UNIVERSITY OF SOUTHAMPTON

FACULTY OF HEALTH SCIENCES

Physiotherapy

Explicit and Implicit Motor Learning During Early Gait Rehabilitation Post Stroke

by

Louise Johnson

Thesis for the degree of Doctor of Philosophy

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ABSTRACT

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EXPLICIT AND IMPLICIT MOTOR LEARNING DURING EARLY GAIT REHABILITATION POST STROKE

Louise Johnson

Learning can be explicit or implicit. Explicit learning takes place intentionally, in the presence of factual task-relevant knowledge; whereas implicit learning takes place unintentionally, without concurrent acquisition of knowledge about task performance. The relative benefits of implicit learning have been well investigated within healthy populations. Research consistently demonstrates that skills learnt implicitly are more likely to be retained, and are more robust under secondary task load. However, study protocols tend to involve laboratory based activities, which do not take into account the complexities of motor learning in natural settings. Direct transferability of the findings to stroke rehabilitation is therefore questionable.

Two factors in explicit and implicit learning are the concepts of attentional capacity and attentional focus. Attentional capacity refers to the ability to attend to and process incoming information, whereas attentional focus refers to the location of attention in relation to specific aspects of the task being performed. Theories propose that focussing on specific movements (internal focus) may actually constrain or interfere with automatic control processes that would normally regulate movement, whereas if attention is focussed towards the movement effect (external focus) the motor system is able to more naturally self-organize, resulting in more effective performance, and learning. An internal focus of attention is therefore allied to explicit learning; whilst an external focus of attention is allied to implicit learning.

This research aimed to improve understanding of explicit and implicit learning within early gait rehabilitation post stroke; primarily through the development and testing of explicit and implicit models of learning interventions. It has comprised three phases; a review of the literature; an observational study to gain insight into current practice; and a feasibility study to test the ability of therapists to deliver interventions with a bias towards either an explicit or implicit approach.

Therapists were found to favour the use of explicit techniques; internally focussed instructions and feedback statements were used in high quantities. Practice therefore appeared to be at odds with current evidence; albeit primarily from healthy populations. Guidance for the delivery of explicit and implicit learning models in clinical practice was developed, and then tested in a feasibility study. Therapists demonstrated the ability to change their practice to bias either explicit or implicit learning; both approaches were found to be acceptable to patients and therapists. Recommendations are made on the content and evaluation of explicit and implicit learning models in future research, and specifically, in a Phase II pilot study.

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DECLARATION OF AUTHORSHIP

I, Louise Johnson

declare that the thesis entitled

Explicit and Implicit Motor Learning During Early Gait Rehabilitation Post Stroke

and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
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No meaningful clinical research would be possible without involvement of the people who the research is about. I would therefore like to thank all of the therapists and patients who volunteered to take part in the various stages of this research programme.

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Finally, thank you to my family who, in many different ways, have supported me throughout.

I dedicate this thesis to my beautiful Maxwell and Polly, who arrived along the way, and who somehow motivated me to finish!

Definitions and Abbreviations

ASU	Acute Stroke Unit
BBS	Berg Balance Scale
CNS	Central Nervous System
DMSRS	Dutch Movement Specific Reinvestment Scale
EMG	Electromyography
fMRI	Functional Magnetic Resonance Imaging
HAI	Hauser Ambulation Index
ICH	Intracerebral Haemorrhage
MRC	Medical Research Council
mRMI	Modified Rivermead Mobility Index
MMSE	Modified Mental State Examination
NOP	Neuro Outpatients
NRS	Numeric Rating Scale
PACS	Partial Anterior Circulatory Syndrome
PET	Positron Emission Tomography
PIS	Participant Information Sheet
POCS	Posterior Circulatory Syndrome
RCT	Randomised Controlled Trial
SRT	Serial Reaction Time
SRU	Stroke Rehabilitation Unit
TACS	Total Anterior Circulatory Syndrome
TEL	Trial and Error Learning

1. INTRODUCTION

1.1 Overview

Theories of sensorimotor learning and their clinical application are of significant interest to therapists working in neurological rehabilitation. Following stroke, damage to the central nervous system (CNS) produces a diversity of physical, cognitive, perceptual and psychological impairments that impact on ability to function during day to day life. Physiotherapy focuses on promoting recovery from such impairments, optimising function, and preventing long term complications. The theoretical premise underpinning neurological physiotherapy is that functional recovery occurs through the (re)learning of movement strategies. Therapy directed towards facilitating the acquisition of functional skills must therefore take into account the processes underlying learning.

Two forms of motor learning – explicit and implicit – were under investigation in this research. Explicit learning takes place intentionally (consciously), in the presence of factual task relevant knowledge; whereas implicit learning takes place without concurrent acquisition of knowledge about the task being performed. These categories of learning are described and discussed in detail in Chapter 3 of this thesis.

The effects of explicit and implicit motor learning strategies have been well investigated with healthy populations. Research has shown that tasks learnt explicitly are less robust (performance is more likely to be adversely effected by a secondary task) and are less likely to be retained over time, than those learnt implicitly (see Masters, 1992). In particular, studies within sport have consistently shown differences in learning relative to the performer's degree of explicit knowledge (see section 3.12). However, there is very little published literature regarding the efficacy of explicit and implicit learning strategies within stroke rehabilitation.

Researchers have explored the concepts of explicit and implicit learning within the stroke population using controlled laboratory based tasks such as serial reaction time tasks (see 3.6.1). Such studies give valuable insights into learning behaviour. However, they do not represent the complexities of real-world motor tasks, limiting their relevance to clinical scenarios.

One particular challenge of conducting clinical research in this area is the lack of any formal description or definition of what constitutes explicit and implicit learning, particularly within the context of neurological rehabilitation. Indeed, in the majority of clinical situations, explicit and implicit learning will be occurring, to varying degrees, in parallel. Defining explicit and implicit learning as discrete concepts is therefore challenging. However, changing the practice environment could alter the relative contribution of one or the other form of learning. Research first needs to understand how explicit and implicit models can be applied, and then needs to compare the two approaches to determine whether there is an optimal learning strategy for adults with stroke, particularly for the relearning of specific functional activities such as sit to stand and walking.

This research project will examine the concepts of explicit and implicit learning in patients with sub-acute stroke. Gait training has been chosen as the basis of this research for two primary reasons: firstly, being able to stand, step and walk is an important and commonly strived-for goal in many patients with stroke, and is therefore the focus of many rehabilitation sessions in the early stages of recovery; secondly, although a complex task, walking is relatively easy to define and to measure in a clinical setting, making it an ideal focus for a clinically based study.

Since the concepts of explicit and implicit learning are not well defined within the context of neurological physiotherapy practice, research must first consider how therapeutic interventions can be applied to create bias towards each type of learning. This thesis reports a programme of preliminary work aimed at developing and testing explicit and implicit strategies for early gait rehabilitation post stroke.

1.2 Research Questions

This programme of research aimed to answer the following questions:

1. What is the current evidence regarding the use of explicit and implicit models of learning in both healthy and neurologically impaired individuals?
2. What strategies do physiotherapists currently use for the rehabilitation of gait; and how do these fit with the explicit and implicit paradigms?
3. Can the content of standard therapy be delineated in order to describe what constitutes an explicit versus and implicit learning environment for early gait rehabilitation?
4. Can therapists effectively deliver interventions to create bias towards explicit or implicit learning, and how this can be monitored or measured within a research setting?

Given the complex nature of physiotherapy interventions, the Medical Research Council Framework for Investigating Complex Interventions (MRC, 2000, MRC, 2008) was used to structure this current research programme. The MRC Framework and the overall structure of this research thesis are outlined in the following chapter.

2. METHODOLOGY and THESIS STRUCTURE

2.1 INTRODUCTION

This chapter outlines the overall programme that was undertaken for this present research. The methodological stages of research were aligned to the first two stages of the Medical Research Council Framework for Investigating Complex Interventions (MRC, 2000, MRC, 2008). These stages are concerned with development of the intervention, and testing its feasibility, and are outlined below in section 2.2.

Randomised controlled trials (RCT's) are needed to demonstrate the comparative effectiveness of explicit and implicit learning on the rehabilitation of people with neurological disorders. An essential pre-requisite to designing a relevant and viable RCT is to understand current physiotherapy practice with respect to explicit and implicit learning and to test the feasibility of modifying the clinical learning environment toward a more implicit or explicit approach. This preliminary work is the focus of this thesis.

2.2 Medical Research Council Framework

The Medical Research Council (MRC) provides guidance for the evaluation of complex interventions. The framework was initially developed in 2000, and subsequently updated in 2008. The notable difference between the two frameworks was that the revised model was less linear in nature, providing a more flexible representation, and giving due weight to the development and implementation phases (MRC, 2000, MRC, 2008).

The MRC framework consists of four phases, as outlined in Figure 1. However, these phases are not necessarily mutually exclusive, and the process of conducting research can therefore be iterative, with stages being addressed simultaneously.

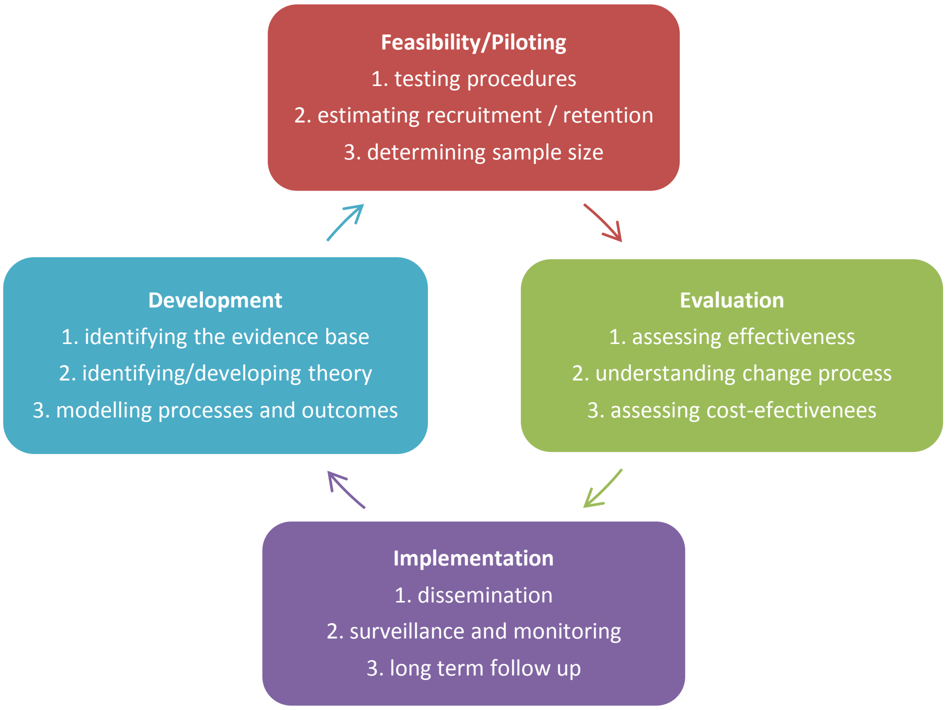


Figure 1 Development and evaluation of complex interventions
Figure outlining the key elements in the development and evaluation of complex interventions (MRC, 2008)

The process from development through to implementation of a complex intervention may take a wide range of different forms. However, best practice is to develop interventions systematically, using the best available evidence and appropriate theory, and then to test them using a carefully phased approach, starting with a series of pilot studies, and moving on to an exploratory and then a definitive evaluation (MRC, 2008).

Previous research studies investigating complex interventions in stroke care are typically focussed at a service delivery level – e.g. stroke unit care or early supported discharge (Kilbride et al., 2005); and few consider complex interventions at a clinical level. Where the MRC framework has been used to structure research protocols, it has typically been with regards to psychological and educational interventions (Redfern et al., 2006, Robinson et al., 2005, Tilling et al., 2005). However, given that the delivery of explicit and implicit approaches within stroke rehabilitation is not well defined, and given the overall complexity of such interventions, the MRC Framework provides a clear and useful structure on which to base this current programme of research.

2.3 What is a complex intervention?

> "Complex interventions in health care, whether therapeutic or preventative, comprise a number of separate elements which seem essential to the proper functioning of the intervention although the 'active ingredient' of the intervention that is effective is difficult to specify" (MRC, 2000)

Complex interventions are widely used in healthcare (Craig et al., 2008), and are conventionally defined as interventions that contain several interacting components (MRC 2008). The term *complexity* can account for various dimensions; these are outlined, along with the implications for research design, in Table 1. Essentially, all research attempting to assess the efficacy of treatment interventions must address three essential components: characterising the participants in the research; characterising the treatments or interventions; and measuring resultant outcomes (Whyte, 2003). The focus of this current research is centred primarily on the second component – characterising the treatment or intervention.

Table 1 What makes an intervention complex?

Dimensions of complexity: • Number of and interactions between components within the experimental and control interventions • Number and difficulty of behaviours required by those delivering or receiving the intervention • Number of groups or organisational levels targeted by the intervention • Number and variability of outcomes • Degree of flexibility or tailoring of the intervention permitted
Implications for development and evaluation • A good theoretical understanding is needed of how the intervention causes change, so that weak links in the causal chain can be identified and strengthened • Lack of impact may reflect implementation failure (or teething problems) rather than genuine ineffectiveness; a thorough process of evaluation is needed to identify implementation problems. • Variability in individual level outcomes may reflect higher level processes; sample sizes may need to be larger to take account of the extra variability, and cluster- rather than individually-randomized designs considered. • Identifying a single primary outcome may not make best use of the data; a range of measures will be needed, and unintended consequences picked up where possible. • Ensuring strict fidelity to a protocol may be inappropriate; the intervention may work better if adaptation to the local setting is allowed.

MRC (2008)

2.4 Motor Learning - a complex intervention?

This research is interested in the processes underlying motor learning post stroke, and in particular is considering the rehabilitation of gait. Evidence from healthy populations suggests that the concepts of explicit and implicit learning are important for skill acquisition. However, little is known about these different forms of learning in stroke rehabilitation, and whilst explicit and implicit learning can be clearly defined in a laboratory setting (see section 3.6.1), their definition and application within a clinical setting is less clear.

