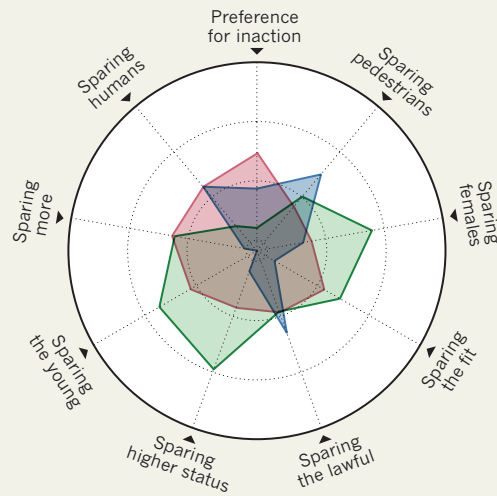
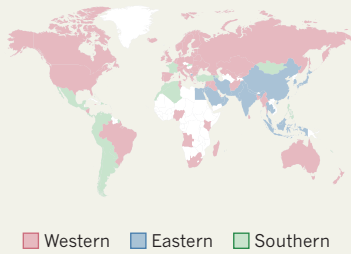


MORAL COMPASS

A survey of 2.3 million people worldwide reveals variations in the moral principles that guide drivers' decisions. Respondents were presented with 13 scenarios, in which a collision that killed some combination of passengers and pedestrians was unavoidable, and asked to decide who they would spare. Scientists used these data to group countries and territories into three groups based on their moral attitudes.



► cultural nuances that governments and makers of self-driving cars must take into account if they want the vehicles to gain public acceptance, they say.

“It’s a remarkable paper,” says Nicholas Christakis, a social scientist at Yale University in New Haven, Connecticut. The debate about whether ethics are universal or vary between cultures is an old one, he says, and now the “twenty-first-century problem” of how to program self-driving cars has reinvigorated it.

Some of the world’s biggest tech companies — including Google, Uber and Tesla — and car-makers now have self-driving-car programmes. Many of these companies argue that the vehicles could improve road safety and ease traffic, but social scientists say the cars raise complex ethical issues.

In 2016, Rahwan’s team stumbled on a paradox about self-driving cars²: in surveys, people

say they want an autonomous vehicle to protect pedestrians, even if it means sacrificing its passengers — but also that they wouldn’t buy self-driving vehicles programmed to act in this way.

Curious to see whether the prospect of self-driving cars might raise other ethical conundrums, Rahwan gathered psychologists, anthropologists and economists to create the online Moral Machine quiz. Within 18 months, it had recorded 40 million decisions made by people from 233 countries and territories.

No matter their age, gender or country of residence, most people spared humans over pets, and groups of people over individuals. These responses are in line with rules proposed in what might be the only governmental guidance on self-driving cars: a 2017 report by the German Ethics Commission on Automated and Connected Driving.

But agreement ends there. When the authors

analysed answers from people in the 130 countries with at least 100 respondents, they found that the nations could be divided into three groups (see ‘Moral compass’). One contains North America and several European and other nations where Christianity has historically been the dominant religion; another includes countries such as Japan, Indonesia and Pakistan, which have strong Confucian or Islamic traditions. A third group consists of Central and South America, as well as France and former French colonies. The first group showed a stronger preference for sacrificing older lives to save younger ones than did the second group, for example.

Test versions of autonomous cars are cruising through several US cities. By 2021, at least five manufacturers hope to have self-driving cars and trucks in wide use.

Bryant Walker Smith, a law professor at the University of South Carolina in Columbia, says that the study is unrealistic because there are few instances in real life in which a vehicle would face a choice between striking two different types of person. “I might as well worry about how automated cars will deal with asteroid strikes,” he says.

But Barbara Wege, who heads a group focused on autonomous-vehicle ethics at the car manufacturer Audi in Ingolstadt, Germany, says that such studies are valuable. Wege argues that self-driving cars would cause fewer accidents, proportionally, than human drivers do each year — but that events involving robots might receive more attention.

Surveys such as the Moral Machine can help to prompt public discussions about inevitable accidents, and so might foster trust. “We need to come up with a social consensus,” she says, “about which risks we are willing to take.” ■

1. Awad, E. *et al.* *Nature* <https://doi.org/10.1038/s41586-018-0637-6> (2018).

2. Bonnefon, J. *et al.* *Science* **352**, 1573–1576 (2016).

DISASTER MANAGEMENT

Data hint at quake forecasts

Italian–earthquake analysis suggests possibility of predicting aftershocks of some quakes.

BY KATE RAVILIOUS

In 2016, three deadly earthquakes struck Italy between August and late October. Now, an analysis suggests the mechanism that might make such quakes unfold over a period of days or weeks, rather than as a single strike. The conclusion has stirred up excitement among earthquake researchers, because it raises the possibility that seismologists could make life-saving forecasts of the big quakes that follow the first, large quake in a sequence. But challenges

remain, including how best to communicate the risk to people who might be affected.

