

The bridge - Part 1

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People have a strong tendency to "explain" behaviour by biological and / or psychological "determinants". High marks come from intelligence, personal reactions are "explained" by personality traits. And of course there are individual reaction patterns, which are predictable within certain limits. In everyday life, this "psychologisation" of human behaviour can be useful. For example, there are (generally) nice people, and more unpredictable people, etc. However, from a scientific point of view - a dynamic systems perspective - behaviour and psychological characteristics can be understood very differently. To make that clear, we march along with soldiers across a bridge....

In London, on June 12, 2000, only two days after opening the pedestrian Millennium Footbridge was closed again. That day, more than 2,000 people walked across the 325-meter bridge. The bridge proved stable until the number of people walking on the bridge deck at the same time exceeds a fairly specific number. The bridge began to wobble, causing people to move with the bridge to maintain stability. Coupled oscillators, also called synchronization: the vibrations of both the bridge and the people "oscillate" synchronously in 1 new pattern. At bridges this phenomenon was already known by marching soldiers. When a certain number of marching soldiers is exceeded, resonances can even cause the bridge to collapse. But with the millennium bridge, it is the other way around, the resonance of the bridge causes people to coordinate their movement behaviour.

This reveals a "secret" of dynamic systems; it does not matter whether people make the bridge move by their marching, or whether the bridge makes people synchronize with its wobbling (resonance), it is about coupled "systems". Human behaviour on such a bridge arises completely independent of personal characteristics, such as gender, long legs or short legs, obesity or perhaps extremely slim.

As early as 1657, when the Dutch scientist Christiaan Huygens had just invented the pendulum clock, it appears that if the timepieces hang from a wooden stick out of phase (i.e. with random / non-synchronized pendulum movements) and are thus 'linked' because the stick transmits the vibrations, they automatically start to move in phase, just like the walkers on the bridge. Metronomes that can transfer their vibrations to each other mechanically (coupled oscillators) also synchronize "automatically". It was later discovered that all celestial objects move in fixed orbits around each other, and thus the "laws of the coupled oscillators" - dynamical systems - determine the behaviour of all elements, both on Earth and in the universe.

Usually the whole is the sum of its parts (added linearly): someone is happy and travelling, so happy travelling. Someone walks across a motionless and stable bridge and thus moves forward. But when hundreds of people walk together, the bridge starts to wobble quite suddenly. Both systems - the pedestrian and the bridge - are coupled into one new pattern, in which the whole is more than the sum of its parts. This is a non-linear effect. With N pedestrians on the bridge there is a linear pattern: each pedestrian moves at his own pace. With $N + 1$ pedestrians, the new pattern emerges, the coupled movement emerges, both discontinuous (non-linear) and automatic: the wobbling of the bridge. Such discontinuous shifts can be observed everywhere: in horses, the shift from walk to trot to canter (3 patterns); from ice to water to steam; traffic flow and congestion, etc. If the number of cars on a road exceeds a certain number (N), one person only needs to brake once and the 'new' pattern - traffic jam - becomes visible. In a traffic jam, 'individual' behaviour suddenly disappears. Psychological measures - IQ, emotional stability, planning skills are marginal at best. Our behaviour is often determined by such dynamic systems. However, we pay very little attention to that.

On February 22, 2002, after adding extra dampers to reduce resonance with the usual pedestrian numbers, the Millennium Bridge was reopened!