Motor learning may be influenced by many different and interacting factors. At a behavioural level, these may relate to the individual, the coach (therapist), the way in which practice is organised or structured, and/or the practice environment. Altering these factors may influence which system an individual is primarily using during learning – either explicit or implicit. It is therefore justified to consider motor learning, and the sub-divisions of explicit and implicit learning, as complex interventions.

Consisting of developmental and feasibility stages, this current programme of research sought to gain a deeper understanding of explicit and implicit learning in the context of neurological physiotherapy practice, using gait rehabilitation to illustrate this.

2.5 Stages of the MRC Framework

2.5.1 Development Phase

The first stage is to establish the theoretical basis of the complex intervention, assessing theory and evidence, preferably through a systematic review, to identify the potential interventions that may be tested, and the study design that may be used to do this.

The development phase for this research included a detailed literature review, which forms Chapters 3 of this thesis. The formal theory relating to explicit and implicit learning was considered, as was existing empirical evidence, primarily from healthy populations. The wider evidence base relating to focus of attention during learning, feedback and dual tasking was also considered as it is argued that these may directly influence explicit and implicit learning processes. The accumulated knowledge from these different sources of empirical evidence provides the foundation for the aims and objectives of the experimental study.

As part of the development phase, the elements of physiotherapy practice that may promote learning through either the explicit or implicit systems were defined and described. This process is known as **modelling.** Although formal frameworks for the modelling of complex interventions are available (Collins et al., 2005, Glasgow et al., 1999, NICE, 2007), these are targeted towards behaviour change interventions, and had limited applicability to this current field of research. Therefore, a pragmatic approach to modelling the characteristics of explicit and implicit learning was adopted.

Informal "paper modelling" involved the collation of ideas and concepts gained through the literature review; producing a mind map of the various elements that may be important to consider within explicit and implicit motor learning paradigms. Consideration was given to whether these variables could or could not be changed or influenced by changes in physiotherapy practice. A more formal process of modelling then took place using data collected through an observational study of current physiotherapy practice. Since explicit and implicit learning is inherent in any clinical situation, this phase sought to examine current practice and describe the factors that may create bias towards one or the other. The analysis process was based on the variables identified through the initial paper modelling phase. Observational methods ensured that the development of the interventions was grounded in, and therefore relevant to, contemporary clinical practice. There were three primary outputs from the development phase:

a) a description of explicit and implicit learning in the context of neurological rehabilitation;
b) the development and testing of an analysis matrix that could be used to identify explicit and implicit behaviours in practice; and
c) the development of guidelines for the delivery of physiotherapy interventions using explicit and implicit approaches, that could be tested in the feasibility trial.

2.5.2 Feasibility/Pilot Phase

The next stage of the MRC Framework involves the testing of procedures through a feasibility or pilot study. Feasibility studies are described as "pieces of research done before a main study in order to answer the question - can this study be done?" (NIHR, 2011). They are used to estimate important parameters that are needed to design the main study. At this stage, interventions are tested for their acceptability and delivery, and rates of recruitment and retention can be estimated, along with the calculation of appropriate sample sizes. Through the testing process, a deeper understanding of the intervention and its possible effects can also be gained. This may include delineating the components of the intervention, giving consideration to how they may interact and what the active components may be (MRC, 2008).

The final phase of this current research consisted of a feasibility study to test the application of the explicit and implicit guidelines within a clinical research setting. The feasibility trial compared explicit and implicit learning during early gait rehabilitation post stroke using a randomised, double blind, matched pairs design. The protocol and findings from this feasibility study are reported in Chapter 5. The main purpose of the feasibility study was to:

a) comprehensively define the intervention as clearly as possible in preparation for any future main trial;
b) determine how well therapists could deliver the interventions in a standardised manner (practicality), establishing the level of training required for a full scale randomised controlled trial; and
c) allow for further refinement and testing of the protocol as a whole.

In addition, the feasibility study aimed to estimate likely rates of recruitment and retention, test the appropriateness of the chosen outcome measures, and estimate the required sample size for a future trial.

The final two stages of the MRC Framework are the Evaluation and Implementation Phases. These are beyond the scope of this thesis, but are proposed as post-doctoral work and, for completeness, are described briefly below.

2.5.3 Evaluation

In the third MRC phase, evidence is put to the test through some form of experimental study. The purpose of this phase is to establish how well the intervention can be controlled in a research setting, and to test the feasibility of the proposed research methodology. Following this, the complex intervention, which will now be well defined, can be evaluated in an appropriately powered and well designed experimental study.

2.5.4 Implementation

The final stage is to establish the long-term and real-life effectiveness of the intervention – for example, it's applicability outside of a research context. This phase is concerned with getting evidence into practice through widespread dissemination.

2.5.5 Summary of the Research Stages

Figure 2 summarises the structure of this thesis in relation to the stages of the MRC Framework.

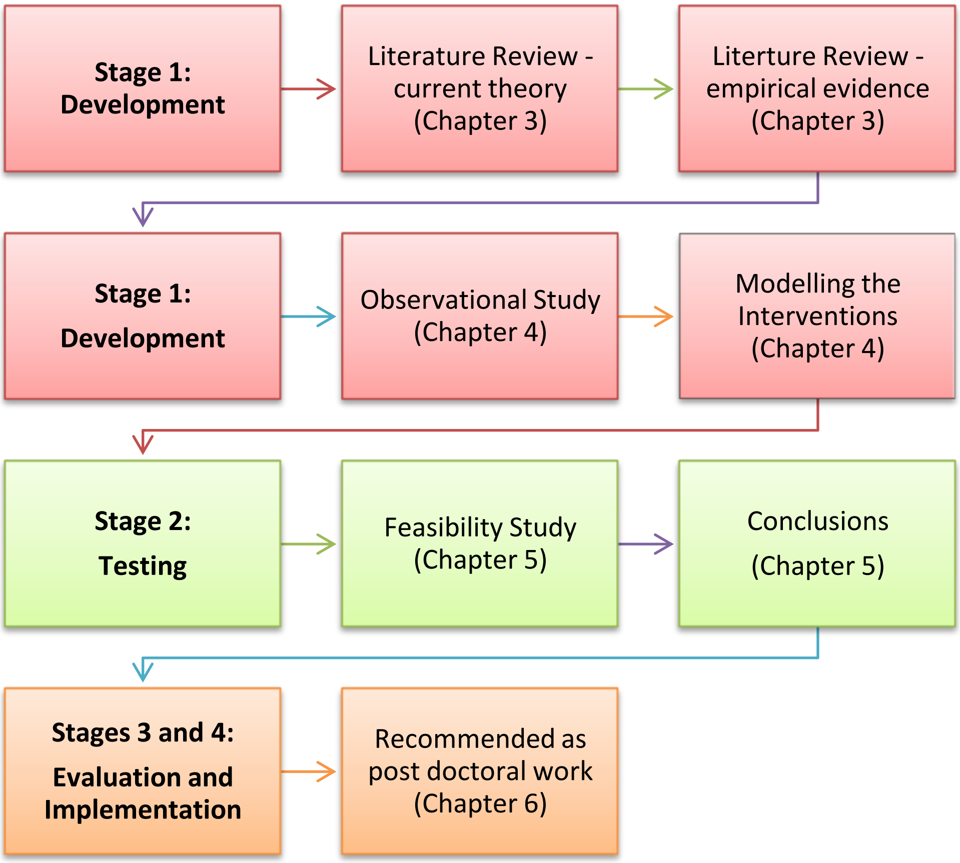


Figure 2 The current research programme
An overview of the stages of the current research programme, in line with the stages of the MRC Framework.

3. MOTOR LEARNING

3.1 INTRODUCTION

This chapter will introduce the underpinning theoretical models for motor learning, focussing primarily on theory relating to the *behavioural* aspects of skill acquisition. The overarching concepts of explicit and implicit learning will be outlined and discussed, with reference to the supporting evidence base. Common strategies and practice conditions for motor learning within the context of neurological rehabilitation will then be considered, drawing on knowledge from behavioural models of motor learning. Since the possession of knowledge by a learner is central to whether the learning taking place is explicit or implicit, the evidence base relating to information provision during learning will be explored; including the impact of information provision on an individual's attentional focus and attentional capacity. Potential associations between different behavioural models and practice conditions and the explicit/implicit paradigm are proposed throughout. Collectively, this review of both theory and evidence contributes to the **development phase** of the MRC Framework.

3.2 Definition of a Motor Skill

A motor skill is a learned sequence of movements that combine to provide a smooth and efficient action (Magill, 2010). Therefore, the term motor skill usually refers to those skills in which both the movement and the outcome of action are emphasised (Newell, 1991), i.e. the skill results in achievement of a functional purpose.

3.3 Definition of Motor Learning

Learning has been defined as:

> "A change in the capability of a person to perform a skill that must be inferred from a relatively permanent improvement in performance as a result of practice or experience"

Magill (2010); p249

3.4 Differentiating Learning from Performance

There are two particularly important elements in this definition of learning. Firstly, that a change occurs in the *capability* or *potential* for an individual to perform a particular skill. Whether or not a person actually performs the skill in a way that is consistent with their potential will depend on the presence of performance variables (factors that may influence a person's performance, but not the learning that they have achieved), such as anxiety or fatigue (Magill, 2010). Secondly, unlike performance, which refers to the behavioural act of executing a skill at a specific time and in a specific situation, learning is *relatively permanent*, and results from changes to long term memory (Magill, 2010).

Although performance and learning are inextricably linked, the distinction between them is important since an intervention may improve performance, but may not necessarily translate into a long term change, i.e. learning. Within rehabilitation, this is often cited as "carryover"; whilst a patient may seemingly improve their ability to perform a task during a therapy session, they may not retain the ability to perform at this improved level. Hence changes to performance can be measured immediately, but learning must be evaluated during retention or transfer tests performed separately to the initial practice episode. Ultimately, rehabilitation should strive to achieve learning, rather than temporary changes in performance.

Magill (2010) outlines five performance characteristics that are typically observed as learning takes place:

1. **Improvement** – performance of the skill shows improvement over a period of time
2. **Consistency** – as learning progresses, performance becomes increasingly more consistent
3. **Stability** – as learning progresses, internal and external perturbations have less of an influence on performance
4. **Persistence** – as the person progresses in learning the skill, the improved performance capability lasts over increasing periods of time (i.e. changes in performance become more permanent)
5. **Adaptability** – the improved performance becomes adaptable to a variety of performance context characteristics (i.e. the skill becomes more generalisable)

These performance characteristics may be influenced by the practice conditions under which learning takes place. This could include factors that may promote more explicit or implicit processes, as discussed throughout this chapter.

3.5 EXPLICIT AND IMPLICIT LEARNING

Most theories agree that learning can be broadly divided into two categories, explicit and implicit; meaning that learning can occur both intentionally and unintentionally. Explicit and implicit processes are thought to occur during all forms of learning, however, this research is specifically concerned with the acquisition of *motor* skills.

3.5.1 Explicit Motor Learning

The term "explicit" refers to learning that takes place in the presence of factual knowledge about the task being practised. During this form of learning, participants are searching for features, rules or some structural property during practice, and they are able to verbalise how they solved the problem (Pohl et al., 2001). The process of explicit learning therefore involves some form of generalised (or generalisable) knowledge that is consciously accessible to the learner (Sun et al., 2005). Typically, this would include knowledge relating to the kinematic features of the movement (also termed knowledge of performance), as well as knowledge relating to overall outcome (also termed knowledge of results). Explicit memories may be formed in as little as one exposure to new information, and can be assessed by testing conscious, articulated knowledge about facts and events (Boyd, 2006). Augmented feedback regarding the correct production or patterning of movement is one way in which such knowledge may be gained. Whilst explicit learning is synonymous with the earlier cognitive stages of skill acquisition, it is not unique to this phase. Performers may utilise explicit knowledge at any stage of learning, although the degree to which this aids performance, particularly in the more autonomous phase, is questionable.

A novice golfer who is learning to putt the ball may do so explicitly. Instructions from a coach may prompt the golfer with regards to their stance, or how to grip and swing the club. Such instructions may draw attention to posture, and to movements at the elbow, shoulder and upper body. If the golfer is thinking about all of these elements, they hold task relevant, declarative knowledge about the activity that they are practicing. Feedback from the coach about the individual elements of movement after each attempt may reinforce this. Cognitive demand is high, with large elements of the movement being performed consciously. This is explicit learning.

3.5.2 Implicit Motor Learning

In contrast, implicit motor learning refers to the acquisition of a skill without the concurrent acquisition of knowledge about the performance of that skill (Maxwell et al., 2000), and without immediate awareness that learning is taking place (Pohl et al., 2001). Behaviours learnt in this way are expressed primarily in performance, rather than in words (Kandel et al., 2000).

The term "implicit learning" includes a number of substrates of learning, such as habituation and sensitisation, as outlined in Figure 3. However, the most complex form of implicit learning, and the one of interest to this research, is procedural learning. Procedural learning involves the acquisition and execution of motor and non- declarative cognitive skills. Where the term implicit learning is used in the remainder of this thesis, it is referring to procedural learning.

