The dynamic acoustics of clapping: How hand shape affects sound

March 11 2025, by Caitlin Hayes

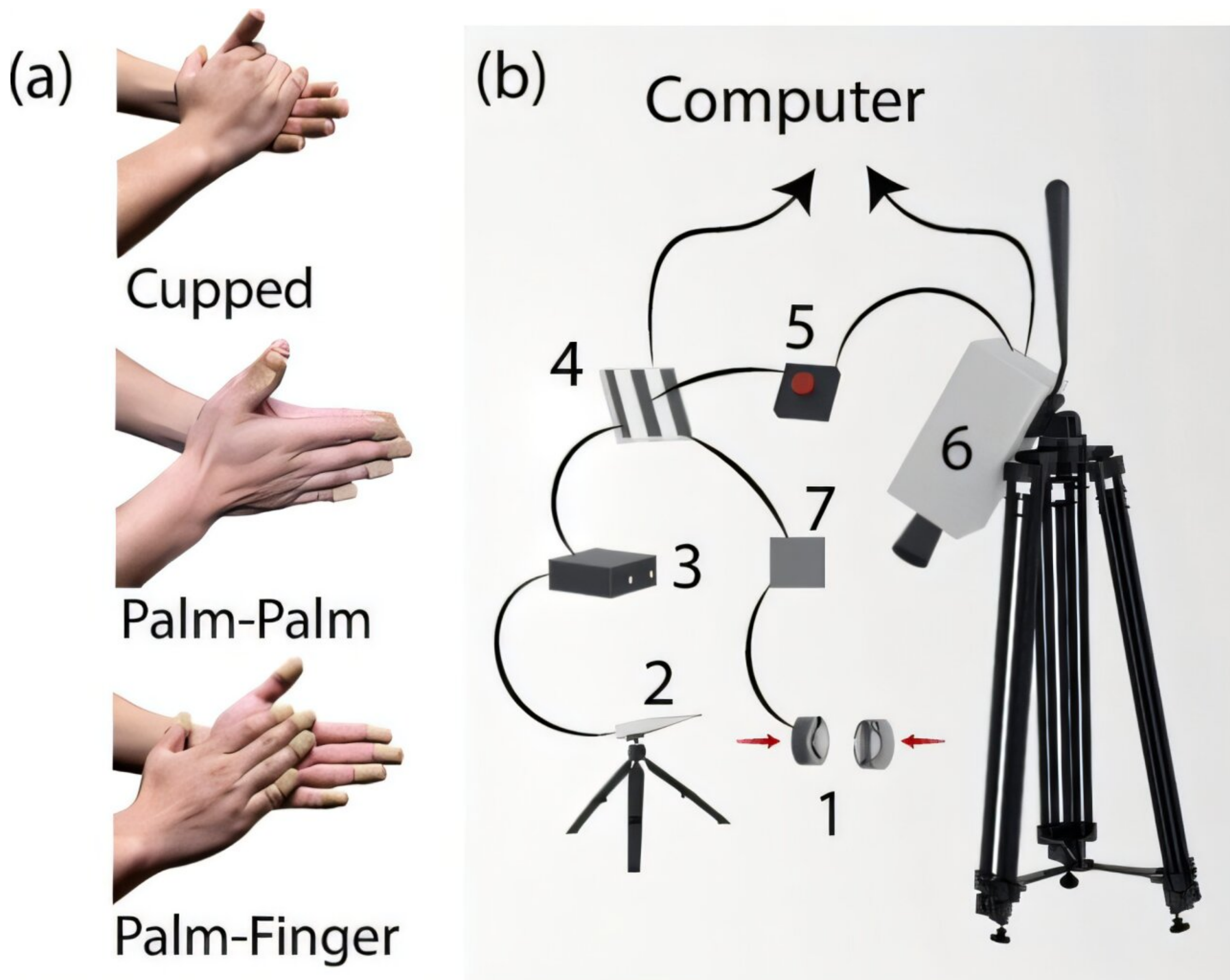

Illustration of the major experimental materials and methods used in the present work. Credit: *Physical Review Research* (2025). DOI: 10.1103/PhysRevResearch.7.013259

In a scene toward the end of the 2006 film, "X-Men: The Last Stand," a character claps and sends a shock wave that knocks out an opposing army. Sunny Jung, professor of biological and environmental engineering in the College of Agriculture and Life Sciences, was intrigued. "It made me curious about how the wave propagates when we clap our hands," Jung said.

