Darwin, in his book "The Voyage of the Beagle," wrote of testimonials from Chileans about the sound of a sandy hill they called the "bellower."

The song of the sands is a low hum at a frequency within the bottom half of a cello's musical range. These dunes only sing when the sand is sliding down their sides. People can set the sand in motion themselves or, more eerily, the wind can create sand avalanches, creating a sudden, booming chorus.

Scientists previously thought the sound arose because avalanching sand created vibrations in the more stable underlayers of the dunes. But evidence that the avalanche of sand itself sings, not the dunes, emerged from experiments in 2009 by researchers who got a shallow pile of sand to sing while spilling down a laboratory incline. Now, the same research team has investigated a deeper mystery of the dunes—how multiple notes can sound simultaneously from one dune.

To study this question, physicist Simon Dagois-Bohy and his fellow researchers at Paris Diderot University in France recorded two different dunes: one near Tarfaya, a port town in southwestern Morocco, and one near Al-Askharah, a coastal town in southeastern Oman. No matter where recordings were made near the Moroccan dune, the sands sang consistently at about 105 hertz, in the neighborhood of G-sharp two octaves below middle C. The Omani sands also sang powerfully, but sometimes unleashed a cacophony of almost every possible frequency from 90 to 150 hertz, or about F-sharp to D, a range of nine notes.

The research will be published this Friday in the American Geophysical Union journal *Geophysical Research Letters*.

Even though the Omani dunes are somewhat sloppy singers, the researchers identified some tones that were slightly stronger than others. But with all the sand avalanching at once, those prominent frequencies were often buried in sea of notes. The scientists also observed that sand grains from the Omani dune came in a much wider range of sizes than their Moroccan counterparts. The Omani dune's grains were 150 to 310 microns, while the Moroccan dune's grains were only 150 to 170 microns.

So Dagois-Bohy and his colleagues brought grains from the Omani dune back to the lab. First, they ran the mix of the Omani sands down a constructed incline, recording its sound with microphones and measuring the sand's vibrations with sensors that floated on the surface. Then, they used a sieve to isolate the sand grains that were between 200 and 250 microns, and ran those sands down the same slope.

The researchers then compared the sound of the isolated sands with the sound of the mixed-size control. They found that while the grains of a broad size range sang noisily, the sands of a narrow size range sang a clear note at about 90 hertz, much like the Moroccan sands do naturally. This suggested that grain size is an important factor in what tone the dunes sing, Dagois-Bohy said.

"The sound we hear is correlated to the size of the grains," he said. "So we can start to say that the size of the grains is important."

The research team suggests the grain size affects the purity of tones generated by the dunes. When grain size varies, the streams of sand flow at varied speeds, producing a wider range of notes. When the grains of sand are all about the same size, the streams of sand within the avalanche move at more consistent speeds, causing the sound to narrow in on specific tones. But scientists still don't know how the erratic motion of flowing grains translates into sounds coherent enough to resemble musical notes, Dagois-Bohy said.

His team's hypothesis is that the vibrations of flowing sand grains synchronize, causing stretches of the sand grains to vibrate in unison. Their thousands of meager vibrations combine to push the air together, like the diaphragm of a loud speaker, Dagois-Bohy said. "But why do they synchronize with each other?" he noted. "That's still not resolved."

"The study attempts, and I think succeeds in many ways, to solve the problem of what's the mechanism" that translates tumbling sand into a song, said Tom Patitsas, a theoretical physicist at Laurentian University in Sudbury, Ontario, who did not participate in the study. Patitsas said the theory behind the sound still requires more elaboration to explain why, for example, the flowing sand still needs a thin layer of stationary sand underneath it to make a sound. He suggests the sliding sands resonate with similar-sized grains beneath the avalanche. Those buried grains may lie in chain-like patterns that intensify the resonance. "Once you have this resonance, the amplitude of the vibration will be large," Patitsas said.

More information: S. Dagois-Bohy, S. Courrech du Pont, and S. Douady. Singing-sand avalanches without dunes. *Laboratoire Matière et Systèmes Complexes*, UMR 7057, CNRS, Université Paris Diderot, Paris, France.
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