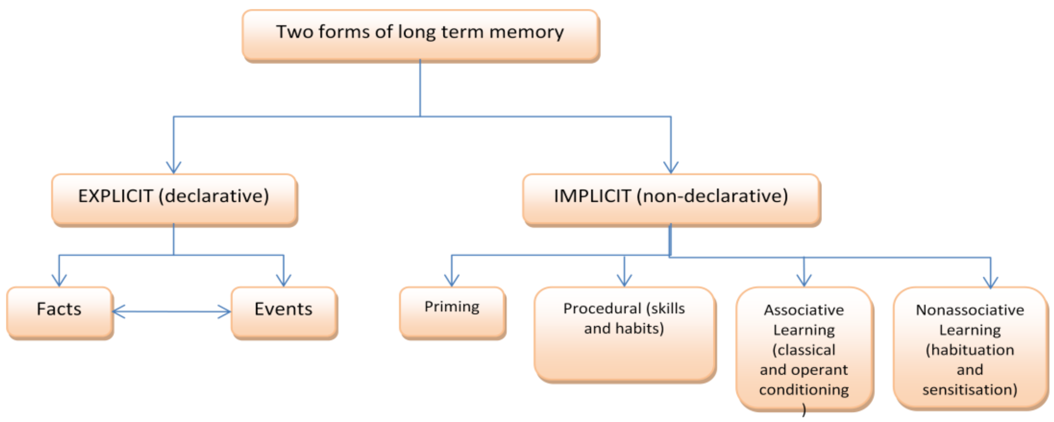


Figure 3 Various Forms of Long Term Memory
Figure to outline the various substrates of both implicit and explicit learning. This research programme is primarily focussed on functional motor learning, which falls into the category of procedural learning. Adapted from Kandel (2000); page 1231

The process of acquiring implicit knowledge is slow, and results from the accumulation of large amounts of practice, often without conscious recollection of the individual components being learnt. Through task repetition, individual learners modify their behaviour in order to improve performance, without having access to factual knowledge or feedback about that performance. Implicit learning is typically thought to be more synonymous with the later autonomous stages of learning, particularly among expert performers. Indeed, at this stage, utilising explicit information may actually be detrimental to skilled performance (e.g. Beilock et al., 2002). However, implicit learning is not a passive process, nor is it altogether unconscious – the learner needs to be able to attend to the task that is practised (Whittlesea and Wright, 1997), and although there may not be a conscious effort to learn, there may be a conscious effort to improve performance or to achieve a goal. It is generally considered that skills learnt implicitly are more likely to be retained over time than those learnt explicitly.

Learning to ride a bike provides a familiar example of a skill that is primarily learnt implicitly (Magill, 2010). When a child is learning to ride a bike, they must coordinate body movement in several different ways. It is difficult to teach a child to ride a bike through providing instruction – rather through practice and repetition the child discovers for himself the key information and refines the skills required to ride the bike until the activity eventually becomes fully automatic, i.e. without conscious thought (Magill, 2010). At this point the skill of riding a bike is retained permanently in the procedural memory, and although most people who can ride a bike would not be able to clearly articulate *how* they learnt or perform that skill, they remain able to perform it efficiently throughout their lives. This is implicit learning.

3.6 Empirical Evidence for Explicit and Implicit Learning

3.6.1 The Serial Reaction Time (SRT) Task

The most common paradigm used to experimentally investigate implicit learning is the Serial Reaction Time (SRT) task. During SRT studies, participants are asked to respond to some form of stimuli with a motor output, for example by pushing a corresponding switch in response to a light turning on. Accuracy and reaction times are measured in order to evaluate performance. Practice is typically provided in blocks, with a sequenced, repeating pattern interspersed amongst otherwise random order patterns. Learning is considered to be implicit when a subject's performance improves during the periods of patterned sequence and declines during periods of random sequence. If the learning is truly implicit, during recall tests the subject will not have conscious awareness that a pattern was present – they have acquired knowledge about the sequence incidentally, without having any conscious knowledge that they have done so (Ferdinand et al., 2008). Thus, the SRT task is widely conceptualised as an implicit learning task, and has been used extensively within research to explore the processes underlying learning and memory (Robertson, 2007).

Early work in this area was carried out by Nissen and Bullemer (1987) who questioned whether it is necessary to attend to a stimulus event (i.e. explicitly) in order to remember it later. Previous work had investigated the relationship between memory and attention by assessing subjects' ability to recall events verbally (Moray, 1959, Norman, 1969), thus requiring conscious awareness. These studies showed that auditory stimuli that are not attended to are poorly remembered. On the basis that there are multiple memory systems which may differ in the extent to which acquisition of information requires attentional processing, Nissen and Bullemer (1987) sought to investigate whether memory for prior experience could also be reflected in the subsequent *performance* of a task that does not require conscious remembering (i.e. through implicit learning). Utilising the SRT task under both single and dual task conditions, results showed that response latency during the repeating sequence was significantly less compared to the random sequence, demonstrating improved performance as a result of implicit learning. Furthermore, the authors also investigated learning in patients with memory disorders resulting from Korsakoff's syndrome. These subjects also demonstrated learning of the trial sequence despite their apparent lack of awareness of the existence of a repeating pattern. These experiments confirmed that the concept of implicit learning existed and could be measured through task performance.

Many versions of the SRT experiment have since been investigated (Ferdinand et al., 2008, Sanchez et al., 2010, Gheysen et al., 2009, Weiermann et al., 2010, Willingham et al., 2000, Moisello et al., 2011, Shanks et al., 2005), with results consistently demonstrating that:

- when compared to explicit conditions, motor skills learnt under implicit conditions are more likely to be retained over time (assessed during retention tests)
- when compared to explicit learning, implicit learning of a sequence is more likely to remain robust under secondary task load
- providing explicit declarative information may degrade performance of a motor skill

3.6.2 Interaction of the Explicit and Implicit Systems

Although both explicit and implicit learning have been actively investigated, the complex and multifaceted interaction between the explicit and the implicit and the importance of this interaction has not been universally recognised (Sun et al., 2005). Whilst much research has focussed on their separability, for example through SRT tests, less has focussed on how the systems interact and understanding of the association between them is therefore limited. In addition, there are very few studies that specifically evaluate explicit and implicit learning during functional motor tasks.

It is often proposed that conscious, explicit processes occur in the early stages of learning, supporting behaviour until a simultaneously acquired implicit representation is sufficiently well developed, at which time the explicit process is simply not used any longer (Masters, 1992). This concept is supported by behavioural models of learning, discussed later in section 3.7. For example, as the novice golfer becomes more proficient at putting the ball, they will be less reliant on explicit information, and may begin to use implicit processes as they refine, develop and embed the skill in a more autonomous way. However, whilst the notion that implicit learning must be preceded by explicit learning may be true of some skills; its importance for all forms of learning is increasingly being challenged. Indeed, there may be value in reducing the degree of explicit knowledge that a learner holds in order to promote implicit processes, since this may be favourable for longevity and robustness of skilled performance. The relevance of this to neurological rehabilitation, where a skill is being *re*-learned, is unknown.

In seeking to determine whether explicit and implicit knowledge are acquired in parallel, Willingham and Goedert-Eschmann (1999) designed a reverse SRT experiment. Participants were assigned to one of two groups: an explicit learning group in which participants were told that stimuli would appear in a 12 unit sequence, which they were to attempt to learn; or an implicit learning group who were not told that there was a sequence, but were simply instructed to respond as quickly as possible without making too many errors. Participants in both groups improved over time during the training blocks, although there was greater variation in the explicit learning group, especially initially. At transfer, participants were either shown the same repeating sequence, or a new novel sequence. Learning scores for those viewing the same sequence at learning and transfer were larger (i.e. better) than participants who saw a new sequence, and these scores were not affected by whether participants had received explicit or implicit instructions during training. The authors conclude that the results of their experiment are consistent with the hypothesis that explicit and implicit learning occur in parallel (Willingham and Goedert-Eschmann, 1999). Whilst this may be true, it is also feasible that both forms of learning were equally effective for the task presented in this experiment. Furthermore, since the time of the transfer test is not stated, it is not clear whether the similarity between groups could be due to the closeness of the learning and test phases. It is possible that follow up at a later period may have shown better retention of skill in the implicit learning group. However, as the results for both groups are similar, the experiment does demonstrate that the explicit information provided to one group was not beneficial over and above the simple instruction given to the implicit learning group. In fact in the early stages of learning it was detrimental to performance.

3.6.3 Limitations of Serial Reaction Time Studies

The SRT experiment is tightly controlled, and provides a means of assessing pure implicit learning. This body of literature provides robust evidence to support the concept of implicit learning – i.e. through performance, individuals are able to express a learned sequence without obtaining any declarative knowledge of that sequence.

Whilst the SRT task does require a motor output (pressing a switch), there is debate regarding whether or not it truly assesses' *motor* learning (Willingham, 1999), or whether the task should be classified as cognitive or perceptual. Generalisability of the findings from SRT studies is therefore limited; whilst they provide an example of implicit learning, little is known about implicit learning during complex motor or functional tasks. Furthermore, these studies typically involve young, healthy adults and it is not known whether the findings are transferable to older or neurologically impaired populations.

Since participants in SRT experiments do not have any awareness about the presence of a sequence, it is assumed that they do not move through cognitive or associative stages of learning, as described in 3.7.1. However, the same may not be true during the acquisition of functional skills, where the level of awareness is less easily controlled. In a functional task, there is a clear goal, so the individual will always have some level of awareness of the task they are attempting to perform, and they are also likely to have prior knowledge of the skill, or transferable knowledge from other skills. Therefore, whilst very few motor skills will be learnt purely implicitly (as in the SRT experiment), bias towards either explicit or implicit processes may be created dependent on the attention and awareness of the learner.

3.6.4 Neural Basis for Explicit and Implicit Learning

Learning is inferred to have occurred when there are lasting changes in performance (Seidler et al., 2005), yet dissociating learning from performance in terms of the neural substrates involved is complex and challenging. Investigation of the neural mechanisms for learning is, therefore, hampered by the fact that learning in itself cannot be easily isolated and measured. This section considers the neural basis for explicit and implicit learning, drawing on evidence from a number of studies that have utilised functional neurological imaging techniques to investigate the central cerebral changes that occur in response to each type of learning.

Whilst the mechanism for learning at a neurophysiological level is common to both explicit and implicit learning, the difference between the two lies primarily at a neuro-anatomical level, with distinct neural systems mediating learning under each set of conditions (Thomas et al., 2004). Supporting evidence for this comes from a series of studies that have used positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) to measure cerebral blood flow as participants perform simple motor learning tasks under different learning conditions. Whilst a number of these studies have reported that separate sites appear to support explicit and implicit processes, there is no clear consensus for which sites are most important in modulating the two types of learning. Most studies have only investigated cerebral activation during implicit learning, and cannot therefore provide a comparison between implicit and explicit processes. Areas commonly reported to be recruited during implicit learning include the basal ganglia (Thomas et al., 2004, Seidler et al., 2005, Rauch et al., 1995, Hazeltine et al., 1997, Fletcher et al., 2005), the hippocampus (Thomas et al., 2004, Degonda et al., 2005, Gheysen et al., 2010), the pre-motor cortex (Thomas et al., 2004, Rauch et al., 1995), the primary motor cortex (Matsumura et al., 2004, Seidler et al., 2005, Grafton et al., 1995, Hazeltine et al., 1997) and the cerebellum (Matsumura et al., 2004).

Given that the activation of brain regions will be influenced, in part, by the type of experimental task being practised, it is perhaps not surprising that implicit motor learning appears to be primarily served by this network of motor system structures. However, due to the difficulty in separating the neural substrate of encoding from that of performance, it is also not entirely clear whether activation of these brain areas represents the encoding of information and therefore learning, or merely changes in performance as the person practices the experimental task. Studies would need to perform functional neuroimaging during both explicit and implicit learning of the same motor task, preferably over an extended period of time, in order to examine these questions.

It is clearly evident that a number of brain structures are involved in implicit learning processes, with the exact level of involvement and interaction likely to be contingent on the functional demands of the task. Owing to the fact that the implicit system is highly distributed, it is nearly impossible to completely disrupt the neuronal circuitry involved with implicit learning (Boyd, 2006). Hence, a number of studies have shown that the ability to learn implicitly is preserved in the presence of neurological damage, including stroke (Boyd, 2001, Meehan et al., 2011). In contrast, the explicit system is mediated primarily by the hippocampus and adjacent medial temporal lobe structures (Reber et al., 1996, Knowlton et al., 1996); which, due to their focal nature, are more susceptible to damage (Boyd, 2006). Promoting implicit processes may therefore be particularly important in the presence of neurological disease.

Using fMRI scanning during a variant of the serial reaction time task (see 3.6.1), Seidler and colleagues (2005) attempted to dissociate performance from learning. They reported that during procedural motor learning, encoding can be characterised by two distinct phases. During the early phase of learning, the highest correlation between activation and subsequent improvements in performance was seen in the motor cortex, and the authors therefore propose that the role of the motor cortex within motor control goes beyond the encoding of simple movement parameters, to include involvement in the consolidation of motor skill learning. During the later phase of learning, changes were seen primarily in the basal ganglia. Whilst much research has focussed on delineating the areas involved with explicit and implicit learning in this way, the question of how they interact, and whether there is parallel development, is gaining increasing attention. Although a number of studies show little evidence of explicit-implicit overlap (Grafton et al., 1995, Hazeltine et al., 1997, Rauch et al., 1995, Honda et al., 1998), the evidence is far from conclusive. Some researchers present evidence to suggest that the anatomical differences between explicit and implicit learning result in competition for neural resources (Poldrack and Packard, 2003), whilst others report contrasting evidence to indicate that explicit and implicit processes occur in parallel, and may even complement each other, raising the possibility that the explicit system might be used to inform or stimulate implicit learning (Boyd, 2006, Willingham, 1999).

Clearly the neural processes involved with learning are extremely complex, and the interaction between the different systems is likely to be condition dependent. Certainly, whilst there is an emerging and growing body of evidence demonstrating that explicit and implicit systems do interact, there is a lack of understanding regarding the circumstances under which this interaction may enhance learning, and the circumstances under which it may disrupt learning. Utilising fMRI to study neuronal activity, Fletcher et al were able to demonstrate that explicit attempts to learn a motor sequence produced a failure of implicit learning, and that this represented a failure of learning itself, rather than merely the expression of that learning (Fletcher et al., 2005). These findings support the well known behavioural effect that explicit information can have a detrimental impact on implicit learning of a motor task – and are supported by other functional imaging studies involving motor (Zhu et al., 2011) and semantic pairing tasks (Degonda et al., 2005).

3.6.5 Explicit and Implicit Learning in Stroke.

There is minimal research specifically considering explicit and/or implicit learning within the stroke population. Similar to research with healthy populations, the limited evidence available tends to investigate controlled tasks such as the serial reaction time task.

