Jens Krause's search for the best subjects to investigate self-organisation led him from honey bees to schools of fish and eventually to people. Little did he know that architects, engineers and even police would soon be knocking on his door.

Jens Krause.

Close to the madding crowd

The conventional view of human behaviour is it is shaped by individual conscious mental activity (I think, I decide, I act) and that it is different in nature and form from animal behaviour. We set out to challenge this notion with a set of experiments which demonstrated that large parts of human collective behaviour (crowd behaviour) can be regarded as self-organised with surprising properties. Self-organisation in this context means that there is no central organisation and that the group properties arise from the interactions between the individuals. This phenomenon is familiar to most of us in the form of Mexican waves in sports stadiums. Here, however, we wanted to explore the implications of self-organised social behaviour in the context of managing crowds in contemporary urban society.

This project started with a seemingly simple question. How many individuals does it take to lead a group? Computer simulations had indicated that this number is between five and ten per cent of the group. We know from some animal groups like honey-bee colonies and fish schools that this prediction approximately matches up with observations. But no experimental test of this piece of theory existed. Initially we were thinking of using animals for this study, but we quickly realised the required training procedures weren't working as well as we had hoped. So we decided to turn to our own undergraduate student population at the University of Leeds for test subjects.

These pilot experiments – involving eight people at most – clearly demonstrated speed and accuracy of movements were greatly improved if one or two leaders led the groups. But then eight people is hardly a crowd. At this point we received a call from a German TV company, WDR (we later repeated this with the Discovery Channel and Channel 5), who offered to organise enough volunteers from the general public to do large-scale tests with hundreds of people. This gave us the exciting prospect of testing whether large crowds could indeed be guided by small informed minorities, but it also opened up the possibility of an extremely expensive, public, large-scale failure, should our pilot experiments not scale up as expected.

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Meeting the film crew at the airport in Cologne, Germany, was already more challenging than we had expected. Five takes of greeting our hosts left us devoid of any emotions and the subsequent simulation of loading non-existent luggage into a waiting van didn't make us feel any better. Things got brighter once we started work on the experiment. People from all over Germany between the ages of 18 and 80 came to a large exhibition hall in central Cologne for the day. Several camera teams were in place and catering provided for all our visitors.

We gave our designated leaders in our crowds two simple rules to follow: stay together and keep walking.

Apart from what we had hoped for, the experiments also threw up a number of unexpected results (see video footage at www.planetearth.nerc.ac.uk; *search: crowd*).

First, as the computer simulations predicted, the minimum number of people needed to guide a group of 200 was indeed somewhere around five per cent. But we watched as control groups that did not contain any informed individuals formed a ring-structure with spontaneous multiple-lane formation in clockwise and anti-clockwise directions. We were surprised to see such a complex social structure emerge from just two simple rules. These experiments showed that human behaviour, just like a lot of animal behaviour, has self-

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organised components. Any individual with information can potentially become a leader so that leadership becomes an exchangeable property.

Swarm intelligence

Another interesting aspect was that people in the group were led without knowing that they were following anybody. This means that they can potentially take advantage of what others know without explicitly realising what it is that others have information about (or even that anybody has pertinent information at all). For this reason one can regard the experiments as an elementary demonstration of swarm intelligence in humans.

What are the implications? Immediately on publication of the first paper we were contacted by people from very diverse backgrounds who provided ideas for applications and collaborations. For example, a police officer wrote saying that during town fights they had noticed that a small group of individuals was usually at the forefront of the trouble and that if they could be controlled then the whole group could be controlled. A historian suggested that in battlefield situations advances and retreats by soldiers often display elements of self-organisation despite all the efforts of the military to establish hierarchies and central control.

Likewise, architects pointed out that information on crowd behaviour would come in useful for the design of football stadiums and public squares. And we have since started running experiments specifically addressing some aspects of how groups can be evacuated from buildings in emergencies. Here it appears that informed individuals in the centre as well on the periphery provide particularly effective crowd control.

At the more fundamental level this work indicates that humans don't always make conscious decisions about everything and often follow others without realising it. This suggests that a large part of our everyday life in pedestrian zones, at work and so on follows principles of self-organisation.

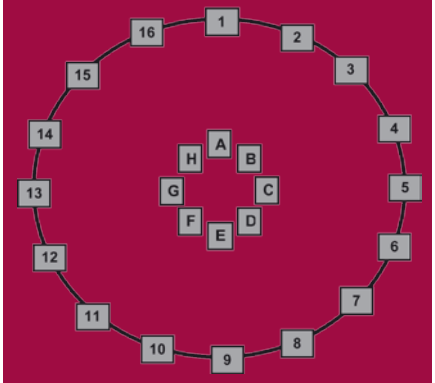
Finally, this work made us realise that there is a lot more we can learn about human nature by carefully observing very ordinary human behaviours such as the way people cross a road and pedestrian flow along busy streets. With population densities ever increasing, an understanding of the dynamics of human crowds will become more important in urban spaces in future whether it is public safety in the context of rapid evacuations from buildings or public squares, whether it is to provide recommendations for efficient guidance of crowds in and out of sports stadiums or underground stations or whether we want to avoid crowds in the first place to prevent any hazards of overcrowding.❖

Standing out from the crowd

The experiment

We asked people to stand on a letter (A-H) on the inner circle. Each group was given the following standard set of instructions: 'When we tell you to begin you should start walking at a normal speed and do not stop before being told to do so. You can walk anywhere inside or outside the circle but you must remain together as a group of eight and you should not talk or gesture to each other.'

As well as these standard instructions, we handed each participant a slip of paper with an individual behavioural rule, one for uninformed individuals ('stay with the group') and one for informed individuals ('go to number X, without leaving the group' where X represents a chosen number on the outer circle).



MORE INFORMATION

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For video footage and animations see www.planetearth.nerc.ac.uk; search: crowd