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Out of control

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IN OCTOBER 1999, a local passenger train passed through a red light at Ladbroke Grove junction and hit a packed express heading into London's busy Paddington station. Thirty-one people lost their lives. In the aftermath of the crash, people were shocked to learn that British train drivers passed through red lights on no fewer than 73 occasions that same month. It's at times of tragedy like these that we wish technology could step in whenever fallible humans fail.

But are we kidding ourselves? Whether in our cars, at work or at home, many of us just assume that technologies designed to take over during an emergency, reduce our workload, or keep our hands free are a good thing. Our own research, however, suggests automation should be approached with extreme care. Simplifying a job or making it physically easier doesn't always make things more straightforward for our brains.

In recent years, researchers like ourselves have been looking at how psychology can guide the design of technology, rather than just expecting people to learn to cope with it. This is one element of the science of ergonomics—and it's already thrown up a few surprises. We're finding that technologies as diverse as hands-free kits for phones in cars and automation systems for railways and aircraft, which are meant to reduce accidents, may do nothing of the kind. At best they may change the nature of accidents. At worst they could actually cause them.

Car manufacturers are getting in on the automation game—perhaps not surprising, given that 90 per cent of road traffic accidents are attributed to human error. Volvo, General Motors, Nissan and Mercedes-Benz are just a few of the companies working on collision-avoidance systems and intelligent skid-control devices. BMW, Jaguar and Mercedes-Benz already sell cars that can automatically adjust their speed to maintain their distance from the car in front. In time, we're also likely to see automatic steering. But are systems like these, which take control from the driver, really the key to safe motoring?

Tunnel vision

We all perform badly when we're overloaded with information or things to do. Stressed people develop a kind of tunnel vision—they try to reduce their workload by filtering out anything that isn't in their central focus of attention. It's not surprising, then, that designers assume that giving drivers less to do gives them less opportunity to get things wrong. But perhaps giving people too little to do is just as dangerous.

In our driving simulator lab at Brunel University in Egham, Surrey, we can recreate the experience of driving with anything from fully manual controls—steering, acceleration, gear changes and braking—to fully automated ones, where the driver simply monitors the car as it drives itself. We measured the spare mental capacity people had when they were driving with different levels of automation, by seeing how effective they were at completing a series of visual puzzles at the same time. We also monitored drivers' eye movements to work out what they were paying attention to at any moment. Not surprisingly, increased levels of automation reduced the mental demands of driving—people had much more time to pay attention to the puzzles.

You'd expect, then, that in the absence of the visual puzzle, the driver in the more automated simulator would have the spare capacity to handle the situation better if something out of the ordinary happened. Strangely, that wasn't the case. If the driver of a fully automated vehicle suddenly had to take control for an emergency stop, they often didn't react at all. Drivers were much better at avoiding a crash if they had at least some level of manual control. It seems that

"underloading" people—giving them no real psychological role to play—is just as dangerous as overloading them.

We now think we know why. Traditionally, researchers have assumed that our attention has a fixed capacity, and that we have to shift attention between tasks more often to take in more information. But it turns out that the scope of our attention can shrink and grow depending on what we're doing—and that automation is one way to make it shrink.

In the automated car, drivers spent longer paying attention to the puzzles. Yet their performance on the puzzles didn't improve in proportion to the time they spent on them. If they spent three times as long, they only solved twice as many puzzles. Just as a computer closes down excess processing power if it's not needed, it seems that the mind sheds excess attention capacity when the task gets simpler.

This attention shrinkage might explain why a sudden surprise is hard to cope with in the automatic car. It demands more attention than you can supply, and leaves you suddenly overloaded. Peter Hancock, a psychologist at the University of Orlando, Florida, and an expert on human interaction with automated systems, says: "It is not the expected demands which the designer neglects. It's only when the child unexpectedly runs onto the road that the automation throws up its metaphorical hands and gleefully returns control to the unready driver—and guess who will get the blame."

So it looks as if we're faced with a paradox—designers use automation to relieve attention overload, because they think overload causes errors. Yet automation can underload a driver, and this can cause problems too. One controversial solution might be to give the driver extra tasks to do, to keep their workload just high enough to stop their attention capacity from shrinking—if only we knew what just the right workload was. Yet how do you keep someone's attention high, and still focused in the right place?