Boyd and colleagues have performed a series of such studies, the results of which are consistent with those experiments performed within healthy populations; not only is implicit learning preserved post stroke, but providing explicit information about the task may actually degrade this learning (Boyd, 2001, Boyd, 2006, Boyd and Winstein, 2004, Boyd and Winstein, 2003).

The most recent of these studies sought to determine whether there is an interaction between implicit motor sequence learning, explicit instructions, lesion location and task type (Boyd, 2006). Two types of task were compared - discrete motor tasks (a serial reaction time task) and continuous motor tasks (a continuous tracking task). Ten patients with chronic basal ganglia stroke, 10 patients with chronic sensorimotor cortex stroke and 10 age matched healthy controls completed three days of practice of both types of motor task, with retention being tested on day four. In order to examine the impact that explicit information has on implicit motor learning, participants were randomised to receive either explicit information, which included information about the location and composition of the repeating sequences, or no-explicit information. The study showed interesting results. Explicit information disrupted acquisition performance in participants with stroke (regardless of lesion location), but unlike other research, not in healthy controls. Similarly, the retention test showed dissociation whereby explicit information actually hindered participants with stroke and aided healthy controls. These findings support the notion that explicit information may actually be less helpful in the development of a motor plan than discovering a motor solution using the implicit system alone. The authors speculate that this may be due to the increased demand placed on working memory by explicit information. The relationship between attentional demand and explicit learning is presented in section 3.13.

A similarly designed study aimed to differentiate whether the severity of stroke had any impact on the ability of an individual to learn implicitly (Pohl et al., 2001). The ability of adults with unilateral chronic stroke (>6 months) to implicitly learn a motor skill using the arm ipsilateral to the side of the brain damage was compared with that of adults without stroke (n = 47; control = 36). Subjects again practiced a SRT task that involved closing switches next to a target light. Practice took place over two consecutive days and was organised into blocks. The instructions were to close the switch corresponding to the light that became lit as quickly as possible. In order to determine whether participants had gained explicit knowledge, they were asked at the end of the recall test whether they had noticed anything about the task. Regardless of their response to this question, participants were then told that there was a patterned sequence embedded within their practice sessions, and were asked to try to reconstruct this by pointing to the switches. Analysis demonstrated that both the stroke and the control groups were able to learn under implicit conditions, although performance of those with stroke was consistently slower than the performance of the control group. Data also suggested that implicit learning may be impaired in those with moderate stroke, but preserved in those with mild stroke, although the sample size was inadequate to determine whether this finding was robust. The authors suggest that for patients with mild stroke, incorporating strategies that will engage an individual in implicit learning may provide a successful avenue to the learning of motor skills during rehabilitation.

A later study by the same authors (Pohl et al., 2006) used a similarly designed intervention to examine the ability of adults with moderate sub-acute stroke (< 45 days post onset) to learn a motor sequence task under implicit conditions. The same procedure using a light box with switches, and with both random and repeated sequences, was employed. Contrary to their hypothesis, analysis showed that participants were able to learn the motor task under implicit conditions, regardless of stroke severity. In contrast to the previous study, the amount of time post stroke onset was notably less. It is not therefore possible to determine whether such implicit learning conditions are only effective in the sub-acute phase post stroke, or whether this ability was in fact dependent on stroke severity. It is feasible that the ability to learn under different conditions may change over time.

Although the descriptions of explicit and implicit learning are clear, they can only really be considered in isolation during carefully planned experimental tasks, such as the SRT task. In the vast majority of real world situations, it is likely that explicit and implicit processes will be occurring in parallel – it would be very difficult to find a situation where only one type is engaged. Explicit and implicit learning are therefore overarching concepts that relate to the processes underlying skill acquisition. Thus, the processes underlying learning can also be described using behavioural models. This next section considers the common behavioural models for motor learning, and their potential association with the explicit and implicit paradigms.

3.7 Behavioural Models for Motor Learning

3.7.1 Stages of Motor Learning

Motor skills vary widely in type and complexity, however, the behavioural processes that individuals go through when acquiring such skills is thought to be similar. A number of authors have attempted to define the performance characteristics that occur at the different stages of the skill learning process, as outlined in Table 2. Each of these theoretical depictions propose that although learning occurs on a continuum, the observable motor performance characteristics change as someone moves from earlier to later stages of learning, or from novice through to expert.

Table 2 Stages of Motor Learning

Author	Early stage of learning ⟶		Later stage of learning
(Fitts and Posner, 1967)	Cognitive (verbal)	Associative	Autonomous (motor)
(Adams, 1971)	Verbal motor (more talk)		Motor (more action)
(Gentile, 1972)	Getting the idea of the movement		Fixation/diversification (closed or open skill)
(Newell, 1991)	Coordination (acquire the pattern)		Control (adapt the pattern as needed)

Adapted from Schmidt and Wrisberg (2000); p13

Table outlining various behavioural models for motor learning, detailing the characteristics from early through to late stages of learning.

The classic learning stages model proposed by Fitts and Posner (1967) is probably the most commonly cited and influential behavioural model used to describe motor learning. It proposes that learning a motor skill involves three stages: cognitive, associative and autonomous (Table 3). Although the stages have since been renamed or redefined by a number of authors as outlined above, the fundamental nature of each stage remains broadly similar to that proposed in the original model.

Table 3 Classic Learning Stages Model

STAGE	CHARACTERISTICS	ATTENTIONAL DEMANDS
Cognitive (verbal)	Movements are slow, inconsistent and inefficient. Considerable cognitive activity is required.	Large parts of the movement are controlled consciously.
Associative	Movements are more fluid, reliable, and efficient. Less cognitive activity is required.	Some parts of the movement are controlled consciously, some automatically
Autonomous (motor)	Movements are accurate, consistent, and efficient. Little or no cognitive activity is required.	Movement is largely controlled automatically.

The Classic Learning Stages Model proposed by Fitts and Posner, outlining the characteristics and attentional demands of each stage (Fitts and Posner, 1967).

Fitts and Posner (1967) propose that early learning is characterised by high levels of cognitive activity, with a tendency for learners to pay attention to the step by step execution of the skill (Wulf et al., 2001). Performance during this phase is highly variable and marked by a large number of errors. Over time, as the learner acquires the fundamental movement pattern, their performance will become more proficient. This is the associative phase of learning; where the learner acquires the capability to detect and identify some of their own movement errors (Magill, 2001), producing more subtle movement adjustments as the motor pattern becomes more consistent and economical. After extensive practice, the learner may reach the autonomous phase, which is characterised by consistently fluent and seemingly effortless movements. At this stage the skill is performed largely automatically (or habitually), with little or no attention, often allowing individuals to effectively perform a second task at the same time. Adams (1971) refers to this stage as the motor stage, suggesting that there is a proportionally greater emphasis on motor, as opposed to cognitive, aspects of the task. In each of the theoretical models proposed in Table 2, the earlier stages of learning are characterised by the individual getting an idea of the required movement, whilst the later stages are characterised by a more automatic and self-governing level of performance.

These models all assume that it is necessary for someone to move through a cognitive stage (i.e. explicit) before they can reach a more autonomous one (i.e. implicit). Whilst this may be true for some scenarios, it may not apply to every situation, and is potentially dependent on the type of skill being learnt, the circumstances under which it is being practised, and the previous knowledge or experience of the performer. It is also important to highlight that the phases of learning proposed in each of these models are not discrete. They occur as part of a continuum of practice time, with a gradual transition from one phase to the next. Indeed, not every person learning a skill will necessarily reach the autonomous phase (Magill, 2001), and it is feasible that someone may revert to a previous stage of learning under certain circumstances.

3.8 Intervention Strategies for Motor Learning in Rehabilitation

In addition to the behavioural models for motor learning, the literature in this field refers to a number of different intervention strategies for structuring practice. In general, intervention strategies that lead to high conscious awareness of how to perform the motor behaviour may promote explicit learning; whereas intervention strategies resulting in low conscious awareness may promote implicit learning (Kleynen et al., 2014). Examples of four intervention strategies are given in the following sections.

3.8.1 Errorless Learning

One example is errorless learning, a term used to describe scenarios where task practice is structured to prevent the learner from making errors during the learning process (Mount et al., 2007). During errorless learning, the subject is encouraged *not* to guess the correct response, and errors are immediately corrected by a coach or other external source. The task is typically broken down into stages, such that the individual does not move on to the next stage until the preceding one has been completed successfully. Errorless learning has been widely explored in a variety of rehabilitation settings, particularly for memory tasks, and in subjects with memory impairment (e.g. dementia or amnesia) (Clare and Jones, 2008). Whilst some authors suggest that errorless learning is an approach that utilises implicit memory (Kessels and Haan, 2003), others propose that the benefits of errorless learning stem from the effects of error prevention on residual explicit memory (Hunkin et al., 1998).

Whilst evidence has shown that errorless learning is of no benefit over and above error-full learning in the elderly population generally (Kessels et al., 2005), it is reported to be particularly beneficial for retention of information in people with cognitive disorders, potentially because it reduces attentional and cognitive demand, and promotes automaticity (therefore being more implicit in nature). Indeed, it is a method that is of relatively greater benefit in people with impaired explicit memory (Clare et al., 2000, Wilson et al., 1994). Those with intact explicit memory may not benefit from error elimination as they retain the ability to detect and monitor errors independently, updating their performance on the basis of intrinsic feedback (Clare and Jones, 2008).

In their systematic review of errorless learning, Clare and Jones (2008) conclude that whilst it may be a beneficial approach in those with brain impairment, and may be better for tasks that require retention of specific and concrete information, evidence for the benefits of errorless learning over and above error-full learning is inconclusive for abstract or high level knowledge, and for long term retention. It is also proposed that in healthy individuals, cognitive tasks learnt under errorless learning conditions are less transferable to novel situations when compared to error-full learning, despite more errors being made in the acquisition phase (Jones et al., 2010). This suggests that the ability to make errors and develop problem solving is important to the learning process. It must be noted that these studies all investigate cognitive memory tasks; transferability to motor learning tasks is unknown.

The effectiveness of errorless learning post stroke has not been widely investigated. One small (n=33) study by Mount and colleagues (2007) compared errorless learning to trial and error learning for the teaching of activities of daily living in patients with acute stroke, using a randomised cross over design. Subjects practised two functional tasks: sock donning and setting up a wheelchair for transfer. Transferability to a similar task was significantly better when trial and error learning was used for the sock donning task, but no other significant between group differences were found. The authors conclude that the effectiveness of errorless learning may be dependent not only on the degree of any memory impairment, but also on the nature of the task to be learned.

Orrel and colleagues (2006, 2009) investigated the use of errorless learning techniques during a dynamic balance task in patients with chronic stroke. Ten adults with stroke and 12 neurologically intact older adults practised a dynamic balance task on a stabilometer under single task (balance only) and concurrent task (balance whilst trying to discover rules of how to perform the balance task) conditions. Two motor learning strategies were compared - learning without errors (deemed as implicit) which used a breaking system to limit movement of the platform which was then progressively reduced throughout the trials; and discovery learning (deemed as explicit) whereby participants were encouraged to discover rules about how to perform the task. Participants performed the balance task over three distinct phases – an acquisition phase followed by a separate test phase, and a delayed retention test performed 1 week later. Although there were no significant differences between groups during the acquisition phase, performance in the explicit group was less efficient during retention tests, and was impaired in the presence of a concurrent cognitive task load, whereas performance in the implicit (errorless) group was not.

The authors of this study frame errorless learning as an implicit paradigm, and discovery learning as an explicit paradigm. However, during errorless learning, it is not possible to know whether the participants were actually learning implicitly – they may have gained knowledge about the task, and about the breaking system that was used to stabilise the platform. In addition, as the subjects were prevented from making errors, they may also have been prevented from developing problem solving in relation to the task. Indeed, the limitation of errors and the immediate correction of mistakes may actually inhibit higher (i.e. implicit) learning (Clare and Jones, 2008). Furthermore, whilst patients in the discovery group were encouraged to discover rules about how to perform the task, they were not given these rules by the researcher. Whilst this is explicit in nature, such that conscious thought processing was encouraged, it is not clear how the participants interpreted this instruction, and where their focus of attention actually was. Whether or not errorless learning is implicit and discovery learning is explicit, particularly for the acquisition of motor tasks, is therefore debatable.

3.8.2 Observational Learning

Another interventional strategy is that of observational learning. Observational learning (or modelling) is the process by which individuals acquire and modify skill through the imitation of observed behaviour of others (Janelle et al., 2003). This observation may occur in a practice setting through directly observing others (e.g. another patient or a therapist), or may occur through the use of video and other media. It has been proposed that the observation of others permits the formation of a cognitive framework that ultimately guides the observer's resulting actions (McCullagh et al., 1990, McCullagh and Weiss, 2001); typically utilising implicit memory (Zlotowitz et al., 2010). Observational learning has been shown to be beneficial in sporting activities, including the accuracy of a soccer pass (Janelle et al., 2003) and coordination during a rhythmic gymnastics rope skill (Magill and Schoenfelder- Zohdi, 1996).

Interestingly, research within healthy populations has suggested that observing an unskilled model may be more beneficial for performance than watching a skilled model; potentially as a result of improved problem solving on the part of the observer (McCullagh and Caird, 1990, Weir and Leavitt, 1990). The authors of these studies argue that by watching an unskilled model learn, the observer can determine how a variety of errors occur and how the model attempts to correct those errors, which in turn, improved their own performance.

The research on learning a motor skill through observation in patients post-stroke is more equivocal. A small study by Zlotowitz and colleagues (2010) (n=16) investigated how successful brain injured patients were in learning a sequence of seven hand movements in a correct order. Participants were randomised to learn the sequence utilising either modelling techniques (in which the therapist repeatedly demonstrated the movements to the patient), or moulding techniques (in which participants were taught the sequence by the experimenter, who used their own hands to passively move the participants hands into the correct shapes within the sequence). Retention was tested after a short (5 minute) and then a longer (30 minute) delay. Whilst there were no differences in retention after the short delay, those in the modelling group outperformed the moulding group after the longer, 30 minute, delay.

