



WHY DOES WALKING WITH COFFEE CAUSE IT TO SPILL?

\$172,000

California

Department of Defense

The Defense Advanced Research Projects Agency (DARPA) boasts that it “explicitly reaches for transformational change instead of incremental advances” as part of its “singular and enduring mission: to make pivotal investments in breakthrough technologies for national security.”⁴³

“Walking with coffee: Why does it spill?” is an example of a recent research project funded by DARPA as part of a \$172,283 grant to University of California at Santa Barbara (UCSB).^{44 45}

The best way to avoid spilling your coffee “was probably to use a lid, and maybe fill your coffee cup a little less,” admits Rouslan Krechetnikov, who conducted the research for DARPA.⁴⁶

While it is unclear how the Pentagon’s science agency would seek to defend American citizens against the threat of spilling hot coffee on themselves, it is certainly a challenge many confront every day.

“In our busy lives, almost all of us have to walk with a cup of coffee. While often we spill the drink, this familiar phenomenon has never been explored systematically,” the researchers state.⁴⁷

After observing attendees at a scientific conference carefully trying to carry their beverages to avoid spilling, Krechetnikov, a mechanical engineer at UCSB, and Hans Mayer, then a graduate student, “decided to divert from weightier subjects” to get to the bottom of the issue.⁴⁸

“I cannot say for sure if coffee spilling has been detrimental to scientific research to any significant extent,” says Krechetnikov. “But it can certainly be disruptive for a train of thought.”⁴⁹

For the experiment, a volunteer walked at different speeds along a straight path while holding a mug filled with coffee.⁵⁰ The volunteer was first recorded walking and looking straight ahead and then a second time walking while focusing on the cup. An image analysis program examined the motion while a tiny sensor on the mug monitored the coffee level in the cup and recorded the instant a spill occurred.⁵¹

The authors explain “in the walking with coffee problem the motions of the human body, while seemingly regular, are quite complex and are coupled to a coffee cup and liquid therein, which makes it difficult to unravel the precise reasons behind coffee spilling.”⁵²

“A closer look at the liquid motion in the cup suggests that not only back-and-forth but also swirling liquid motions can be excited by walking at typical speeds,” the authors write.⁵³

The researchers found walking slower and focusing on the cup reduce the chance of spilling.

“We spill coffee either by accelerating too much for a given coffee level (fluid statics) or through more complicated dynamical phenomena due to the particular range of sizes of common coffee cups, which is dictated by the convenience of carrying them and the normal consumption of coffee by humans.”⁵⁴

But focus is a key issue. “Time to spill generally depends on whether walking is in a focused or unfocused regime and increases with decreasing maximum acceleration (walking speed). The difference between the focused and unfocused regimes suggests that walking with coffee is a control problem.”⁵⁵

The researchers suggest additional studies may be necessary to take into account other factors such as gender, temperature of the beverage, and the type of container. The authors write “future comparative studies may provide further insights into the variability of the discussed phenomena. For example, gender differences —gait velocity and step length are lower and step frequency is higher for women than for men—may lead to differences in coffee spilling.” Furthermore, they say “another relevant question to study is the influence of the degree of danger of the fluid in a cup, e.g., hot vs cold.”⁵⁶

Changing the design of a coffee mug could reduce spilling, according to the study, but that is unlikely to occur. “Despite the variety of spill control options, the simplicity and convenience of a common coffee cup will likely continue to outweigh the side effect of coffee drinking studied here—occasional spilling,” they note.⁵⁷

Science magazine says Krechetnikov and Mayer’s answers to avoiding a spill “may not come as a big surprise. Starting your walk slower—that is, accelerating less—will help. So will leaving a decent gap between the top of the coffee and the mug’s rim; this should be at least one-eighth of the mug’s diameter—for a normal mug, about a centimeter should do it. But the researchers’ ‘take home’ advice is to look at what you’re doing—so long as your mug isn’t filled too high, a watched mug almost guarantees a clean run.”⁵⁸

“Most people will have worked out these tips for themselves,” points out Matthew Turner, a mathematician who specializes in liquid sloshing at the University of Surrey in Guildford, United Kingdom. He notes engineers already know of slosh-control techniques, but mug makers are unlikely to adopt these features. “I expect it is more cost-effective for manufacturers to just provide a lid for our coffee mugs, which some already do,” Turner says.⁵⁹



The best way to avoid spilling your coffee is to put a lid on your cup, according to a DARPA researcher.

Physicist Andrzej Herczynski at Boston College said he “was personally a bit disappointed that the study is limited to cylindrical mugs ... leaving out the very common curved or conical cups, such as those used for cappuccinos and lattes in Italy.”⁶⁰

“We just wanted to satisfy our curiosity,” says Krechetnikov. Quoting renowned 20th century scientist Linus Pauling, he says “satisfaction of one’s curiosity is one of the greatest sources of happiness in life.”⁶¹

It’s time for DARPA to wake up and smell the coffee and put a lid on unnecessary studies.

