The science behind Tour de France's hide-and-seek tactics

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Get in line. Riders keeping out of the wind on the road to Sheffield. Credit: Adam Bowie, CC BY

When the Tour de France comes to town, it's a chance to get your gladrags on. This year's Grand Depart in Yorkshire saw Leeds decked out with yellow flowers, bikes placed in coffee bar windows, statues wearing yellow jerseys and locals showing off yellow ties or Tour de France socks. For the riders, though, the science that governs their sport means it's about being as inconspicuous as possible.

Tour cyclists will ride 21 stages and cover more than 3,600km over the three weeks and a mix of flat, hilly and mountainous stages (and let's not forget the cobbles and the wind) in a feat of endurance which simply demands an intense focus on sport science to get athletes to Paris for the final day.

No surprise then, that pacing is a crucial part of the puzzle as riders and coaches aim to take advantage of their own strengths while hanging in there while others make most of theirs. The purest test of this will come in the time trial from Bergerac to Perigueux when each rider climbs into a skinsuit and propels themselves against the clock for 54km.

Research has shown that a flat time trial demands a relatively even pace to get the most out of a rider. This year, however, the stage 20 route goes over some lumps and bumps which change the optimal pacing strategy. When cyclists race over hilly and/or windy terrain in general, riders can be advised to vary their power output in parallel with hill gradient and wind direction, to minimise differences in speed over the race. They're not on their own judging this.

Advances in portable GPS systems give rider and coaches essential input data to allow even more accurate predictions of performance on a specific time trial, incorporating hilliness and windiness. Incorporated in an advanced cycling model, the GPS information can even be used to assist in making choices related to cycling material and equipment before they roll down the start ramp.

Yellow fever. Credit: Bert Otten, CC BY

Follow the leader

Most stages, however, are not lone efforts. And it's here where riders, team leaders particularly, will seek refuge at every opportunity to enjoy the large beneficial effect of drafting: hiding behind your opponent.

The scientific basis for this benefit has to do with principles that are well known in aerodynamics. A key aspect is Bernoulli's principle, named after the Swiss physicist and mathematician Daniel Bernoulli. This is the principle that explains why aeroplanes can fly, but also the same principle that makes the shower curtain move towards you while taking a hot shower.

This principle states that an increase in the speed of air molecules coincides with a decrease in pressure. When a cyclist moves through the air on his way to the finish line, the air molecules in front of him are moving with a relatively low velocity. In front of the cyclist, there is thus an area of relatively high pressure. Due to the dynamics caused by the passage of the cyclist, air molecules behind the cyclist will be moving with a high velocity, that is, a low pressure. A small vacuum might even occur behind the cyclist (no molecules at all).

The pressure difference between front (high pressure) and back (low pressure) causes an increase in air resistance "pushing" the cyclist back. Now we get to the benefit of hiding behind your opponent: if the person in front of you has created an area of low pressure behind him, and you are close to him, that area is in front of you. So by cycling close to the rider in front of you, you can make use of his low pressure area, creating a lower pressure difference between your front and backside.

Power game

This leads to a lower air resistance. In terms of power output and effort, this means that a cyclist that rides closely behind another cyclist at 40km/h (this is about the average speed during the Tour de France nowadays) can get away with a power output that is 15% less than that of the rider at the front. Because of the nonlinear relationship that exists between power output and velocity, the benefit of drafting is larger at higher velocities, so during the flat stages drafting is more important than during the mountain stages.

However, there is also a downside of drafting: riding close to the wheel in front is more dangerous, and every Tour de France is known for some famous "chutes": think of Dutchman Johnny Hoogerland who landed in barbed wire in 2011, when his opponent was hit by a team car and Hoogerland was unable to avoid him. But there are always crashes caused purely by proximity, the most dramatic of which this year has been the innocuous clash of wheels which brought down defending champion Chris Froome.

It's a simple decision though. You cannot ride out front in the wind for 3,600km, however strong you might be, so you take the risks, ride through the pain and hope the rewards follow. Sports science might be able to explain the theory, calculate the power outputs and design the recovery programme. But it's the riders that must find the motivation to get back on the bike day after day, even if they do spend all their time as hidden as they possibly can be.

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