This study provides some evidence to support the use of observational learning techniques for acquisition of a sequential task in the presence of neurological impairment. However, the task employed in this study consisted of a series of separate actions, which is similar in construct to the washing, dressing and transfer type tasks that have been employed in studies investigating trial and error (see below) and errorless learning. Such tasks are novel, and consist of a series of discrete stages. They therefore differ from ballistic motor tasks such as walking, which require reciprocal repetition of the same repeating motor pattern. The relevance of these findings to gait rehabilitation is therefore not clear.

3.8.3 Discovery Learning

The concept of discovery learning has been applied differently by researchers. For example, some studies investigating the benefits of discovery learning within sport have contained an explicit instruction to actively “discover” the underlying principles of the situation or task (Williams et al., 2002), whilst others define discovery learning as a process in which people search for salient information within the environment in order to make appropriate performance decisions (Raab et al., 2009). As there is limited agreement on exactly what a discovery learning condition might be, there is no agreement on whether implicit or explicit processes underlie discovery learning. However, it is widely accepted that discovery learning can be guided (i.e. with verbal guidance/rules and therefore utilising cognitive memory) or unguided (i.e. without verbal guidance/rules, and therefore utilising perception and environmental cues) (Raab et al., 2009). It is perhaps the distinction between guided and unguided discovery learning that denotes whether the task is learnt in an explicit or implicit manner (explicit being guided; implicit being unguided).

For example, Hodges and Lee (2009) define discovery learning as learning that takes place in the absence of any specific instruction about how to perform the task, leading to a more exploratory learning strategy during which the learner becomes more familiar with the dynamics of the task and variations in intrinsic information sources. Based on this definition, which is primarily unguided in nature, discovery learning could be considered to be implicit. When investigating learning during a bimanual complex arm coordination task in healthy young adults, Hodges and Lee (1999) found that individuals who initially received no instructions (deemed discovery learning) outperformed those who received general instructions in terms of performance accuracy during both acquisition and retention, and outperformed those who received specific instructions when performance was tested in the presence of a secondary task (Hodges and Lee, 1999).

In contrast, in the study by Orrell and colleagues, the term discovery learning was used as an explicit learning paradigm, in which participants practising a balance task were instructed to discover rules about how to perform the task (semi-guided). With their definition of discovery learning, Orrell and colleagues (2006) found discovery learning to be less effective during both retention and in the presence of a secondary task, when compared to errorless learning.

Therefore, it is the differing definitions of discovery learning used by Hodges and Lee (1999) and Orrell and colleagues (2006) that are conflicting, rather than the actual findings of their studies.

3.8.4 Trial and Error Learning

Finally, some researchers use the term trial-and-error learning to describe a process in which the subject is encouraged to try and guess or figure out the correct response, and learn from the errors made (Mount et al., 2007), using intrinsic and/or extrinsic feedback mechanisms (Prather, 1971). This paradigm may therefore lead to conscious cognitive processing in relation to the task being performed, as learners actively test hypotheses in order to attempt to improve their performance (Maxwell et al., 2001) – potentially fitting with the explicit learning paradigm. However, there is little to clearly differentiate trial and error learning from discovery learning, and the associations to the explicit and implicit paradigms are therefore unclear.

In the study by Mount and colleagues (2007), participants in the trial and error group were permitted to make errors as they practised the functional task, but were also provided with progressively more specific verbal cues to correct those errors. Therefore, the presence of verbal cues would feasibly make the task more explicit in nature; as would any prompt for the individual to consciously try to modify their behaviour in order to improve performance. Whether or not trial and error learning is explicit or implicit would therefore depend on the exact nature of task relevant information possessed by the learner, e.g. the amount and nature of verbal instruction and feedback that they are given.

3.8.5 Summary of Interventional Strategies

These examples of interventional strategies for motor learning highlight the lack of consistent terminology and agreed definitions relating to different approaches to motor learning. These inconsistencies make it challenging to draw conclusions from the literature, as study designs cannot be easily compared. Furthermore, the mechanisms underlying each type of learning are not well understood, and the associations between these models and the overarching concepts of explicit and implicit learning are not always clear. A more standardised approach to defining the delivery of rehabilitation interventions from a behavioural point of view is important if research in this field is to truly inform practice. As the existence of explicit and implicit learning processes is supported by empirical evidence (i.e. SRT and neural imaging studies), utilising the overarching concepts of explicit and implicit learning as a framework on which to describe the behavioural approaches to delivering rehabilitation may bring some consistency to the research in this field.

3.9 Summary of the Characteristics of Explicit and Implicit Learning

So far, this chapter has described the theoretical and neurological basis for the concepts of explicit and implicit learning. Whilst these forms of learning can be applied in a purist form during controlled laboratory based studies, in natural settings it is more likely that they occur, to varying degrees, in parallel. Therefore the concepts of implicit and explicit learning are not mutually exclusive – they occur on a continuum. Interventional strategies for motor learning have also been discussed, highlighting potential associations with explicit and implicit learning, but also the challenges presented by a lack of consistent terminology.

Despite this, there are clear and consistent descriptions of explicit and implicit learning in the literature, which can be summarised as follows (see also Table 4):

- Explicit learning takes place intentionally, in the presence of task relevant knowledge about the task being performed. It involves cognitive processes (i.e. the person is thinking about what they are doing and why they are doing it); and is therefore a conscious form of learning. Tasks learnt explicitly can be expressed in words – i.e. someone can describe how they have achieved performance of a task.
- In contrast, implicit learning is unintentional – meaning that learning takes place without conscious effort. There may be conscious effort to achieve a goal, but not to the specific component of the task required to do so. In this sense, it is more automatic than cognitive. Implicit learning is expressed through performance, rather than words.

EXPLICIT ⟷	**IMPLICIT**
• Intentional • Task relevant knowledge • Cognitive • Conscious • Expressed in words	• Unintentional • Without task relevant knowledge • Automatic • Sub-conscious • Expressed in performance

Table 4 Characteristics of Explicit and Implicit Learning
The key characteristics of explicit and implicit learning, which occur on a continuum.

Although not discrete concepts, the relative bias towards either the explicit or implicit systems is likely to be dependent on various factors relating to the individual, the task, and the learning environment. For example, during practice, therapists may attempt to facilitate learning by using verbal and/or physical guidance, providing feedback about performance, suggesting modifications to movement patterns, and giving encouragement (Thorpe and Valvano, 2002). It is feasible that through manipulating such conditions, it is possible to emphasise either implicit or explicit learning, or to change the relative contribution of each.

At present, there is very little published research that connects the delivery of rehabilitation with the underlying concepts of explicit and implicit learning. The remainder of this chapter describes how certain practice conditions may relate to explicit and implicit learning, based on the characteristics described above. In particular, the evidence base relating to the role of information provision on motor skill learning will be reviewed. This area has been chosen due to the theoretical association with the concepts of explicit and implicit learning, the inherent use of verbal communication during physiotherapy practice, and the strong body of evidence that exists within healthy populations.

This section begins by giving a brief description of the concepts of attentional focus and attentional capacity, and their relevance to motor learning. Following this is a discussion of the key theoretical models concerned with the impact of explicit information provision on both attention and learning. The role that instructions and feedback may play in directing attentional focus and influencing motor learning will then be discussed. Then, the relationship between the frequency and timing of instructions, attentional capacity and motor learning will be introduced. Finally, other potential confounding variables will be presented and acknowledged at the end of this chapter.

3.10 THE ROLE OF INFORMATION PROVISION IN EXPLICIT AND IMPLICIT MOTOR LEARNING

The Serial Reaction Time studies discussed in section 3.6.1 examine learning in the presence and absence of explicit information about the task. This body of research supports the concept that learning can take place both explicitly and implicitly, with the possession of declarative knowledge about the task being performed being the primary factor that differentiates between the two (see Table 4). The provision of instructions and feedback from an external source (i.e. a therapist or a coach) is therefore fundamental to these two types of learning. The timing, frequency and content of information provided through the delivery of instructions and feedback will determine the task relevant information that is held by the learner, where their attention lies, and the demands placed on attentional capacity. The concepts of attentional focus and attentional capacity, and their relationship to motor learning, therefore warrant consideration.

3.10.1 Attentional Focus

The first concept relating to attention and motor learning is that of attentional focus. During performance, an individual can focus their attention in one of two ways: internally or externally. An internal focus is directed towards components of the movement itself, whereas an external focus is directed towards the effect that the movement has on the environment, or the end goal (van Vliet and Wulf, 2006). For example, an instruction with an internal focus may be “straighten your knees and tuck your bottom in”, whereas an example of an instruction with an external focus would be “look ahead at the clock on the wall in front of you”. Attentional focus has consistently been shown to affect motor learning (see 3.12), perhaps due to its influence on the performer’s cognitive-affective status (Wulf et al., 2010a).

During explicit learning, attention is more likely to be focussed internally - the individuals focus will be toward *how* they are moving, with the promotion of conscious thought in relation to that movement. Instructions and feedback that draw attention towards how to perform a task are therefore more likely to promote cognitive processes and subsequently influence explicit learning.

In contrast, the automatic, unintentional nature of implicit learning means that attention during this form of learning is more likely to be focussed externally. Externally focussed information does not tell the learner how to move; instead, it simply instructs the individual to “do”, prompting them to perform an action automatically, without necessarily thinking about how to do so. This prompt to perform may not necessarily be verbal, for example, it may be visual in the form of gesture, or tactile in the form of manual guidance.

The view that attentional focus is important in distinguishing between implicit and explicit learning is supported by recent (as yet unpublished) work by researchers in the Netherlands, who have conducted a Delphi survey exploring the terminology and definitions relating to implicit and explicit learning models in rehabilitation settings. Preliminary reports from the expert consensus indicate that focus of attention is considered to be an important element in the promotion of either implicit (external focus) or explicit (internal focus) processes (Kleynen et al., 2013b). The evidence base relating to attentional focus and motor learning is discussed further in section 3.12.

3.10.2 Attentional Capacity

The second concept relating to learning and attention is that of attentional capacity. Whether performed consciously or subconsciously, almost everything we do requires at least some attention (Wulf, 2007). Therefore, attention refers to what we are thinking about (or not thinking about), or what we are aware of (or not aware of), when we perform activities (Magill, 2011). Additionally, attention may be viewed as the amount of cognitive effort that individuals put into performing activities (Magill, 2011).

When instructions and feedback are provided by an external "coach", they will, to some degree, generate an attentional load on the receiver, who will need adequate resources to attend to and interpret the incoming information. High quantities of instruction and feedback will place demands on working memory. Information in the form of instructions may interfere with the practiced movement; whilst at the same time, the practised movement may interfere with the comprehension of the instructions (Haggard et al., 2000). These factors relate to attentional capacity and the central resources available for information processing. During explicit learning, demands on attentional capacity will be higher, relative to implicit learning. When receiving instructions, as in explicit learning, learners need to divide their capacity between remembering the information they have been given, interpreting it and actually performing the skill. In these circumstances, attentional demand may be high. During implicit learning, information from an external source may be less; if the person is receiving fewer complex instructions and feedback, then the demands placed on attentional capacity are likely to be lower. Attentional capacity is therefore a key component when considering the difference between what is explicit and what is implicit. The evidence base relating to attentional capacity is discussed further in section 3.13.

3.11 Theories relating to conscious attention and motor learning.

A number of authors have proposed theories relating to the effects of conscious attention on performance and learning. These theories relate directly to attention (either capacity, focus or both) and motor skill performance.

3.11.1 Action Effect Hypothesis (attentional focus)

The view that it is beneficial to performance to focus on the effects of movement rather than the movement itself was formalised by Prinz, who proposed the Action Effect Principle (Prinz, 1997). This principle assumes that actions are best planned and controlled by their intended effects – i.e. by maintaining an external focus. The theoretical basis for this relates to how sensory and motor information is coded in memory. Prinz argues a common coding approach, in which perceptions and actions relating to the same task share a common representational domain in memory. As a result of this, Prinz contends that representations of action effects play an important role in the planning and the control of those actions; postulating that for actions to be effective, afferent and efferent information must exhibit a high degree of compatibility, therefore movements need to be planned in terms of their desired outcome. The advantageous nature of an external focus has since been reported in numerous studies, and is discussed in depth later in this chapter.

3.11.2 Constrained Action Hypothesis (attentional focus)

There has been ongoing debate about the topic of attentional focus and skill performance, with Wulf and colleagues building on the work of Prinz (1007) and contributing significantly to the evidence base in this area. The theoretical approach proposed by Wulf and colleagues suggests that when participants are prompted to focus on their specific movements (internal focus), they may actually constrain or interfere with automatic control processes that would normally regulate movement, whereas if attention is focussed towards the movement effect (external focus) the motor system is able to more naturally self-organize (Wulf et al., 2001). By adopting an external focus, unconscious or automatic processes control the movement, resulting in more effective performance, and learning (Vance et al., 2004). This conceptualisation is known as the Constrained Action Hypothesis.

Studies utilising surface EMG, in which neuromuscular activity is shown to reduce under external focus conditions, provide some preliminary evidence to support the Constrained Action Hypothesis. Such studies (see section 4.6.6) indicate that under external focus conditions, movement production is more efficient (Vance et al., 2004, Wulf et al., 2010b, Zachry et al., 2005) - a finding that supports the notion that when attention is directed externally, the motor system is able to organise itself more efficiently.

The action effect and constrained action theories imply that external focus instructions promote the automatic processing of information governing motor control; whereas focussing on the movements themselves elevates this information to the level of conscious control, presumably by explicit working memory (Poolton et al., 2006a). If there is less conscious interference in the control processes under external focus conditions, then carryover into similar and novel situation (i.e. learning) may be enhanced. Such processes are likely to rely on implicit memory.

