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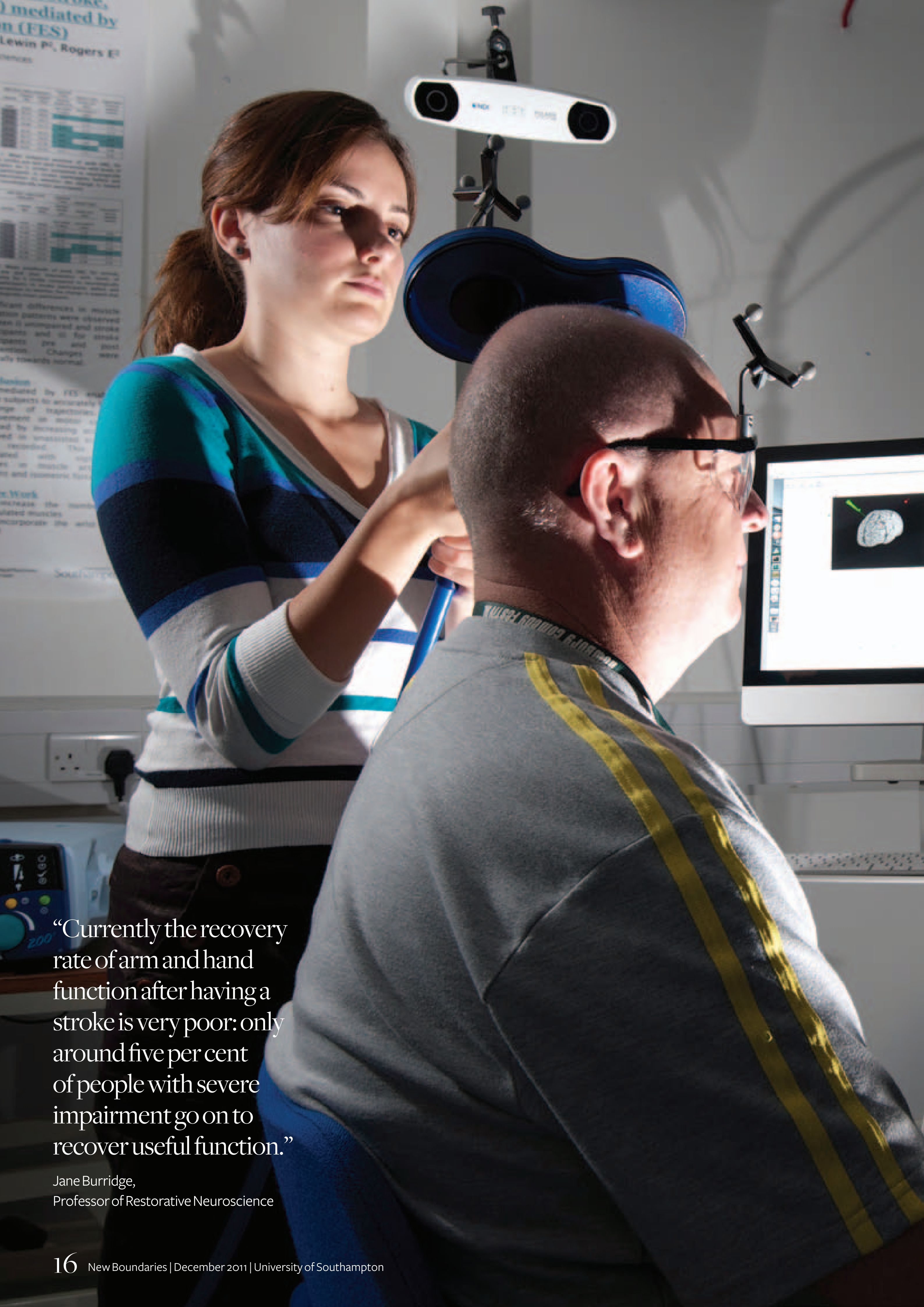


"Currently the recovery rate of arm and hand function after having a stroke is very poor: only around five per cent of people with severe impairment go on to recover useful function."

Jane Burridge,
Professor of Restorative Neuroscience

Helping people recover from stroke

Every year around 15 million people globally have a stroke; it's the third most common cause of death in the UK and the leading cause of severe disability. Now pioneering Southampton research could help people regain movement and feeling in their arms and hands much more effectively after having a stroke.

A stroke happens when the blood supply to part of the brain is cut off. This causes some of the brain cells (neurones) to become damaged or die, breaking the connections between the brain and the muscles and often preventing the person from moving their limbs. Southampton researchers are carrying out groundbreaking research using rehabilitation robots and functional electrical stimulation to enable people who have had a stroke to move their arms and hands again. They are also developing novel tactile devices that stimulate the sense of touch to help people regain lost sensation.