Jung is senior author of a study, published in *Physical Review Research*, that elucidates the complex physical mechanisms and fluid dynamics involved in a handclap, with potential applications in bioacoustics and personal identification, whereby a handclap could be used to identify someone.

"Clapping hands is a daily, human activity and form of communication," Jung said. "We use it in religious rituals, or to express appreciation: to resonate ourselves and excite ourselves. We wanted to explore how we generate the sound depending on how we clap our hands."

The researchers used high-speed cameras to track the hand motion, air flow and sound of 10 volunteers clapping, measuring the different frequencies when the size and shape of the cavity between hands changes: when clapping with cupped hands, flat hands or fingers to palm. They found the larger the cavity between palms, the lower the frequency of the clap, with the hands acting as a resonator—whereby the sound comes from the force of air through the hand's cavity and the opening between the thumb and index finger.

"It's the air column pushed by this jet flow of air coming out of the hand cavity that causes the disturbance in the air, and that's the sound we hear," said first author Yicong Fu, doctoral student in the field of mechanical engineering.

The researchers compared the human data to that produced with simplified replicas, as well as theoretical projections of how air would move through a traditional resonator, called a Helmholtz resonator.

"We confirmed both experimentally and computationally that the Helmholtz resonator can predict the frequency of the human handclap," Fu said. "It's a confirmation of this unifying principle that may be helpful in other fields, especially bioacoustics, because that principle may help explain all kinds of bioacoustics phenomena, especially those involving soft material collision and jet flow."

"This is also a fundamental principle of the musical instrument," Jung said, "that depending on the size of the cavity and the length of the neck opening, you create a different sound—we showed that this also applies to handclapping."

Additionally, the researchers studied why claps are so short, compared to sound made through a traditional resonator, finding that the softness of the hands plays a role: the soft tissues of the hands vibrate after impact, absorbing energy and dampening the sound.

"When there's more vibration in the material, the sound attenuates much more quickly," Fu said. "So, if you want to get the attention of another person very far from you, and you want the sound to last longer, you might want to choose a certain type of handclapping shape that makes your hand more rigid."

The research further opens the door to the idea of using a handclap as a personal identifier or signature; another of Jung's students is testing whether a handclap could be used to take attendance in a class, for example.

"The handclap is actually a very characteristic thing, because we have different sizes of hand, techniques, different skin textures and softness—that all results in different sound performances," Fu said. "Now that we understand the physics of it, we can use the sound to identify the person."

Previous studies have investigated either the simplified theoretical mechanics behind the handclap or statistical analysis using human subjects, but the connection between the two is new. With an experimental setup that assessed sound and air flow; the size, shape and texture of the hand; and the force, speed and pressure of the clap, the researchers were able to capture multiple variables that incorporated materials science, fluid mechanics and acoustics.

"This is the most thorough study on this topic," Fu said. "The way we set it up helped visualize the phenomena, and because it's so comprehensive, we're able to generate more knowledge from it."

For Jung, the study also satisfies a curiosity. "This started as wanting to understand something I saw and something we do every day," he said. "When I see something, I try to question why it happens."

More information: Yicong Fu et al, Revealing the sound, flow excitation, and collision dynamics of human handclaps, *Physical Review Research* (2025). DOI: 10.1103/PhysRevResearch.7.013259

Provided by Cornell University

provided for information purposes only.