Currently, seismologists can forecast earthquakes only in vague terms — say, estimating a 30% chance of one in a large region in the next 50 years. Most earthquakes take the form of a single large quake followed by aftershocks of decreasing size. But in ‘sequence quakes’, such as the 2016 Italy event, energy is released in a stop–start manner: several large quakes are interspersed with smaller aftershocks. Scientists aren’t sure why this happens.

The latest research — which was published in August and will be presented at the American Geophysical Union Fall Meeting in December in Washington DC — suggests that the answer might lie in the interplay of faults and the movement of underground fluids (R. J. Walters *et al.* *Earth Planet. Sci. Lett.* **500**, 1–14; 2018). This knowledge could, in theory, be used to predict potentially deadly follow-up quakes.

Sequence quakes occur in all tectonically active areas of the world, but they are thought to be more prevalent in geologically young

fault systems. In Italy's Apennine mountains, which run the length of the country, these quakes occur every few decades, most recently in 2016, 1997 and 1979. More than 300 people died between 24 August and 30 October 2016 as a result of the three earthquakes that hit central Italy, each larger than magnitude 6. The small, historic town of Amatrice was badly damaged by the first quake, and 299 people died.

“Essentially, we can consider sequence quakes as ‘failed’ big earthquakes,” says Richard Walters, a geophysicist at Durham University, UK, who led the research. “The initial stress conditions are the same, but the cascading rupture of multiple segments takes place over days to weeks instead of over seconds.”

COMPARE AND CONTRAST

To find out why, Walters and his colleagues took advantage of the wealth of satellite data from the Italian 2016 quakes. The satellites — part of Europe's Sentinel Earth-observing constellation — provided images of the shape of the ground surface. Because the data were taken roughly every 1.5 days, the scientists were able to compare images from before and after each quake and calculate how the ground had moved.

Combining these data with seismological and ground-based measurements, the team found that a network of smaller, cross-cutting faults underlies the Apennine region. The researchers say that these small faults act as barriers to the rupture process, preventing major faults from being ‘unzipped’ in one go. Had the faults all failed at once, the region would have experienced a single earthquake with a magnitude of about 6.7 — some 50% stronger than the largest individual quake that did strike.

Studying the thousands of small aftershocks



The Italian town of Amatrice was largely demolished in three earthquakes in 2016.

that followed the first quake, the team observed tiny quakes creeping northwards at a rate of around 100 metres a day — and found that this matched the speed at which naturally occurring underground fluids would be expected to move along fault lines. “The pattern of small aftershocks suggests that each subsequent quake is triggered by the increased pressure associated with fluids being pumped through the network of minor faults,” says Walters. The second quake, two months later, occurred exactly when the aftershocks — and fluid, as predicted by the team's models — reached the next major fault line. “The fluids are being driven by pressure changes. When they reach a fault, the increased pressure ‘unclamps’ the fault and allows it to move,” says Walters.

Nicola D’Agostino, a geoscientist at the National Institute of Geophysics and Volcanology in Rome, finds the mechanism plausible. D’Agostino also agrees that it's theoretically possible to forecast the later quakes, but says it could be tricky to know when a quake is a one-off event and when it is the start of a sequence.

Stephen Hicks, an earthquake scientist at the University of Southampton, UK, thinks that the findings will change how geoscientists work. “Normally, we don't try and interpret aftershocks until later, but I think this will spur scientists into analysing more-subtle features in real time,” he says. “The challenge will be to monitor and interpret the data quickly enough to provide a meaningful forecast.” ■

PUBLISHING

China's academics await national journal blacklist

But some researchers say the policy won't succeed in improving research quality.

BY DAVID CYRANOSKI

A proposal by the Chinese government to create its own blacklist of journals is creating much debate among the country's scientists, who are still waiting for the list to be revealed, five months after the plan was announced.

Preparation of the list has been shrouded in secrecy. The government says it will include journals that it considers to be of poor quality or those seeking excessive profit, but it has not released its selection criteria, nor has it said

when the policy will take effect.

A couple of commercial blacklists exist, and some Chinese institutions already have lists of journals that researchers should avoid, but lists run by government agencies are rare. The Chinese government hopes that a national policy will improve research integrity by reducing the number of low-quality or fraudulent articles from Chinese authors. Academics will receive warnings if they submit to the selected publications.

But some researchers say that a national blacklist won't fix these problems and will

be difficult to manage. Lists of approved publications are a better tool for improving research quality, they say.

The science ministry was tasked with creating a blacklist in May, when the government announced a crackdown on scientific misconduct after numerous cases of fake peer reviews, plagiarism and the use of fraudulent data. At the time, the government said that the list would include domestic and international scientific journals, and that publications in these journals would no longer be counted towards a scientist's applications ▶