A novel combination

"Currently the recovery rate of arm and hand function after having a stroke is very poor: only around five per cent of people with severe impairment go on to recover useful function," says Jane Burridge, Professor of Restorative Neuroscience. "This is largely because after a stroke many people have reduced movement so don't get the opportunity to practise exercises," she adds. Jane is leading the Southampton team conducting the first randomised controlled trial in the world to study the combination of electrical brain stimulation – known as trans-cranial direct current stimulation, or tDCS – and rehabilitation robots.

The rehabilitation robot supports the arm and helps it to move, enabling patients to regain movement and coordination. While practising in the robot, tDCS, a low-level continuous electrical current, is passed across the brain through electrodes on the head. It raises the electrical excitability of the neurones, helping them to send signals to make the muscles move. As well as helping patients practise a motor skill, tDCS may also stimulate recovery of damaged neurones so that new connections can be made.

The researchers are able to monitor the activity of the neurones using trans-cranial magnetic stimulation (TMS) pulses, which stimulate the brain with a weak magnetic field causing small muscle contractions. The relationship between the strength of the TMS pulses and the muscle contraction provides information about the connections between the neurones and the muscles. In this way, the researchers are able to not only see if someone is getting better, but also understand why. The team is conducting a preliminary trial with five participants using tDCS and rehabilitation robots, to test the technique. With funding from the UK's Wessex Medical Trust, they will be expanding this into a larger trial with 40 participants who have recently returned home after a stroke.

As well as using tDCS to stimulate neurones in the brain, Jane's team is also studying the effect of using functional electrical stimulation (FES) to activate the muscles of the arm directly while participants are exercising in the robot. FES assists them to perform simple tasks repeatedly and so recover useful movement. In one trial, for example, participants played a computer game that involved moving a ball along a tube. The researchers looked at the difference, or error, between how they performed at this task and a perfect score, and stimulated the muscle by a controlled amount to correct for the error. "When you're practising a skill like tennis, you learn and refine your performance by adjusting to whether you have hit the ball inside or outside of the court," says Jane. "If you have had a stroke and can't move, then you can't get that practice and correction. The electrical stimulation enables people to move their arm and helps them to correct the error and improve at the task." ▸

Southampton researchers are conducting the first randomised controlled trial in the world to study the combination of electrical brain stimulation and rehabilitation robots. The robot (pictured here) supports the patient's arm to help improve movement and coordination

"The multidisciplinary collaboration and state-of-the-art facilities at the University of Southampton have been crucial to the success of this project."

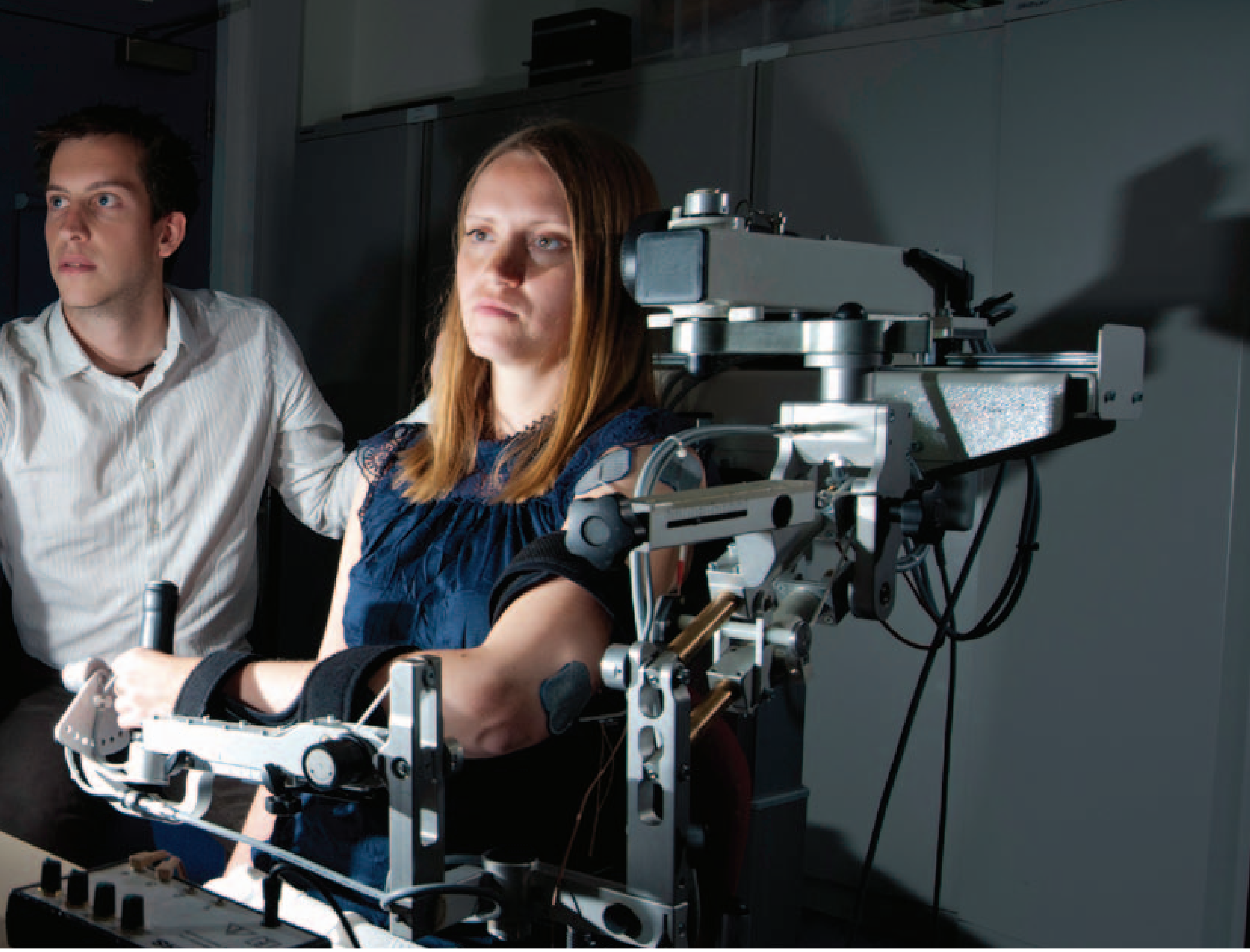
Dr Geoff Merrett,
Lecturer in Electronics and Computer Science