3.11.3 Reinvestment Theory (attentional capacity and focus)

In an attempt to unite the many different views regarding the effects of conscious attention on motor performance and learning, Masters (1992) presented the theory of reinvestment. It is unclear at which stage of learning reinvestment becomes disruptive, but assuming that a movement is at least partially automated, reinvestment is defined as:

> "the manipulation of conscious, explicit, rule based knowledge, by working memory, to control the mechanics of one's movements during motor output"
>
> (Masters and Maxwell, 2004; p208)

Unlike the action affect principle and the constrained action hypothesis, both of which provide a theoretical explanation for the benefits of an external focus, reinvestment theory provides a model by which movement may be disrupted in the presence of explicit knowledge. The theory supports the idea that relatively automated motor processes can be disrupted if they are run using consciously accessed, declarative knowledge to control the mechanics of the movements (Masters and Maxwell, 2008). The mechanism that underlies reinvestment is argued to be as a result of a progression-regression process through which relatively high level performance can regress to early stages of skill development in which execution is more reliant on explicit knowledge (Masters and Maxwell, 2008), i.e. reverting from the automatic to the cognitive stage in Fitts and Posner's model (see 3.7) . Complex skills with many units become broken down into sequences of smaller, separate units, similar to how performance was organised in early learning. Once broken down, each unit must be activated and run separately, which slows performance and, at each transition between units, creates an error that was not present in the "chunked" control structure, as might be seen in the cognitive stage of learning. Furthermore, the authors argue that this propensity to control movements consciously, which they suggest is intuitive rather than empirical, can vary from one person to the next and from one context to another, i.e. some people are more likely to "reinvest" than others. There is an alternative view, that individuals may have differing preferences towards internal or external focus conditions. This is supported by two small studies involving billiards (Ehrlenspiel et al., 2004) and darts (McKay and Wulf, 2012). In both of these studies, players whose preference was towards a distal external focus were found perform better than those whose preference was toward a proximal external focus, and both groups demonstrated a less consistent performance when receiving internal focus instructions. Interestingly, a preference of a distal external focus was far more common.

Reinvestment theory therefore supports the proposition argued by proponents of implicit learning that once movements become automatic, little cognitive attention is required to enable effective and efficient performance. It has also been proposed that the more task relevant knowledge that a learner acquires, the greater the likelihood that they will reinvest under pressure (Poolton et al., 2004, Masters and Maxwell, 2004, Liao and Masters, 2002). It is therefore suggested that implicit motor learning can give the learner immunity from reinvestment, presumably by minimising accumulation of consciously accessible task relevant knowledge that can be used to control movements at a conscious level (Masters and Maxwell, 2008). It is not clear how the propensity to reinvest impacts learning over time, however, distraction techniques or an external focus of attention may reduce reinvestment. Equally, utilising implicit motor learning techniques to restrain the build-up of movement specific knowledge may reduce dependency on declarative knowledge structures during movement (Masters and Maxwell, 2008).

The relationship between functional impairment and propensity for skill breakdown post stroke has been investigated using a cross sectional survey design (Orrell et al., 2009). In this study, 148 people with stroke, and 148 non-disabled adults completed the Movement Specific Reinvestment Scale, a psychometric scale that aims to predict and quantify the propensity with which someone is likely to reinvest (Masters and Maxwell, 2008). Correlation and multiple regression analyses were then conducted to examine the relationship between functional impairment and likelihood for reinvestment. Results indicated that, when compared to healthy controls, people with stroke had a greater propensity for reinvestment – with time spent in rehabilitation and conscious (explicit) motor processing being significant predictors. These findings indicate that exclusive reliance on conscious motor processing strategies in the rehabilitation setting may be an impediment to regaining functional independence (Orrell et al., 2009).

Based on Reinvestment Theory, recent work has proposed a number of reasons why the breakdown of skill under explicit learning and/or internal attentional focus conditions may be seen more readily in patients with stroke (Kleynen et al., 2011). These have been summarised as:

- Stroke patients often report the need to consciously control the execution of their movements and are encouraged to do so by their therapists.
- During rehabilitation, stroke patients may receive many verbal and explicit instructions on how to perform a movement.

- Movements are constantly evaluated by rehabilitation staff which may increase stress/pressure to perform well.
- Patients may have reduced attentional capacity and slowed information processing as a result of the neurological damage.
- Movement deficits may lead to a negative body image and low self-esteem and therefore increased self consciousness.

(Kleynen et al., 2011)

These points propose that explicit learning conditions lead to skill breakdown post stroke, and that both practice conditions and neurological impairments can contribute to this.

The remainder of this chapter appraises the evidence base that has led to the development of these theories. Empirical evidence relating to information provision and the role of attentional capacity and attentional focus on learning, in both healthy and neurologically impaired individuals, is presented and discussed.

3.12 CONTENT OF INFORMATION, ATTENTIONAL FOCUS AND MOTOR LEARNING

3.12.1 Attentional Focus of Information during Learning

In line with Fitts and Posner's model of motor learning (see 3.7), it is widely assumed that carefully delivered feedback, that directs an individual's attention towards how to improve their performance, is of benefit in the earlier (cognitive) stage of learning. Yet once the skill becomes more automated, drawing attention to the step-by-step component processes may disrupt execution (Beilock et al., 2002). Although there is some evidence to support this presumption (e.g. Poolton et al., 2006a), there is a lack of generalisable empirical evidence to support the notion that feedback information is required in the earlier stages of learning. It is equally feasible that motor learning does not necessarily have to progress through the cognitive (explicit) declarative stage (Masters, 1992), and that learning can occur implicitly from the outset. This has led researchers to examine the impact that externally delivered instructions and feedback, which promotes explicit knowledge of the task, has on both performance and learning.

3.12.2 Studies examining attentional focus in healthy individuals

Researchers investigating attentional focus during performance and learning have examined various motor tasks. A significant volume of work in this area has been carried out by Wulf and colleagues, with one of the first studies involving a ski simulator task (Wulf et al., 1998). During this study, healthy participants were randomised into one of three groups; they were either instructed to focus on the outer foot (internal focus), on the effects of the movement (external focus) or were given no instructions at all (discovery learning group). Participants in the external focus group produced superior performance throughout learning and in delayed retention when compared to the other groups. Subsequent work by Wulf et al (2001) further examined the beneficial effect of directing attention externally, this time using a dynamic balance task. Consistent with earlier experiments, the external focus group produced generally smaller balance errors than did the internal focus group and also demonstrated lower response times, indicating a higher degree of automaticity and less conscious interference in the control processes associated with the balance task. This lack of conscious interference could be related to the use of implicit processes.

Whilst not all studies have shown gains in *performance* under external focus conditions, they consistently demonstrate improvements for *learning*. For example, Emmanuel et al. (2008) instructed novice darts players to throw darts into the centre of a circular target. Instructions for the internal focus group were directed at movements of the shoulder, arm, and fingers (i.e. more explicit) whereas instructions for the external focus group were directed at the target, the dart, and the dart's course (i.e. more implicit). Whilst there was no significant difference in performance accuracy between groups during the acquisition phase (performance), the external focus group outperformed the internal focus group during retention tests one day later (learning). This basic finding that inducing an external focus of attention is more advantageous to *learning* when compared to an internal focus has since been replicated in numerous studies involving motor tasks with differing properties, including baseball (Castaneda and Gray, 2007), field hockey (Jackson et al., 2006), and soccer (Beilock et al., 2002).

A range of studies comparing internal and external focus of attention are summarised in Table 5. These studies examine a variety of motor tasks, and involve both novice and expert performers. Studies that include a follow up stage consistently demonstrate the relative benefits of an external focus of attention for motor learning in both novices and experts. If promoting an external focus does result in a less cognitive and more automatic/self governed level of performance, as described in the Constrained Action Hypothesis (see 3.11.2), then the underlying processes for learning under external focus conditions are likely to be biased toward the implicit system. This body of evidence therefore supports the notion that implicit approaches to motor *learning* are more beneficial for retention of motor skill; with the benefits to initial *performance* being more equivocal and potentially dependent on the task and the expertise of the performer. Directing focus of attention externally may be one way to promote such implicit processes.

Table 5 Experimental studies investigating internal and external focus conditions

Nº	Author (year)	Task	Control Group?	Novice or Expert	n	Significant Group Differences (favouring external focus conditions)	
						During practice (performance)	At follow up (learning)
1	(Wulf et al., 1998)	Ski Simulator	Yes	Novice	33	Yes	Yes
2	(Wulf and Shea, 1999)	Stabilometer	No	Novice	32	No	Yes
3	(Wulf et al., 2001)	Stabilometer	No	Novice	28	No	Yes
4	(Liao and Masters, 2002)	Basketball	No	Novice	40	Yes	Not assessed
5	(McNevin and Wulf, 2002)	Postural Sway	Yes	n/a	19	Yes	n/a
6	(Wulf et al., 2002): Experiment 1	Volleyball	No	Both	48	Novice: Yes Expert: Yes	Novice: Yes Expert: Yes
7	(Beilock et al., 2002): Experiment 1	Golf Putting	No	Expert	21	Yes	Not assessed
8	(Beilock et al., 2002): Experiment 2	Soccer Dribbling	No	Both	20	Novice: No Expert: Yes when using dominant foot; No when using non-dominant foot	Not assessed

9	(Ford et al., 2005)	Football Dribbling	Yes	Both	20	Novice: No Expert: Yes	Not assessed
10	(Jackson et al., 2006)	Field Hockey Dribbling	No	Expert	34	Yes	Not assessed
11	(Poolton et al., 2006a): Experiment 1	Golf Putting	No	Novice	30	No	No
12	(Poolton et al., 2006a): Experiment 2	Golf Putting	No	Novice	39	Yes	Yes
13	(Wilson et al., 2007)	Simulated Rally Driving	Yes	Novice	24	No	Not assessed
14	(Vuillerme and Nafati, 2007)	Postural Sway	No	Novice	16	Yes	Not assessed
15	(Castaneda and Gray, 2007)	Baseball Batting	No	Both	16	Novice: No Expert: Yes	Not assessed
16	(Emanuel et al., 2008)	Dart Throwing	No	Novice	32	No	Yes
17	(Nafati and Vuillerme, 2011)	Postural Control	No	Novice	12	Yes	Not assessed
18	(Lawrence et al., 2011)	Gymnastics Routine	No	Expert	40	No	No
19	(Zarghami et al., 2012)	Discus	No	Novice	20	Yes	Not assessed
20	(Schorer et al., 2012)	Darts	No	Both	12	Novice: No Expert: No	Not assessed
21	(Lohse, 2012)	Isometric Force Production	No	Novice	24	Yes	Yes

3.12.2.1 Benefits of internal focus compared to control conditions

A number of studies comparing internal versus external focus of attention have included control conditions where participants receive no attentional focus instructions (Wulf et al., 1998, Ford et al., 2005, Koedijker et al., 2011). This inclusion of a control group allows for identification of the causal direction (beneficial or detrimental) of an internal and an external focus condition. Such experiments have shown that not only do external focus instructions result in more effective leaning than internal focus instructions, but they are also preferential to no instruction at all, leading to the interpretation that an external focus actually seems to enhance learning. One explanation for this finding is that learners inherently adopt a more explicit form of learning (i.e. consciously controlling their movements and adopting an internal focus of attention), unless prompted to do otherwise. This may be particularly true among novices. In certain scenarios, deliberately encouraging an external focus of attention may therefore be necessary to actually promote implicit learning. This may be important in rehabilitation settings where an individual's self consciousness and self awareness in relation to movement may be high (Kleynen et al., 2013c), feeding into the tendency to consciously control movement (i.e. explicitly). Evaluating the knowledge of learners post experiment through interview would be one way to gain insight into this.

The studies by Koedjicker et al (2011), Costeneda and Grey (2007) and Ford (2005) all allowed participants to practice each of the different conditions in succession. Interestingly, despite investigating different skills, these studies all showed a beneficial effect of external focus among expert performers, but not among novices. One explanation for this could be that the novices were less able to switch their attention between the different conditions, whereas the experts could easily revert from an internal to an external focus (which is also likely to be their preference) when prompted to do so. Assuming that an external focus does promote more implicit processes, this further supports the proposition that to promote implicit learning, directly promoting an external focus of attention may be necessary.

3.12.2.2 Benefits of internal focus relative to the type of motor task

In order to investigate the generalisability of research showing the benefits of an external focus of attention, researchers have begun to investigate a wider range of motor tasks. Recent work by Koedijker and colleagues (2011) investigated focus of attention during the externally paced and repetitive skill of the forehand table tennis shot. In two experiments involving both experts and novices, balls were fired from a mechanical server and participants had to strike repeated forehand drives aimed at a target. Participants were instructed to hit balls under five different conditions: single task (baseline control); skill focussed instruction (internal focus); dual task instruction (external focus); speeded ball frequency; slowed ball frequency. The external focus condition involved an unrelated dual task in which verbal responses were given to auditory stimuli (i.e. a dual task aimed at directing attention away from the motor task). Consistent with previous experiments, experts showed poorer accuracy when a skill-focused instruction directed their attention to control of their movements, or when the frequency of balls was slowed to allow more time to hit the ball. As skill focussed instructions would promote explicit learning processes, this provides evidence to support the promotion of implicit learning within expert performers. However, contrary to the authors hypothesis, novices were unaffected by external focus (dual-task) conditions, relative to performance in the control (single-task) condition. They hypothesise that this could be because the dual task (word-monitoring) demanded too few attentional resources to be disruptive. The use of a dual-task condition to elicit an external focus of attention is perhaps a limitation of the study design. Whilst a dual task may direct focus of attention away from the motor task under investigation, it is not an external focus that is related to that task. Indeed, tasks such as table tennis do provide a natural source of extrinsic feedback, as the performer is aware of whether or not they hit the target, and this cannot be completely eliminated within the experimental design. Utilising a separate secondary task may therefore actually detract from an external focus that is actually related to the task being performed. Thus, this study gives evidence to support the detrimental effect of an internal focus of attention, but does not give clear evidence to support an external focus related to the goal of the task under investigation.

The majority of studies comparing the effect of an internal versus an external focus involve activities that require object manipulation – such as throwing a ball at a target or putting in golf. Only a few studies have investigated whole body movements. For example, in a study by Porter et al (2010), healthy subjects performed a standing long jump task under either internal or external focus conditions. Those in the internal focus condition followed instructions to jump as far as possible whilst focussing attention on extending their knees as rapidly as possible (i.e. more explicit); whilst the external focus condition were instructed to focus their attention on jumping as far past the start line as possible (i.e. more implicit). Consistent with findings from object manipulation studies, the results showed a significant difference between groups in favour of external focus conditions (Porter et al., 2010). This enhanced performance under external focus conditions has been shown in other studies involving whole body activities including a vertical jump and reach task (Wulf et al., 2007) and treadmill running (Schucker et al., 2009).

