# State Fair rides: Thrills, chills and chaos theory made real

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You know that feeling -- your stomach is in your throat -- when you're on a roller coaster and the car takes that first big plunge?

Your insides are crawling or you're losing feeling in your legs, and you think it's just nerves. But NASA scientist and trained astronaut Patricia Cowings says, no, it's real.

"Your stomach and all of your guts are really floating up under your rib cage," Cowings said. "And almost all fluids in your body move toward your head." You're experiencing for a split second what it's like to be an astronaut in space.

There's a science of thrills, and it's rooted in simple physiology and physics. The rides at state fairs and amusement parks that twist, twirl, hurl and drop you were very intentionally engineered to take you to the edge. The swirling lights and spinning pods only hint at the chaos that was harnessed to create them.

Consider the Tilt-A-Whirl.

Richard Kautz, a scientist at the National Institute of Standards and Technology, studied the simple, yet unpredictable motion of the classic carnival ride when he was on sabbatical 16 years ago.

He observed the ride's sensitivity to small disturbances. Riders have a lot of say in the intensity of their experience, Kautz said. "If they throw

their weight around a bit, they can turn a sort of 'blah' whirl into a really good whirl."

He had identified a central tenet of chaotic motion: that even a tiny disturbance grows exponentially, and in a sort of domino effect greatly alters the course of events to come.

The Tilt-a-Whirl at Cal Expo is a purple, unassuming affair, an easy ride to overlook on your way to the coasters. When the Midway came to life one evening last week, the ride roared into motion every few minutes with a new batch of passengers, and cars flew by.

Sometimes a car went over a hill and hung motionless; other times it gave a dizzying series of whirls. The unpredictability is what people like.

"It's exciting because you don't know which way it's going to go," said Holly Repace, who had just gotten off the ride. Her mom, Sue Repace, had sat that one out.

"I grew up on the Tilt-a-Whirl," she said. "But I can't go on the rides like I used to."

And there's a physiological reason for that.

Spinning, tumbling rides inflict mayhem on our vestibular system, said NASA's Cowings. That's the set of organs responsible for our sense of balance.

Tiny rocks in our inner ears sense orientation, and fluid-filled rings detect spinning. When what our eyes see and what our body does conflict with what our inner ear is reporting, we get sick.

That's why you shouldn't close your eyes, Cowings said. "That makes

you more susceptible."

Children younger than 6 or 7 are immune to motion sickness because their vestibular systems are not yet mature. Studies show that susceptibility peaks around age 10 and declines into adulthood. But by then, researchers say, most adults have learned to avoid this type of situation.

Eight-year-old Minnie Chadwick's parents were among those not riding the Tilt-a-Whirl that warm night last week. "Look, there she is, laughing," said dad John Chadwick, content on the sidelines.

Legend has it, 84 years ago, a child's amusement inspired the ride's original design. In a Minnesota home in 1926, Herbert Sellner sat his son in a swivel chair and tipped it every which way.

Chaos theory did not exist for another 40 years. "Here he was giving a perfect description of it," Kautz said.

Just what is chaos?

Minnie's mom, Colette Chadwick, unaware of the gravitational pull she was exerting on her daughter's ride, took a few steps closer to snap pictures.

According to Kautz, that act alone -- stepping forward, then back -- altered the motion of every car in the ride. Within two minutes, a car that would have spun one way is now spinning another.

What if she were farther away? If the Tilt-a-Whirl were in Denver and Colette Chadwick in New York? "Then it would take about five minutes" for the first car to reverse direction, Kautz said.

When Minnie got off the ride, none the wiser, she bounced over to her parents. "It spins really fast," she said. "Can I go again?"

Not all of the 64 rides on the Midway owe their thrills to chaos.

The classic roller coaster is a hair-raising time, but it's not chaotic, Kautz said. It's a controlled fall.

Cars are pulled up a huge ramp, then let go. The ride to the bottom coasts over hills and valleys, shoots through loops and turns, all under the influence of gravity alone.

Not too far away, a bowl-shaped ride called Starship 3000 spins up and riders find themselves glued to the wall. When the wall rises, feet leave the ground. It's not magic -- just friction.

The tricks are many, but inner ear, beware, "the nausea will be the same," Kautz said, laughing. "That's a constant."