Clearly you have to be careful about what extra tasks you do while you're driving. As in-car Internet services and mobile-phone-based tracking systems develop apace, we find it extremely worrying that Charles Spence from the University of Oxford and Jon Driver from University College London have found that the risk of having an accident while driving and phoning at the same time is about the same as drinking and driving. We know from our own research that talking on the phone interferes with driving performance more than talking to a passenger does. Many people have assumed the problem is having the hands occupied—and the obvious technological solution is hands-free sets. But Spence and Driver have found that using a hands-free mobile phone is no less risky than a hand-held.

So should we be following Portugal's lead in banning all mobile phones from cars? Or is there a better solution? If it's not the physical distraction of holding the phone that's the problem, then perhaps we should look at the psychology.

Another long-standing theory of attention says that we have separate "channels" for hearing and for seeing. If that's true, the sounds of a phone conversation would reach the brain and be dealt with by a totally different system to the view of the road. Spence and Driver don't believe our attention system can be so compartmentalised, or there'd be no conflict between talking on the phone and driving. Instead, they think that our hearing and seeing channels are linked in a number of ways, and that one of these links depends on where the signal comes from.

Spence and Driver asked volunteers to watch a moving road scene on a computer monitor while repeating a stream of recorded speech that was played to them. They looked at how well people could pick up information from both sources depending on where the sound originates—from a headset, the passenger seat, or in front of the driver. They discovered that people took in most information if the sights and sounds came from the same place.

In other words, phoning and driving at the same time should be easier and safer if the voice seems to come from the road you're watching. This makes good sense. From the moment we're born we instinctively turn our attention towards sounds. And we nearly always look at the person we're talking to. Spence and Driver suggest the phone's loudspeaker should be in front of the driver—in effect, you'd have a talking windscreen.

While clever use of technology might help focus our attention on the road, can it also keep our eyes open? Sleepy drivers are blamed for as many as 30 per cent of road accidents. So perhaps it's not surprising that there are plenty of automatic fatigue-detection technologies in the works that spray the driver with cold water or change the radio station if they spot the telltale signs that he or she is dozing off—lane drifting, a lack of steering movements or even drooping eyelids (New Scientist, 21 July, p 24). They sound like a great idea, but are they monitoring completely the wrong thing?

Michael Russo, a lieutenant colonel in the US Army and neuroscientist at the Walter Reed Army Institute of Research in Maryland, found that when tired truck drivers crashed in a driving simulator, only a few of them were actually asleep. Instead, when he and his colleagues investigated how well the tired drivers were paying attention to their surroundings, they found what amounted to a form of tunnel vision. "These people are awake, conscious and driving, but not paying attention to their peripheral visual field," says Russo.

He says that the frontal and parietal areas of the brain, which are vital for visual attention, spatial awareness and decision making, become particularly sluggish when you're tired. He even likens it to the metabolic equivalent of a mild stroke. The message is that tired drivers are more likely to crash because they fail to notice pedestrians, other vehicles, changing road conditions or road signs—not because they're asleep. He suggests that a low-tech stimulant like a cup of coffee might be more effective than any technological fix for detecting sleepiness.

Fit to drive

Whether or not the detection systems are monitoring the right thing, there are other concerns about them. The Australian National Road Transport Commission has already voiced its concern about automatic fatigue-detection systems, warning that drivers may ignore their own judgement if an automatic system tells them they're fit to drive.

Similar concerns about over-reliance on technology have also been voiced about the automatic train protection or ATP system, whose introduction was called for after the Paddington crash. It has a simple task: to apply the brakes if a train passes a danger signal. At any other time, it shouldn't interfere with the driver's job. Yet Swedish researchers have found that ATP can actually influence the behaviour of train drivers, to the point where it could counteract the safety gain.

One problem with automatic safety systems is that people form expectations about what they are designed to do, and can even learn to depend on them. Instead of driving normally, train drivers might push the ATP system to its limits, skirting the boundaries of safe performance. Lisbeth Harms of the Swedish Road and Transport Research Institute is worried that equipment intended to reduce driver error might not be appropriately designed. Speaking at an ergonomics conference in Stratford-upon-Avon in 1996, Harms concluded that while ATP has the potential to reduce Paddington-type incidents, it might not eradicate them. It could even spawn new types of errors. Drivers might end up relying on ATP rather than the signals themselves—the last line of defence becoming the first point of control.

One thing's for sure—automation doesn't automatically make things safer. While we don't wish to hold back the tide of technological progress, we must be cautious about how we use it. Automation systems should still engage drivers in the business of driving, rather than trying to make them redundant. If we can't work out how to do this, perhaps we should put automation systems on hold until we can.

With so much technology at their disposal, designers might say this defeats the object. It essentially takes us back to square one, with the driver firmly behind the wheel. But until we really know our own minds, that's exactly where the driver should be.

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