With the exception of treadmill running, all of these activities are also discrete motor tasks, in that they have a defined beginning and end point. Evidence for an internal versus external focus in continuous motor tasks is minimal, and whether the findings are relevant to less novel activities such as gait rehabilitation is not known. However, since the provision of internally focussed instructions encourages a controlled and therefore explicit mode of information processing, it is perhaps not surprising that they will negatively impact on tasks that would otherwise be relatively automatic. Such tasks may be performed better if governed implicitly.

3.12.2.3 The "distance effect" of an external focus of attention

Recent studies have begun to explore whether the distance of an external focus (relative to the body) has any impact on learning. These studies generally show that a more distal external focus (i.e. further from the body) is superior to a proximal external focus (Porter et al., 2012, McKay and Wulf, 2012, Shafizadeh et al., 2011, Bell and Hardy, 2009).

For example, Porter et al (2012) investigated the effect of increasing the distance of an external focus of attention on standing long jump performance. Using a counterbalanced within-participant design, recreationally trained male subjects (n = 35) performed 2 standing long jumps following 3 different sets of verbal instructions (total of 6 jumps; each separated by 1 minute of seated rest). One set of instructions was designed to focus attention externally near the body; another set of instructions directed attention externally to a target further from the body; the last set of instructions served as a control condition and did not encourage a specific focus of attention. The results indicated that both of the external focus conditions elicited jump distances that were significantly greater than the control condition. In addition, the subjects in the distal external focus condition jumped significantly further than those in the proximal external focus condition. Therefore, increasing the distance of an external focus of attention, relative to the body, immediately improved standing long jump performance (Porter et al., 2012). One explanation for the improved performance during conditions where the focus of attention was further from the body could be related to the type of task under consideration – i.e. that distance jumped is the outcome measure. Therefore focussing towards a distant target resulted in better performance.

However, similar findings have been demonstrated during a golf chipping task, where shot accuracy in experienced golfers was enhanced by a focus on the ball trajectory (distal) compared to the club head (proximal) (Shafizadeh et al., 2011). It could be hypothesised that increasing the distance of the external focus lessens the contribution of explicit processes and further promotes or reinforces implicit processes, when compared to an external focus that is closer to the body.

Recent work by McKay and Wulf (2012) examined which type of external focus (distal or proximal) performers would prefer, and whether using their preference would affect performance. Thirty seven novice participants were given an opportunity to practice a dart throwing task under distal (towards the bulls eye) and proximal (towards the dart) external focus conditions, only once, and without any knowledge of results. This allowed participants to compare the different foci, but ensured that their decision about which one they preferred was not biased by knowledge of the movement outcome. Participants were then asked which condition they preferred, following which they performed two sets of trials – one with a proximal focus and one with a distal focus. Half of the participants used their preferred focus first, and the other half used their non-preferred focus first. Throwing accuracy was significantly enhanced when performers focussed distally to the bull's eye, compared to focussing proximally toward the darts course. Not only did significantly more participants prefer a distal focus, but those who preferred to focus distally also performed significantly more effectively than those who preferred to focus proximally – a finding that was present under both focus conditions. That is, independent of which focus participants preferred, those who expressed a preference for focussing on the bull's eye were more accurate under both distal and proximal focus conditions, compared to those who preferred to focus on the dart. This could result from participants' being biased toward their preferred focus, regardless of the condition under which they were supposed to be practising.

All of the tasks investigated in these studies involve an end point that is distant from the body (i.e. a target on a dart board), or have the overall goal of achieving distance, for example in long jump. Therefore, the fact that performance is enhanced when the focus is more distal may also be attributed to the fact that focus is also more directly on the overall goal of the task being performed, rather than the distance itself. Indeed McKay and Wulf (2012) suggest that a more distal external focus facilitates movement accuracy to a greater extent than a more proximal focus because it is more easily distinguishable from the body movement, resulting in a more global and effective movement pattern. This is in line with implicit motor learning theory, where the participant is focussed toward the overall goal, not the movement required to achieve it.

Only one study comparing distal to proximal external focus of attention has included a retention phase to assess learning (Shafizadeh et al., 2011). In this study, 30 healthy volunteers practiced a golf putting task, completing 50 trials in the acquisition phase, and 10 trials in the delayed retention phase 24 hours later. Participants were randomised into one of three groups. The target focus group attended to the target (distal), the club swing focus group attended to the execution of the club's swing (proximal), and the target-club swing focus group attended to both. Results showed the target-club swing focus group (i.e. a combination of both proximal and distal focus) had better accuracy scores in both the acquisition and retention phases than the other groups. The authors concluded that external focus instruction helped the learners to integrate target cue with action cue and is more effective in skill learning than other external-focus instructions. Further research is required to understand the generalisability of these findings.

3.12.2.4 Generalisability to the elderly population

There are several factors specific to elderly populations that may impact on the relative benefits of explicit or implicit learning – for example, cognitive decline or slower information processing may make explicit approaches, which are reliant on cognitive processing, less effective. Whilst the majority of studies within healthy populations involve young adults, typically students, a few researchers have specifically considered the effects of attentional focus on learning in older populations.

Chiviacowsky and colleagues (2010) investigated the impact of focus of attention on balance performance utilising a stabilometer in older adults ($\overline{x}$ age = 69.4 years). The task required participants to stand on a balance platform (stabilometer) tilting to the left and right, and to try to keep the platform as close to horizontal as possible during each 30 second trial. The external focus group was instructed to concentrate on keeping markers on the platform horizontal, while the internal focus group was instructed to concentrate on keeping their feet horizontal. Participants performed 10 practice trials on day 1, with focus reminders given before each trial. Learning was assessed by a retention test, consisting of five trials without instructions, performed 1 day later. The external focus group significantly outperformed the internal focus group during retention testing.

However, other studies involving elderly populations have shown no benefit of an external focus. A small study investigating the use of a functional balance training system [Biodex Stability System] over a 5 week period with older adults (81 years +/- 6) showed no significant differences in balance performance between internal and external focus groups (de Bruin et al., 2009). Both groups practiced a balance task on stable and unstable platforms with concurrent feedback on a video screen. The internal focus group were informed that the moving point on the video screen represented their body centre of gravity, and were instructed to focus on this whilst concentrating on their belly. Thus, their focus was towards both internal and external components. The external focus group performed the same task, but was prompted towards a spirit level attached to the platform which corresponded to the marker on the video screen; this external focus prompt was therefore very proximal (i.e. close to the learners' feet). Since both sets of conditions required very similar behaviour (weight shift to follow a target), it could be argued that the real time feedback from the video screen, which was identical for the two groups, evoked an external focus and therefore led to the similar outcomes. Clearly such concurrent feedback is not always readily available during real life motor learning.

The learning benefits of an external attentional focus may therefore be generalisable to older learners, but the underlying learning processes (implicit or explicit) are more likely to be affected by concomitant variables, such as deficits in attention or physical ability.

3.12.3 Limitations of Internal and External Focus of Attention Studies

One major limitation of this body of evidence is that many studies fail to assess learning through the use of retention or transfer tests. It is feasible that whilst an improved performance is not seen during practice, there may be a benefit to novices at carryover. This has certainly been shown in a number of studies involving novices, where there has not been a significant benefit of external focus during practice, but this has become evident at follow up, demonstrating the benefits of external focus for carryover and learning (Shea and Wulf, 1999, Wulf et al., 2001, Chiviacowsky et al., 2010, Emanuel et al., 2008).

A second limitation of the study design adopted by many researchers is that participants are frequently not randomised to either an internal or external focus group, rather they practice the task under both sets of conditions, albeit separately. This design measures performance only, and assumes that there is no carryover or interaction between the two conditions. In reality, there is a real possibility of practice effects impacting on performance results, and also likelihood that actual attentional focus of the performer is less distinct if they have previously been instructed differently. For example, if the experimental design prompts a golfer to focus internally on their elbow movement for an initial task, and then externally on the path of the ball for the second task, how can the researcher truly know exactly where the focus of attention lies? Certainly, once an individual's knowledge is explicit, it is likely to remain explicit to a degree, even if prompted to focus externally. Indeed, it has been suggested that internally focussed instructions may cause rumination, in which thoughts continue to focus around a common theme even when the stimulus is not present (Masters and Maxwell, 2008). This could feed into learning that is governed explicitly.

3.12.4 Neuromuscular and Metabolic Activity

There is evidently a significant body of research to advocate the use of an external focus during skill acquisition in healthy adults, with findings replicated across a wide range of skill domains. Whilst the majority of studies measure performance at a behavioural level, more recent research has sought to examine the underlying neuromuscular mechanisms for these findings.

Working on the assumption that, for any given task, lower EMG activity is synonymous with more efficient force production, several studies have demonstrated that the benefits of an external focus extend to a neuromuscular level. For example, Vance and colleagues (2004) carried out a series of experiments using a bicep curl task and measuring EMG activity of biceps and triceps. Healthy subjects were prompted to adopt either an internal (focussing on their arms) or an external (focussing on the movements of the curl bar) focus of attention. Interpretation of findings was based on the premise that recruitment of fewer motor units is synonymous with greater automaticity/efficiency of movement. Therefore it was hypothesised that there would be less motor unit recruitment under external as opposed to internal focus conditions. Results showed that external focus conditions were associated with reduced neuromuscular activity; and potentially more effective recruitment of motor units. Movements were also generally executed with greater speed in the external focus group, which may also indicate greater automaticity. There was no control group, so it is not clear whether external focus conditions resulted in a reduction of muscular activity, or internal focus conditions led to an increase in activity; as there was no comparison to muscle activity in so called "normal" conditions. However, this study does provide some preliminary evidence to suggest that in healthy individuals, neuromuscular activity is more efficient under external focus conditions (Vance et al., 2004). Comparable studies in which subjects performed an isometric plantar flexion task with their dominant leg have produced similar results (Lohse et al., 2011, Lohse, 2012). Again, subjects were verbally prompted to focus either internally on their leg muscles, or externally on the platform they were pushing against. Internal focus conditions increased error in isometric force production and led to significantly greater co-contraction of the soleus and tibialis anterior, demonstrating less efficient neuromuscular coordination.

These findings have also been replicated in more complex motor tasks such as basketball shooting (Zachry et al., 2005) and vertical jumping (Wulf et al., 2010b). In the study by Zachry and colleagues, participants performed basketball free throws under both internal focus (wrist motion) and external focus (basket) conditions. EMG activity was recorded in forearm and elbow muscles of each participant's shooting arm. Results showed that not only was free throw accuracy greater when participants adopted an external focus, but EMG activity of the biceps and triceps muscles was lower with an external relative to an internal focus. Thus an external focus of attention is likely to enhance movement economy. Zachry et al (2005) suggest this is as a result of reduced "noise" in the motor system that would otherwise hamper fine movement control making the outcome of the movement less reliable. This premise is supported by the finding that increased EMG activity in the internal focus condition was not limited to the main agonist muscles (i.e. the muscles to which attention was directed) but also other muscle groups, including antagonists. Wulf et al (2010) produced similar findings for a vertical jump and reach task. Again, performance (jump height) was better with an external compared to an internal focus, and while there were no differences in muscle onset times between attentional focus conditions, EMG activity was generally lower with an external focus. These findings add to the evidence that an external focus facilitates the production of effective and efficient movement patterns (Wulf et al., 2010).

Further to this evidence relating to neuromuscular activity, Schucker et al sought to examine whether improved efficiency was also seen at a physiological level, by considering the effects on an internal versus an external focus on running economy (oxygen consumption). Trained runners were instructed to focus their attention on three different aspects whilst running on a treadmill; attention was focussed on the running movement (internal), on their breathing (internal), and on their surroundings (external). Results showed an increased running economy in the external focus condition, demonstrating that in line with studies that measure motor control, an external focus of attention is better than an internal focus in terms of the physiological performance measure of oxygen consumption during endurance sport (Schucker et al., 2009).

If an external focus of attention is synonymous with implicit learning, this evidence would suggest that adopting more implicit approaches to learning may be effective in terms of movement efficiency, as well as automaticity.

3.13 QUANTITY OF INFORMATION, ATTENTIONAL CAPACITY AND MOTOR LEARNING

3.13.1 Quantity of Information and Motor Learning

In addition to the focus of attention derived from instructions and feedback, evidence suggests that quantity of information also has an important influence on motor learning. This is perhaps due, in part, to the demands that higher frequencies of information provision place on attentional capacity. If explicit learning is cognitive and conscious, and implicit learning is automatic and subconscious (see 3.9), then the role of cognitive factors such as attention are particularly relevant to the concepts of explicit and implicit learning.

The following sections will discuss two areas of research relevant to this concept. Research concerning the role of attentional capacity during gait primarily comes from dual tasking studies. The fact that gait changes are accentuated during dual task conditions supports the premise that gait is not purely “automatic”, and must therefore involve some degree of cognitive processing (Beurskens and Bock, 2012). An overview of the theory and evidence relating to dual tasking and gait, and its relevance to the current research programme, is presented in section 3.13.2.

Secondly, studies investigating quantity of information provision during motor task learning have shown differences in performance relative to the frequency of feedback provision. In explicit learning, the learner possesses a higher degree of task relevant knowledge, compared to implicit learning. As this current research will examine ways in with the delivery of therapy can be changed to influence which type of learning (implicit or explicit) is utilised, practical elements such as the frequency of feedback delivery may be important in determining the knowledge held by the learner. Studies relating to frequency of feedback provision are discussed in section 3.13.3.

3.13.2 Empirical Evidence Relating to Attentional Capacity

Attentional capacity is historically assumed to be limited in humans - i.e. people have difficulty doing two things at once (Magill, 2001). Therefore, when the processing requirements of two tasks exceed the capability of the cognitive system, interference across tasks occurs and one or both tasks may be impaired (Eysenck and Keane, 1996). It is suggested that even a minimal amount of verbal information within healthy populations may exceed a person’s attention-capacity limits (Magill, 2001). This could have implications for the use of verbal communication during therapy sessions, which is known to be high in stroke rehabilitation (Talvitie and Reunanen, 2002, Durham et al., 2008). In order to investigate these assumptions, dual tasking paradigms are often employed.

