

Final report summary:

Targeted aiming practice and brain stimulation in upper arm recovery

Enhancing the role of the contralesional hemisphere to promote recovery of shoulder and upper arm function – a pilot study

Why did we fund this research?

Movements during daily life are performed at various speeds depending on the requirements of the task. For example, quickly crossing the road during a short traffic light cycle or accurately and slowly placing a key into a lock.

In rehabilitation after a stroke, most arm movement exercises are performed slowly, as it was thought that performing arm movements too fast could result in increased muscle stiffness known as spasticity, which would hinder recovery.

Therefore one aim of this study was to understand the effect upon recovery of arm movement rehabilitation at different speeds.

In addition, most of the research into upper limb rehabilitation after stroke has focused on returning function to the hand, with much less known about arm movement closer to the body, at the upper arm and shoulder. Importantly, scientists have found that there is a distinct difference in the way the brain controls movement at the hand, as opposed to further up the arm. At the hand, only the side of the brain opposite the hand is involved in controlling its movement. However, for the upper arm and shoulder, both the right and left sides of the brain have been shown to be involved.

The importance of this phenomenon is that in people with arm weakness after stroke, the side of the brain undamaged by stroke may be encouraged to help with recovery of upper arm and shoulder movement and thus improve their ability to reach.

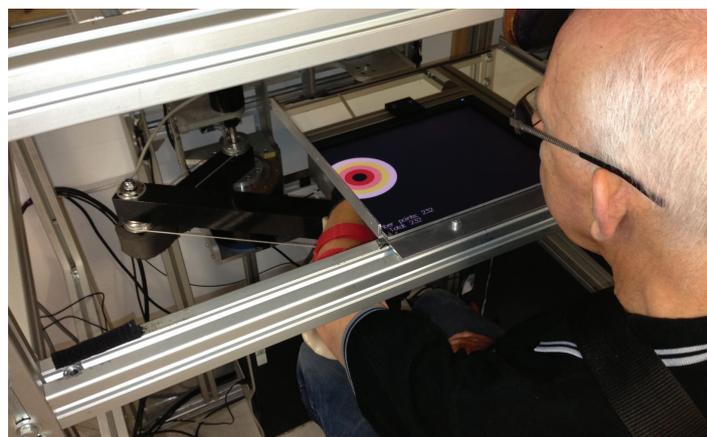
In this study, a pilot experiment was conducted with 14 healthy people without stroke. They were trained to use a robotic arm manipulator to practise a reaching task (630 repetitions per day) for six days. They performed the task at four different speeds, from slow to fast. The participant's accuracy of reaching was the primary measurement recorded, with additional measurements including the trajectory of their movement also obtained. This gave the researchers a comparison of healthy subjects with the main experiment involving stroke survivors.

Then followed a main experiment involving 37 stroke survivors (very close to the recruitment goal of 40) who were between 3 and 6 months after stroke.

The stroke survivors performed the same reaching task as the healthy subjects. However, they only practised for five days rather than six, and had additional measurements of their movement impairment before and after their participation in the training. These included the Fugl-Meyer test, to assess movement ability after stroke, and the NIHSS (National Institutes of Health Stroke Scale), which is a measure of a range of impairments caused by stroke.

In addition, a smaller group of 22 of these stroke survivors underwent safe, non-invasive brain stimulation called TMS (transcranial magnetic stimulation) to measure how many new brain cell connections each side of their brain had made as a result of the reaching task training. The process of forming new brain cell connections with learning is known as 'neuro-plasticity', and the prediction was that the healthy side of the brain, unaffected by stroke, would grow more connections to compensate for the dysfunction of the side damaged by stroke.

The study was carried out by researchers at the Institute of Neurology, UCL (University College London), and involved assistance from colleagues at the Institute of Cognitive Neuroscience, also at UCL to build the robotic equipment.



Stroke survivor performing the reaching task with the robotic manipulator

What did the researchers find?

