Big Crowds Flow Like Water in Amazing (and Terrifying) Ways

Hydrodynamic theory helps to explain how large human crowds flow like water

Christopher Bergland
The Athlete's Brain

Photo: Kevin Dooley
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Large human crowds behave much like collective behavior that can be explained by hydrodynamics and hydrodynamic theory, according to a new study (Bain and Bartolo, 2019) published today in the journal Science. This pioneering research by Nicolas Bain and Denis Bartolo of Gulliver Laboratory in Paris, France, has implications for how crowds of people flow the easiest in ways that appear to override so-called "intersocietal conflict" between individuals.

This paper, "Dynamic Response and Hydrodynamics of Polarized Crowds," was co-authored by Nicolas Bain and Denis Bartolo of Gulliver Laboratory in Paris, France. Denis Bartolo, Ph.D., is a pioneer in physics at the ENS de Lyon working under the direction of Bartolo. The groundbreaking research presented in this paper focuses on studying human crowds from an active matter physicist's point of view.

For this large-scale research on human crowd movement through the lens of hydrodynamic theory, Bain and Bartolo set up cameras at a bicycle race as they could film the flow of thousands of marathon runners being funneled into a narrow tunnel. Bicycle racing is one of those of the world's largest marathons (Chicago, Paris, and Atlanta).

For this study, the researchers focused on the entire crowd as a singular entity and applied hydrodynamic theory to human crowd movement that was based on "minimal behavioral assumptions. The authors sum up their study's design and significance:

> *Mesmerizing impressions of virtuosity of pattern observed in bird flocks, fish schools, insect swarms, and even human crowds are effectively rendered in terms of a few simple rules. Yet, the mechanisms underlying the emergence of the collective dynamics of groups of living creatures in response to physical, social, or biological impulses, however, remains a formidable challenge.*
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> *Modeling crowd motion is central to situations as diverse as risk prevention, the design of pedestrian infrastructures, and the management of crowds. We use data of thousands of road-race participants in starting corrals to delineate the flowing behavior of polarized crowds by probing its response to focusing motion. Building on these observations, we lay out a hydrodynamic theory of polarized crowds and demonstrate its predictive power. We unveil a hydrodynamic instability that, we argue, underlies the ubiquitous pseudo-laminar spatiotemporal crowd arrangement.*

As you can see in the video below, when Bain and Bartolo analyzed the collective movement of swarms of marathon runners at the starting line of a bicycle race, they found that the "focusing motion" of the bicycle race created a ripple effect that would cascade from the back and front of the line, but not from side to side. Unlike some life-threatening "crowds flowing like a tsunami" situations that I will discuss later in this post, the thousands of marathon runners participating in these well-organized running events slowly make progress toward the starting line under the clearly encouraged guidance of race day staffers.

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Interestingly, the "hydrodynamic swarm" of marathon runners seeking to start a race, "pulsated" in a pseudo-laminar fashion. Using hydrodynamic theory (using predictive mathematical models), the researchers were able to solve rarely predict how these dynamics would play out from one marathon start rig line to another.

How You Ever Been "Dead Away" in a Sea of Humanity That Felt Like a Tidal Wave?

While I was reading about the latest research on large crowds flowing like water and behaving in predictable patterns based on hydrodynamics, I had flashbacks to specific circumstances in both sports and daily life where I've been caught in a tidal wave of human bodies. I'm a big fan of the NFL and soft grass and alpine scenic landscapes/natural decors and audio/visual displays that constitute the latest findings by Bain and Bartolo on the hydrodynamics of human crowds.

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Before reading further, Can you recollect any firsthand experiences of feeling the physical sense of human beings acting like a wall of water that could pick up, hold pressure, and flowing which direction your body was going to move?

When I asked myself this question earlier today, four examples spring to mind. I'm a big fan of the Grateful Dead and I've been to over 100 live shows spanning years and especially since, After reading the latest study by Bain and Bartolo, I realize that the closest I've come to thinking I was going to die was in situations where the water-like movements of a massive crowd — who had no idea that their collective actions were creating life-threatening danger — almost embodied hydrodynamics in a distant part of the group.

As a marathon runner, I've experienced the exact wave like phenomenon that Bain and Bartolo captured on film for their latest study as a participant being "herded" by race-day volunteers into a starting corral. For me, this experience of being "herded" into a starting corral happened during the most elaborate 10 pacifiers crowd" series of racing of water in a sea of humanity is when I'm among 30,000+ marathon runners at the starting line of the world's largest marathon in New York City.

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As you can see in the video above, the first mile of the NYC marathon takes runners from Staten Island to Brooklyn via the Verrazano-Narrows Bridge. Being shoulder-to-shoulder and running stride-for-stride with other participants is a phenomenon that I'm a big fan of and I'm not ashamed to admit it. This is the only time during a marathon where it feels like my feet aren't even touching the ground, and I'm being carried forward by a gigantic wave of strangers working towards a common goal. This is a life-affirming experience.

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As a native New Yorker, there are countless times that I've also experienced the "wave of humanity" pushing my body to and first in ways that every morning control while commuting on the subway during rush hour. Anyone who has gotten on or off an MTA train heading in or out of Manhattan during rush hour has probably felt the hydrodynamics of crowds flowing like water.

For most of my life, I lived on 14th Street and now I live in a 14th subway stop. I've seen people hold hands and fall down and get trampled on. I've seen people hold hands and fall down and get trampled on. I've seen people hold hands and fall down and get trampled on