Real-time feedback a boon in rehab

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Physiotherapist Karl Schurr helps Vera on stepping tiles adapted for bed use. Credit: Sahlan Hayes

Laser-cut acrylic tiles with a 3D printed core and the capacity to be wired up to "interact" with patients offer a new tool for people recovering from stroke and other brain injury.

The highly sensitive stepping tiles are linked to a computer with customised software that gives both patient and therapist graphic real-time feedback on a range of rehabilitation tasks. Patients can use the tiles while standing, sitting or lying down.

The tiles were designed by Associate Professor Bert Bongers and his team in the Interactivation Studio at the University of Technology, Sydney (UTS) and are now part of the world's largest trial looking at the rehab potential of computer games, iPad apps and interfaces such as the Nintendo Wii.

The three-year study, funded by the National Health and Medical Research Council, is led by physical activity researcher Professor Cathie Sherrington, from the George Institute for Global Health and the University of Sydney. It involves 300 patients and a team of health professionals, engineers, designers and consumers.

About 50,000 Australians suffered a new or recurrent stroke last year and more than half of them were left with a disability that affects their ability to live independently.

"Smartphones, tablets and computer games are part of most households these days … and we know that more exercise is associated with better [rehabilitation] outcomes," says Professor Sherrington.

"Technology may provide a way to achieve more exercise without extra staff time as the devices offer feedback and encouragement and can be fun."

One of the trial sites is Bankstown-Lidcombe Hospital, where physiotherapist Karl Schurr is using the stepping tiles in the "hall of champions", as the hospital gym is affectionately known.

On a specially designed tilt bed at the end of the room, Schurr is helping 71-year-old Vera (Not her real name) with a therapy routine that will help her regain some strength in her right leg after a severe stroke in late January.

"Push, push, all the way … there you go … and relax," says Schurr. "And push … push … that's the one … make it big." Vera bends and straightens her leg, her foot applying pressure to a plastic tile at the end of the bed.

The distinguishing feature of this therapy – and, for Schurr, perhaps the most exciting – is that his patient, whose stroke also left her with cognitive impairment and limited communication skills, can see her efforts on a laptop screen beside the bed. Achievement is writ large, via the bold interface of dots and circles that react as Vera pushes and relaxes her leg.

Schurr says the tiles provide clear, essential information for people with brain damage with the aim of helping them "learn to change the ways their brains work … When Vera is pushing, we've got to make sure she's getting good feedback."

Three weeks ago, Vera was low and unmotivated, unable to do anything with her right leg. The enormous progress she has made since, says Schurr, means she should be mobile enough in a month or so to leave hospital to live with a family member – "probably not walking, though [in time] she may learn to walk".

In the Faculty of Design, Architecture and Building at UTS, Dr Bongers has been exploring interactive rehabilitation since 2009, when he began collaborating with Dr Stuart Smith, now Adjunct Professor of Disruptive Technologies at the University of the Sunshine Coast. The first iteration of stepping tiles was developed by UTS industrial design student

Rebecca Hall, based on a sensing principle Dr Bongers used for an interactive architectural project in the Netherlands.

Dr Bongers says the tiles meet three key challenges in rehabilitation: boredom or lack of motivation (patients receive good feedback and tasks can made more fun); one size does not fit all (tiles can be customised according to patients' therapy needs and progress); and independence (portability and ease of use allow patients to practise with or without a therapist).

"All successful designers understand what people's needs are; they respond to that. So we spent a long time just hanging out on the ward, observing, talking to people – sometimes through formal interviews, often informally," says Dr Bongers.

"Often the hardest thing is to find out what people actually need … most of the time they don't know what they want … You need to observe, elicit, look at the implicit interactions of what people do."

Rehabilitation tasks are often repetitive and the increments of progress small. As in many computer games, the stepping tiles are set up to have patients continually striving to improve their performance – to reach a pre-programmed target and push on to the next level.

"The real-time feedback provides motivation that is difficult to unlock otherwise," says Dr Bongers. "The digital interface also saves time for therapists who are able to draw data from the application … rather than spend their Friday afternoons inputting [patient] data."

Because the tiles are made using open-source hardware and instant manufacturing techniques, such as 3D printing, Dr Bongers says, "we can change things … slightly bigger, on an angle, different colour … you can change these things very quickly."

He says ideally a stroke patient would use this interactive technology "from day one, the earlier the better … the best chance of recovery comes in the first hours, first days after a stroke. There's no time to lose."

Dr Bongers' team has many ideas for interactive modules for therapies, exercises and aged care, some of which have been developed as proof-of-concept demonstrators. The tiles are sold as on-demand products.

Back in the hospital gym at Bankstown, Peter Connelly, 55, of Campbelltown, is using the stepping tiles to learn to walk again. His left leg was amputated above the knee in November because of complications from a blood clot and he recently started wearing a prosthesis.

He has migrated from crutches to a pair of walking sticks – the tiles are part of a suite of rehab activities designed to teach him to use his prosthetic leg safely and effectively. The tiles count the repetitions of his steps, and show how his weight is distributed, while a therapist advises on his technique.

"The hard thing for people with a stump is that they get no information as to where they are in space," says Schurr. "What Peter's learning to do is to get his weight on to that [amputated] leg and on to the forefoot … he's got to learn to trust that prosthesis, which is a real leap of faith."

Schurr, who has been a physiotherapist for 30 years, says the next decade will be one of exciting progress for rehabilitation as researchers and designers work with health professionals to produce equipment that is cheap and readily available.

He also anticipates technology allowing stroke survivors to communicate with one another, via rehab apps, for example.

"I've worked with people with stroke for a long, long time but I still don't know what's like to have a stroke. Other stroke survivors do … there's this real community of people out there … working very hard [at their rehab].

"Stroke survivors could have an app on their phone and talk to one another about how their practice is going and show people how they're changing over time."

Dr Bongers and his team are collaborating with technology company Snepo to reprogram the stepping tiles' software as a smartphone or tablet app. The design of the tiles is also being refined for easy manufacturing in low volumes.

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