Improving the memory of stroke survivors

University of Canterbury researchers have designed a cutting-edge computer-based treatment that improves the memory of stroke survivors.

Professor Tanja Mitrovic and Dr Moffat Mathews (Computer Science and Software Engineering) have led a project which has enhanced the prospective memory — the ability to remember to do actions in the future — of stroke survivors.

Stroke is a leading cause of death and a major contributor to disability in New Zealand, and Mitrovic says current rehabilitation research and practice predominantly focus on managing disabilities rather than improving cognitive outcomes. Deficits in prospective memory also reduce independence and adversely affect quality of life.

"Research developing effective computer-based cognitive rehabilitation is of high importance. The extent of impairment following a stroke directly affects aspects of daily functioning and often necessitates constant care," she says.

"Customised rehabilitation, performed by trained medical staff, is required but is labour-intensive and expensive. Neuropsychological research suggests that appropriate cognitive training could improve functioning, remediate core deficits, and positively affect quality of life, which is what we set out to do and successfully achieved."

The research, funded by the Marsden Fund, involved developing a treatment based on visual imagery and a virtual reality environment which was tested on 15 stroke survivors aged between 45 and 82 years in a 10 session study.

"Our visual imagery training teaches participants to remember a list of tasks with their associated cues using visual imagery as a mnemonic strategy," Mitrovic says.

"The training is presented in audio, images, video and written text. During training, participants gradually progress from remembering individual pairs of words to remembering complex, real-world tasks.

"We made several videos that we used in the study of driving around Christchurch on different routes. So, before they started, we would give them a set of tasks to remember by using this technique. Then they would start watching the videos and when they saw a place or something important they would stop the video and record whatever they were supposed to do."

The virtual reality environment was designed to help participants remember to do key everyday actions, from remembering to call the doctor for an appointment at 4pm, to remembering to bring in the washing if it starts raining, or collecting a parcel from the door that was delivered by a courier.

"We designed typical household scenes in a home with all the household items they may need. At the beginning of each session we would give them a set of problems to remember and they were supposed to move around the virtual environment and perform the tasks using a joystick.

"The results of our treatment, which were assessed using the CAMPROMT test, an internationally recognised, independent, reliable and valid psychological test of prospective memory functioning, showed a significant improvement in prospective memory functioning.

"Our lab study revealed that the prospective memory skills of participants improved significantly after the treatment and virtual reality practice," Mitrovic says.

"Even more impressively a delayed test conducted four weeks after the virtual reality practice show that the improvement is stable.

"Analysis of the data collected from the visual imagery training, as well as the data from the video and virtual reality practice, show the participants have improved their performance during the study."

Mathews says the team, which also included Research Fellow Jay Holland, Professor Stellan Ohlsson from the University of Illinois, Chicago, psychologist Dr Audrey McKinlay from the University of Melbourne, and UC students Anthony Bracegirdle, Scott Ogden, Jon Rutherford, Tegan Harisson, Matt Lang and Sam Dopping-Hepenstal, conducted multiple projects to inform the best way to undertake the study with stroke survivors.

"We have had a number of studies leading into this. We have evaluated our approach with three groups of people: healthy young people, healthy older people, and stroke survivors. Having different studies has provided us with a cross-dimensional view on how prospective memory works in these age ranges," Mathews says.

He says that extensive research was undertaken with healthy people to determine the best input device for post-stroke survivors, some of whom would be physically disabled, to successfully participate in the study.

These included investigating brain-computer interfaces that use electroencephalography (EEG) to access neural activity that could enable participants to control software by using facial expressions and thoughts in the virtual reality environment.

"Some participants in the study reported discomfort after about half an hour of wearing the EEG device. The conclusion was that it required too much training time and therefore it would not be a good solution for a stroke survivor," Mathews says.

Further studies were conducted into different input devices such as a joystick, keyboard and Razer Hydra, which are two hand-held controllers that sense motion and can be used to navigate around the environment and interact with it; as well as an Oculus Rift, which is a virtual reality headset that gives the user a sense of actually being in the environment with a stereoscopic view, providing full 3D immersion in the environment.

"Each participant trialled the system six times: three different devices for interaction using the keyboard, joystick, and Razer Hydra, without the Oculus Rift, and the same devices were also trialled with the Oculus Rift.

"The participants completed several tasks in a specific order, such as taking items from the pantry or turning on the radio. The participants then completed a short survey and rated their experiences with the devices. It was found that users preferred the joystick for interaction and also that the Oculus Rift induced motion sickness in an alarming number of participants with 18 experiencing motion sickness, five of those so much so they had to stop and finish the experiment early."

Another device, the Tobii eye tracker, was also investigated to determine if it would allow users to control the computer using eye movements.

"Tobii gives sufficiently precise information about the user's eye-gaze, which is robust to head movements. The version of virtual reality controlled solely by the eye gaze was developed, which allowed the user to move around the environment by looking to the left or right of the viewport. In order to select objects or interact with them, the user could blink," Mathews says.

"In the end we determined the easiest and most efficient way for the stroke survivors to conduct the study was to use a joystick."

Mitrovic says she is delighted so much hard work has resulted in a positive result with post-stroke patients being assisted in regaining their cognitive skills by improving prospective memory.

"We are now hoping to work with clinicians and investigate brain injury to see whether the system we have developed could also assist others recovering their cognitive skills and improve their prospective memory," she says.

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