Futurology gets a little more exact

From the way we drive to how we vote, physicists reckon they can forecast human behaviour. Philip Ball explains the so-called 'physics of society'

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Imagine that you could predict whether house prices are about to crash. Or how a political party could choose policies guaranteeing electoral victory. Or whether a new set of criminal laws will reduce crime, or whether a new road will reduce traffic, or even whether your favourite pub will be overcrowded on the nights it shows live football.

Sounds good, doesn't it? But when it comes to human behaviour, politicians, pollsters, urban planners and economists have a decidedly mixed record of predicting the future or anticipating the consequences of their decisions. Because we have free will, futurology can never be an exact science.

Yet help may now be at hand from an unlikely source: physics. In the past few years, physicists have started applying their ideas to the social sciences in an attempt to figure out whether there exists a "physics of society". At the same time, social and political scientists have begun to adopt some of the methods pioneered in physics to understand and predict the behaviour of large groups of people. Unlikely as it might sound, there are signs that aspects of social behaviour follow mathematical laws akin to those obeyed by insensate matter in the physical sciences.

According to this picture, we sometimes act en masse as though we are a collection of atoms interacting with one another through forces of attraction and repulsion. This doesn't mean that everyone does the same thing, but it can mean that ourquirks get submerged beneath averages and mass movements. It doesn't mean that we lack free will, but it does suggest that we might not be as free as we'd like to believe.

For one thing, our choices are often very limited. And we sometimes do all we can to limit them even more. That's why we have conventions about how to dress, how to shake hands, on which side of the road to drive. Without such customs and rules, life would present an impossible confusion of choices. But one of the most striking findings to emerge from the new physics of society is that a major constraint on our free will is our interactions with other people. We influence what each other does. Sometimes that can lead to more conformity than we'd expect in a collection of independent individuals. And sometimes it can lead to sudden changes in social behaviour, like those described in the American writer Malcolm Gladwell's book The Tipping Point.

Physicists are used to seeing things like this. In a lump of iron, for example, each atom is like a tiny compass that can point its magnetic needle in a particular direction. Individually, each atom is free to choose its own orientation; but because of the magnetic forces between them, all the atoms tend to align their needles. Brazilian physicists have used a magnetic model like this to explain why the voting statistics of the 1998 Brazilian elections aren't what one would expect from a collection of independent decisions: the voting patterns show a clear signature of collective behaviour. This is what we'd expect if everyone is trying to convert their neighbours to their own political orientation. This puts an interesting twist on what we understand by democracy.

One of the social systems that shows the clearest signs of behaviour analogous to a collection of inanimate particles is traffic flow. That's probably because our choices are particularly constrained on the road - in general, all we do is aim to go in a specific direction, in single file, at the speed of our choosing. But we will, on the whole, reduce this speed if necessary to avoid the risk of collision.

Physicists have devised models of traffic flow in which each vehicle is represented by a particle programmed to move according to these rules. They find that the resulting flow looks spookily realistic. It can seize up into the kind of "phantom jams" that seem to have no cause. And it can develop the recurring waves of stop-and-go congestion familiar to motorway drivers.

Some traffic physicists argue that traffic exists in three distinct states: free flow, congested flow and jams. These are analogous to the gas, liquid and solid states of matter, and one flow state seems to switch to another abruptly, like the sudden "phase transitions" of melting, freezing seen in matter. Understanding what triggers these transitions in traffic might lead to better road designs and traffic regulations.

Similar models of mass movement have been applied to crowds of pedestrians. Researchers in Germany have used these models to understand how trails get trodden down spontaneously on areas of grass, which might help park designers build more agreeable paths. Particle-pedestrian models reveal what can go wrong when people try to flee in panic from a crowded room. The switch from orderly movement to a panic state can again be abrupt, and can lead to inefficient use of exits. Insights like this could improve building safety, and researchers at University College London are using such models to look for better crowd-management measures for the Notting Hill carnival.

Particles that attract and repel one another are also a good basis for understanding how coalitions and alliances form. Businesses might form conglomerates with some rivals in the hope of securing dominance for their own products and forcing other rivals out of the market. Likewise, in times of war countries might be prepared to band together to defeat a common enemy. Researchers in the US have shown that, by making crude estimates of the strength of the forces of "attraction" and "repulsion" between European countries in 1936, they could predict how the 17 countries would split into Axis and Allied camps in the second world war. Physicists in France have applied a similar model to try to understand the break-up of the former Yugoslavia and Soviet Union, and the expansion of the European Union.

Another area of social science that lends itself to a physics-based approach is economics. Here the "particles" are market traders, and they interact through trading transactions: buying and selling, which in turn sets commodity prices for future transactions. In addition, the traders are influenced by each others' decisions, which can cause herd-like behaviour and can trigger waves of buying or selling that destabilise the market. This "agent-based" approach to economics, which is being adopted by some leading economists such as Nobel laureate Kenneth Arrow, challenges some of the long-cherished notions about free markets, such as that they operate in equilibrium and lead to the most efficient distribution of goods.

Social physics won't solve all of society's problems, but it might provide a more rational basis for making social decisions. It can be hard to predict the effect of particular laws and policies once they are unleashed on a highly interactive population. By using agent-based modelling, and by understanding the analogies that such models often show with behaviour seen in physics, it might become possible to base some of those decisions on more than wishful thinking or dodgy statistics. In other words, it might become easier to anticipate the kinds of society that might result from certain choices. The hardest issue, of course - and here physics can offer no help - is to decide what kind of society we want in the first place.

Philip Ball's new book Critical Mass: the Physics of Society is published by William Heinemann on Feb 12. To order a copy for £17 plus p&p (rrp £20), call the Guardian book service on 0870 066 7979.