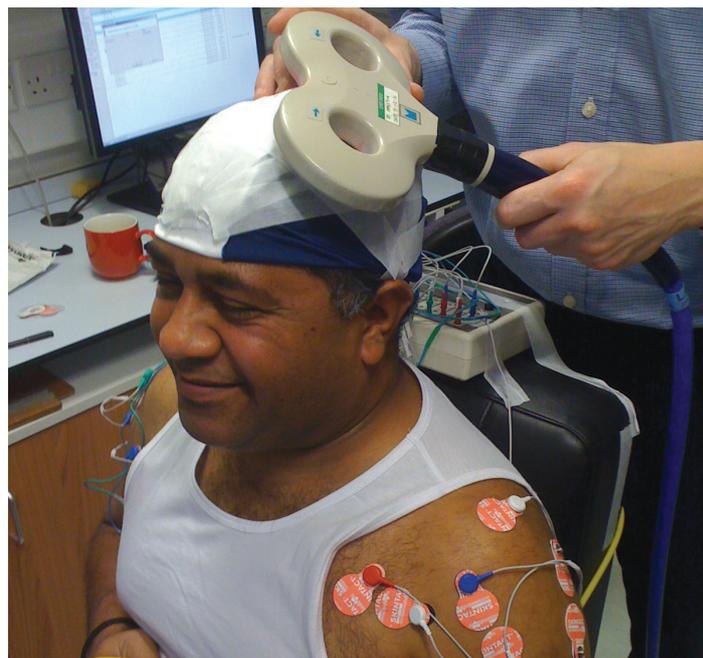
Performing the task at high speed did not cause increased spasticity in the stroke survivors who took part, but conversely caused a reduction in spasticity, and improved their functional ability to reach when not using the robotic training device.

For the healthy participants who took part, the accuracy of their movement, whether performed at high or low speed, improved with training and to the same degree. The training biased all other reaching movement toward the speed at which they trained. This meant that after training at slow speed, all subsequent reaching movements whether fast or slow, became slower. Likewise if they had trained at fast speeds, all their movements were biased to being performed faster. The findings were published in an article entitled, 'Movement speed is biased by prior experience', in the *Journal of Neurophysiology* in January 2014.

In the group of 37 stroke survivors who performed the reaching task, the researchers found that all but the most severely impaired participants made improvements in their reaching ability, irrespective of whether they performed slow or fast training. However, unlike the group of healthy participants who performed the training, effects of training at fast speeds did not translate to faster movement at slow speed, or vice versa. The researchers suggest that this may be due to two separate and distinct forms of learning taking place. At slow speed, the stroke survivors improved their accuracy through better integration of feedback they received during the task, whilst at fast speed their accuracy was improved by increased excitability of the movement areas of their brain, and predictive, feedforward learning mechanisms.

The result from measuring neuro-plasticity with TMS of the 22 stroke survivors was that contrary to expectation, no new brain cell connections were observed in the undamaged side of the brain, only the side damaged by stroke. The researchers suggest that this may be due to the fact that the stroke survivors studied were in the chronic stages of stroke (3-6 months after stroke) and that study with stroke survivors in the early days of having a stroke, when neuro-plastic processes are thought to be at their maximum, could provide a different result.

Due to the promising findings of the study, the research group are now seeking to explore the application of the reaching task training with stroke survivors in the early days after stroke, where brain plasticity is reported to be greatest, and to help them make a better recovery. To do this they have formed a collaboration with the Universities of Manchester and Salford, and obtained a Stroke Association Postdoctoral Fellowship for their research physiotherapist, Dr Ulricke Hammerbeck, to continue to manage the project.



Brain connectivity being measured with TMS (transcranial magnetic stimulation).

What does this mean for stroke survivors?

It suggests that stroke survivors with arm weakness after stroke benefit from performing arm rehabilitation at fast speeds. This reduces their levels of spasticity, and improves their functional outcome, rather than increase levels of spasticity as had been previously thought. Overall, the findings of the research suggest that stroke survivors should receive arm rehabilitation exercises performed at a range of speeds that reflect the range of reaching tasks they must be able to perform in their daily lives, to maximise their functional outcomes after stroke.

We are the Stroke Association

The Stroke Association is the leading stroke charity in the UK. We believe in the power of research to save lives, prevent stroke and ensure that people make the best recovery they can after a stroke.

We're here for you. If you'd like to know more, please get in touch.

Stroke Helpline: 0303 3033 100

Website: stroke.org.uk

Email: info@stroke.org.uk

From a textphone: 18001 0303 3033 100

Our research programme is totally funded by voluntary donations.

Please help us to fund more vital research.

Call our Donations line on **0300 3300740**,
or visit stroke.org.uk

Together we can conquer stroke