This study, funded by the Engineering and Physical Sciences Research Council (EPSRC), is based on an approach known as iterative learning control: the participants repeat the task, see how they have performed and then, through practice, they continually improve. These preliminary trials have shown that the technique is very promising and the team is now working towards designing systems that patients can use at home, improving their recovery and bringing significant cost savings for the NHS. "The long-term aim of this research is to give physiotherapists practical and smart tools to help stroke patients take responsibility for their own rehabilitation. The techniques we are using tap into the way people normally learn a new skill, and our overall aim is to give them the support that enables them to practise," says Jane.

Sensory aspect

Southampton researchers are also developing novel devices that help stroke patients regain the sense of touch in their arms and hands. Dr Geoff Merrett, who is leading the project, says: "The sensory aspect of stroke rehabilitation hasn't had much attention so far, but it is vital. It's all very well being able to move your hand to pick up an object, but when you can't feel that object, you don't know whether it's slipping out of your hand or whether it's hot or cold. The devices we're designing will reinforce those perceptions."

The team has now developed three different devices that provide a sensation by stimulating the receptors in the fingers. These include a 'vibration' tactile device; a motor-driven squeezer device; and a 'shape memory alloy' device that, between them, can apply a range of sensations including temperature, pressure and vibration. A group of stroke patients and healthy participants gave detailed feedback on how they felt the devices had performed. "Most stroke rehabilitation systems ignore the role of sensation and they only allow people repetitive movement," says Dr Sara Demain, a physiotherapist at the University of Southampton, who works with people



who have experienced a stroke. “Our aim is to develop a technology that provides people with a sense of holding something or of feeling something, like, for example, holding a hot cup of tea, and we want to integrate this with improving motor function.”

The results showed that participants with the most severe impairments reacted best to the vibration and the least impaired reacted best to the shape memory alloy devices, so it’s likely that the final version of the device will include a combination of different modalities. The testing also revealed that the devices need to be small, light and not obstruct movement so that they don’t impede the normal function. “It’s incredibly important to take on board the views of the user from day one if you want to create an effective new technology that people will actually use. We have taken this feedback, as well as feedback from clinicians and carers, into consideration to design new, improved versions of the devices,” says Dr Cheryl Metcalf, a lecturer in biomechanics whose research spans the fields of both health science and electronics. “By considering all these perspectives, especially in an economic climate like this, we hope to come up with a device that will be accepted not only by the patient community, but also by funding bodies like the NHS,” Cheryl adds.

The project received initial funding from the University of Southampton’s Adventures in Research fund, and the team has just secured further funding from the UK’s Technology Strategy Board to continue this research towards a workable prototype in a few years’ time, which will then be ready to go through clinical trials. The ultimate goal is to translate the device out of the clinical setting and into people’s homes, so it can be part of a toolkit to be used alongside other technologies such as tDCS, rehabilitation robots and conventional therapies.

“The multidisciplinary collaboration and state-of-the-art facilities at the University of Southampton have been crucial to the success of this project,” Geoff says. “We have a team of physiotherapists, electronic engineers, biomechanists, psychologists, and a mechanical engineer all bringing their insights. And with our new equipment, we have been able to print out the 3D plastic devices directly.”

This research looks set to have a major impact on stroke rehabilitation research. As Jane says: “Anyone who has had to endure the debilitating effects of a stroke, either themselves or in helping a loved one in that situation, will know just how difficult it can be. Through our research across the different disciplines, and with the help of people who have had a stroke, we are really hoping to transform the recovery process and make life more manageable for those who find themselves in that situation in the future.”

For more information, visit
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