

Design of Interactive Technology for Stroke Patient Rehabilitation

by Michelle Pickrell

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the degree of

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under the supervision of Associate Professor Bert Bongers
and Professor Elise van den Hoven

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Faculty of Design, Architecture and Building

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Certificate of Original Authorship

I, Michelle Pickrell, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Design, Architecture and Building at the University of Technology Sydney. This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

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Key terms explained

These are the terms which are referred to in this thesis:

Feedback – Feedback is defined as any information about a patient's performance that is presented back to the patient.

Immediate feedback – Feedback delivered to a patient while they are completing a repetition of an exercise. This is feedback about the patient's movement, including whether they conducted the repetition correctly and whether they used any compensatory movements. The intention behind the immediate feedback is to give patients the information that they need to be able to correct their movement for the next repetition. Immediate feedback may be in the form of numbers, as well as graphical elements such as bars and graphs.

Session feedback – Feedback delivered to a patient about the progress of the session, and the number of repetitions completed and yet to complete. This includes the number of correct and incorrect repetitions they have completed as well as how they are tracking against their repetition goal.

Progress feedback – Feedback that presents progress over multiple sessions, often in the form of a graph and using numbers. This allows the physiotherapists and patients to identify trends in the data and to track improvement over time.

Gerontechnology – The interdisciplinary study of gerontology and technology, which has the aim to use technology to enhance the lives of older adults (Birkland, 2019).

Hyperextension – The extension of a joint past its normal range (Ehrlich & Schroeder, 2005).

Hyperflexion – The bending inwards of a joint past its normal range (Ehrlich & Schroeder, 2005).

Interaction – A process of mutual influence between two or more entities, including control and feedback of processes and physical manipulation of objects and interfaces, in any mode and/or modality.

Interface - The part of the interactive system that facilitates input and output (control, feedback and information representation), in any mode and/or modality.

Modality – The way information is perceived, through the sensory modalities (related to the sensory channels such as vision, auditory or tactual), and expressive modalities (the way we express ourselves, e.g. through voice, gestures, or manipulation) (Bongers, 2006).

Mode – The way information is represented, from iconic (mimetic e.g. images) to symbolic (abstract e.g. text).

Occupational therapy – The practice of supporting and enabling people to participate in activities of daily life (Hinojosa & Blount, 2004).

Occupational therapist – A person who works closely with patients and supports them to engage in the occupations they need to at their stage of life. This can be through training as well as modification of their environment to allow them to better engage in tasks of daily living (Barney & Perkinson, 2016).

Participant – A person who was involved in one of the studies in this thesis, who was not a patient or a physiotherapist at Bankstown-Lidcombe Hospital. This was primarily people who had also undergone rehabilitation at some point in the last few years. However, some were designers and some physiotherapists who worked in other areas of physiotherapy.

Patient – Someone who has suffered from a stroke and is undergoing rehabilitation in the rehabilitation gym.

Physiotherapy (Physical therapy) – The practice of assessing, planning and implementing rehabilitation programs that improve or restore motor functions, maximise movement ability, relieve pain syndromes and treat or prevent physical

challenges associated with disease, injury or other impairments (World Health Organisation, 2004).

Physiotherapist (Physical therapist) – A person who evaluates and establishes a care plan for people with health problems resulting from injury or disease. A physiotherapist may provide exercise intervention and evaluation including assessing joint motion, muscle strength, cardiopulmonary function and ability to perform tasks of daily living (Curtis, 2002).

Rehabilitation (Medical rehabilitation) – Rehabilitation is a process aimed at enabling people to reach and maintain an optimal level of physical, sensory, intellectual, psychological, and social function. This includes the tools they need to be independent (World Health Organisation, 2011).

Stroke – Brain injury caused by an abnormality of the blood supply to brain usually caused by blockage or bleeding (Caplan, 2006).

Hemorrhagic stroke – A stroke which results from the bursting of a blood vessel. This causes the vessel to bleed out into the brain, causing swelling and damage to the surrounding tissue (Meyer, Derr & Caswell, 2007).

Ischaemic stroke – A stroke which results from a blockage within a blood vessel in the brain. There are two types of ischaemic stroke, thrombotic and embolic. A thrombotic stroke results from a clot forming within one of the arteries, which supply blood to the brain. An embolic stroke forms outside of the brain and is pushed into the brain and blocks an artery (Klenerman, 2015).

Timeframe – The time period in which information is delivered. This includes immediate, session-based and progress feedback timings.

Abstract

This thesis explores the possibilities of using interactive technologies to deliver feedback to patients who are undergoing stroke rehabilitation. It was identified that unlike many other types of physical rehabilitation, stroke patient rehabilitation usually does not include interactive technologies which deliver feedback to patients about their performance. We also identified that there is a lack of interactive technologies which track a patient's progress and performance improvements over time.

Stroke rehabilitation therapies are by necessity repetitive, and as a consequence can be tedious for patients. Many Sydney-based hospitals are set up with equipment such as pegs, wooden blocks and manual hand counters which are useful for patients who are re-learning to manipulate objects and to complete everyday tasks. However, this equipment does not allow for easy identification of smaller day-to-day improvements.

This thesis is divided into two parts. The first part has the aim of understanding feedback, motivation, and technology use in stroke patient rehabilitation. Observations of patients undergoing rehabilitation with their physiotherapists were conducted, as well as twenty-six interviews with patients and physiotherapists. The types of feedback that are most suitable for patients when performing their rehabilitation exercises were explored. Motivation was discussed with patients as they self-reported their fluctuations in motivation over time. Technology use was explored through interviews and observations with patients and physiotherapists.

The second part reports a user-centred design process to explore feedback delivery to stroke patients using interactive technology. This included an iterative design process where different feedback types were designed and tested with five physiotherapists and twenty-eight patients. This resulted in an evaluated design that delivers feedback to patients in different modes and timeframes.

There are three main contributions of this thesis. The first is a set of design criteria and tools for researchers and designers who are creating interactive technologies for stroke patient rehabilitation. The second is a set of findings exploring the use of technology-delivered feedback for stroke patient rehabilitation. The third contribution is the interactive rehabilitation system that was created to deliver performance feedback to patients.

The main conclusion of this thesis is the clear potential for interactive technologies to deliver different types of feedback which can be personalised for patients depending on their situation. A further conclusion is the importance of having physiotherapists and patients involved throughout the development of new tools for the practice to ensure that the interactive technologies are designed to be appropriate for this context, easy to set-up and reliable.