Dual tasking studies explore two primary constructs of performance and learning. Firstly, a number of studies investigating the impact of internal versus external focus conditions on performance and learning have utilised dual tasking procedures as a means of deriving an external focus of attention (e.g. Koedijker et al., 2011). The fact that researchers have used dual tasking paradigms to facilitate implicit motor learning provides support for the theory that directing attention away from performance of the task is aligned with implicit learning. These studies are discussed, alongside other empirical evidence relating to focus of attention, in section 3.12. The second purpose of dual tasking studies is to determine the impact or interference caused on one task when a second task is performed simultaneously. During such studies, the primary task is usually the task of interest and is typically, although not always, a sensorimotor task (e.g. balance or walking). The second task is generally cognitive. These studies provide insight into attentional capacity during skill performance or learning.

In normal circumstances, when people are required to perform sensorimotor and cognitive tasks simultaneously, such as riding a bike and holding a conversation, they are thought to either perform the motor task "automatically", without the need for cognitive control (Cockburn, 1998), or the two will compete and attentional capacity will need to be divided between them, i.e. attention must be divided between the sensorimotor task of cycling and the cognitive task of having a conversation. When attention is divided it may cause interference with one or both tasks, as attentional capacity may not be sufficient to share between tasks. The same may be true when an individual is performing a sensorimotor task and also attending to and acting upon verbal instructions and feedback, as in explicit learning.

Mechanisms underlying dual task interference are not fully understood, however a number of theories are proposed to explain these dual task detriments. Most commonly, it is theorised that a reduction in efficacy of the sensorimotor task may occur to a varying degree according to the demands of concurrent cognitive processing, as the sharing of attentional resources between two domains of functioning reduces the amount of attention that is available for the sensorimotor task (Huxhold et al., 2006). It has been suggested that this interference may be particularly significant if both tasks use a common processing component: for example, concurrent performance of two cognitive tasks, such as reading whilst holding a conversation (Haggard et al., 2000).

Motor tasks such as walking are sometimes thought to be immune from this interference because they are "automatic" – a view that assumes that movement control does not require central cognitive resources (Haggard et al., 2000), for example if skills are learnt and performed implicitly. Within healthy individuals this may theoretically be true; or indeed the level of cognitive resource required for walking may be insignificant in that is does not interfere with other concurrent tasks, hence most healthy adults do not have difficulty walking whilst holding a conversation. However, this assumption is challenged by studies within healthy populations that show a detrimental interference to postural or gait tasks when a sufficiently challenging simultaneous cognitive task is introduced (Lajoie et al., 1993), thus going some way to suggest that attention does play an important role in such sensorimotor activities. Indeed, dual task studies within both healthy (Huxhold et al., 2006, Faulkner et al., 2006) and neurologically impaired populations (Hyndman and Ashburn, 2004, Bowen et al., 2001, Plummer-D'Amato et al., 2008, Haggard et al., 2000) have repeatedly shown that performance efficacy may decrease under dual task conditions when compared to single task conditions – providing support for the theory that cognition does play a critical role in gait. This requirement for cognitive resources during balance and walking is known to increase with age (Lajoie et al., 1996), and is further supported by evidence showing gait related changes to be more common in those with cognitive impairment (Beurskens and Bock, 2012, Al-Yahya et al., 2011).

If attention capacity limits are reduced post neurological event, then consideration needs to be given to the demands placed through excessive verbal communication during therapy. Indeed, in older but neurologically intact adults, it has been hypothesised that age related declines at both central and peripheral levels lead to a higher need for cognitive involvement in sensorimotor processing (Li and Lindenberger, 2002). At the same time, impaired cognitive capacities and the associated losses in prefrontal working memory and attention functions commonly found in older adults may, in turn, impair the successful employment of such attentional resource requirements (Huxhold et al., 2006). Importantly, the point at which this attentional resource competition changes from being beneficial to detrimental may vary between individuals dependent on their existing attention capacity limits, which are influenced by a number of factors including age and the task being performed. Such changes could be attributed to an overall reduction in the individual's information processing capacity, or to an increased requirement for central processing for previously automatic activity such as gait. Although most of these studies are relatively small, the results are both statistically and clinically significant, providing support for the theory that combining a verbal cognitive task with a physical one (i.e. walking) can be challenging for patients with stroke or acquired brain injury, and can be detrimental to certain performance parameters (e.g. gait velocity, stride length and balance). It is generally proposed that it is the processing involved in verbal interactions which has adverse effects on velocity and balance; such processing requirements will be higher during explicit learning, relative to implicit learning.

Evidence has also shown severity of physical impairment to influence the degree to which a secondary task load interferes with movement. A large study investigating dual cognitive and walking tasks in older adults found that not only did both cognitive and motor performance decline in dual tasking conditions, but that the greatest degradation to walking time occurred in the participants who were already slow walkers and who had weaker quadriceps strength (Faulkner et al., 2006); potentially indicating that as walking becomes more physically difficult, it also draws on greater cognitive resource. This again may have implications for those with neurological pathology that directly affects the sensorimotor systems, and the level of disability may influence the degree to which explicit instructions aid or interfere with learning. Thus motor performance may be more vulnerable to secondary task or cognitive interference in those with neurological impairment, where central processing, attentional capacity and physical function may all be impaired. In such patients the effects of dual tasking may be exacerbated – i.e. the level of difficulty at which paying attention to a secondary task becomes counterproductive will be lower. Compromised executive control as a result of the neurological pathology may underlie this cognitive-motor interference (Plummer-D'Amato et al., 2008). Practically, this interference may be reduced if more implicit approaches to learning, that lessen cognitive demand, are adopted.

Whilst the dual tasking literature generally supports the idea that individuals have difficulty doing two things at once, methodological differences make comparison across studies difficult. In particular, studies vary considerably in terms of the combination of tasks employed and the measures used to determine performance. In their meta-analysis into the effects of age and task domain on dial task performance, Riby and colleagues (2004) grouped studies into three broad categories according to the type of primary task under investigation. Analysis showed a strong overall effect size for increasing dual task detriments with increasing age, with task domain proving to be critical in moderating the magnitude of this dual task effect. Notably, tasks that involved substantial controlled processing components (e.g. episodic memory tasks) or a significant motor component (e.g. walking or tracking tasks) showed greater dual task interference than those that relied on more automatic processes (e.g. implicit memory tasks)

(Riby et al., 2004). One limitation of this meta-analysis is the degree of subjectivity in grouping the tasks, and the lack of homogeneity within those groups. For example, the motor group included studies that involved walking, driving and novel upper limb tracking tasks. However, evidence to support the basic finding that dual task performance reduces with increasing age strong, and is supported by others (Verhaeghen et al., 2003)

More recently, a comprehensive meta-analysis by Al-Yahaya *et al* (2011) examined studies in which dual tasking methodologies were used to measure cognitive motor interference (CMI) specifically on the motor task of gait. In this analysis, cognitive tasks were classified into 5 categories: reaction time tasks; discrimination and decision making tasks; mental tracking tasks; working memory tasks; and verbal fluency tasks. Studies involving both healthy and neurologically impaired individuals were included. Overall, the effect of different cognitive tasks was most prominent on gait speed, and was strongly related to both increasing age and reduced cognitive function (measured using the MMSE); again supporting the theory that gait is not purely automatic, but does rely on cognitive function. The type of cognitive activity employed as a second task was also found to be an important factor. For example, whilst a correlation between age and CMI was found overall, this finding did not apply to verbal fluency tasks. Furthermore, tasks that involved internal interfering factors (e.g. mental tracking) appeared to interfere with gait performance more than those that involved external interfering factors (e.g. reaction time). When comparing healthy and neurologically impaired individuals, dual task detriments appeared to be similar, with the exception of cognitive tasks in the mental tracking domain, which had a greater CMI in participants with neurological disorders (Al-Yahya et al., 2011).

In all dual tasking studies, the cognitive task is disparate from walking itself, and therefore fundamentally differs from typical rehabilitation scenarios, where the performer is required to process instructions and feedback that relate to walking. When considering the classifications of cognitive task compared in the meta-analysis by Al-Yahya and colleagues (2011), the delivery of verbal instructions and feedback during gait practice is probably most aligned either to the category of "mental tracking tasks" (tasks that require holding verbal information in the mind while performing a mental process); or that of "working memory tasks" (tasks that require holding verbal information in the mind which is available for processing, but does not require manipulation). Interestingly, these types of task, described as involving internal interfering factors, had the greatest detrimental effect on gait speed in people with neurological disorders. The authors postulate that this is due to the differing neural networks involved in modulating different types of cognitive task. For example, mental tracking and verbal fluency tasks share complex neural networks which are interlinked with those of gait control, and therefore may interfere with the neural networks of gait, and therefore gait performance. Whereas cognitive tasks that involve external influencing factors, such as reaction time tasks, share “stimulus driven” lower order networks, resulting in less interference compared to higher-order networks (Al-Yahya et al., 2011). Promoting “stimulus driven” learning, for example by evoking an external focus of attention and reducing higher cognitive processing (i.e. through implicit learning), may therefore be important in reducing unwanted dual task interference during rehabilitation.

Theoretically, the cognitive nature of explicit learning will require greater attentional resource relative to implicit learning. Drawing on the findings of dual tasking studies, it could be hypothesised that the processing of explicit information, as delivered in the form of internally focussed instructions/feedback, may impact the cognitive resources available for actually performing the motor task. Furthermore, the role of cognition during walking may be significantly greater in the presence of neurological disease and/or physical impairment. Cognitive ability is therefore an important consideration when designing motor learning programmes during rehabilitation; promoting a more implicit mode of learning may be one way of reducing cognitive demand. Therefore, the results from this body of dual tasking literature may have important implications for if, how and when therapists use verbal instruction during mobility practice and rehabilitation sessions. They go some way to indicate that the impact of concurrent verbal activity on walking ability in real life rehabilitation situations, which are inevitably more complex than the laboratory based studies described in section 3.9.2, may potentially be even more significant, and could determine a patient’s responsiveness to rehabilitation (Cockburn, 1998). Poor dual task performance may complicate therapy treatment, and patients may benefit from therapy which minimises the requirement of dual task performance (particularly in the earlier stages of skill acquisition), or that are specifically designed and selected to improve levels of dual task performance, as required for real life situations (Haggard et al., 2000). The use of strategies that are more aligned to an implicit approach may be one way to achieve this

However, whilst dual tasking research supports the notion that increased cognitive activity through the frequent use of instructions and feedback may impact on motor performance, the evidence in this field is not directly related to the concept of explicit learning. During dual tasking studies, the verbal activity performed as the secondary task is typically a simple concurrent but unrelated task that is not related to walking itself – e.g. auditory reaction time tasks whereby the learner has to give a verbal response to an auditory signal such as a tone or a spoken word/phrase; or short term memory tasks whereby the learner has to recall information that was given to them previously. Whether or not the findings are directly applicable to rehabilitation situations whereby instructions and feedback are being delivered in order to attempt to enhance performance is not known. Although concurrent instruction and feedback could be considered as a form of dual task, as the patient is required to process and act upon the information that they are being given, this type of verbal interaction differs from those used in the aforementioned studies in terms of both its focus and its complexity. More specifically, during explicit forms of learning, instruction and feedback will be relevant to the walking, either as practical advice (e.g. positioning or sequencing instructions) or intended to motivate or reassure; and is likely to be more complex, involving several higher level cognitive processes (such as sustained attention, language, processing, remembering and sequencing) (Bowen et al., 2001).

3.13.3 Frequency and Timing of Feedback Delivery

Dual tasking studies provide insights into the role of attention capacity within motor performance and learning, and compare cognitive tasks of different types and difficulty. However, they do not provide evidence relating to the *quantity* of information delivered during performance. This section discusses the evidence base relating specifically to the frequency and timing of information during motor skill performance.

Regardless of the focus of attention derived from instructions and feedback, their quantity and timing relevant to the task being practised may also be important when making the distinction between explicit and implicit learning. If explicit learning is dependent on the possession of task relevant knowledge, then verbal information that is delivered a) prior to task practice and b) repeatedly throughout performance, will increase the amount of task relevant knowledge, may reinforce that knowledge, and may therefore reinforce explicit learning. Therefore, reducing the frequency of instructions and feedback could make the learning environment less explicit.

Instructions and feedback may be provided concurrently, immediately following or delayed in time with respect to the relevant action (Winstein, 1991). Concurrent feedback refers to the use of supplementary information that is presented to the learner during the actual action (Schmidt and Wulf, 1997). Such feedback may be given in different formats, but the general premise is that it occurs continuously and concurrently with the real time performance, prompting constant adjustment from the learner. This is explicit.

Concurrent and continuous feedback often appears to be effective as it guides the learner powerfully to the correct response, minimises errors and holds behaviour on target. However, the performance gains made during practice may not be carried over once the feedback is withdrawn – people who have practiced with concurrent continuous feedback during training often perform worse during retention tests than do people who have practiced with no such feedback (Schmidt and Wulf, 1997). In contrast to concurrent feedback, summary or average feedback is delayed until after a series of trials have been completed; feedback is then given in a way that summarises performance during the preceding trials. Whereas summary feedback involves feedback about every trial in the set, average feedback refers to the average performance on that set of trials (van Vliet and Wulf, 2006).

Poolton and colleagues (2006) have investigated the relationship between focus of attention and quantity of information through two experiments involving a golf putting task. In the first experiment, healthy participants practiced a golf putting task after being given a single instruction to focus either on their hands (internal focus) or on the movement of the putter (external focus). Whilst no group differences were evident during learning and retention, the performance of the external focus group remained robust under secondary task load, whilst the internal focus group showed a drop in performance. The fundamental question arising from this first experiment was the causality of skill failure under secondary task load – whether due to increased load on working memory (i.e. attentional capacity) as a result of the internal focus condition, or specifically due to attention being focussed internally (i.e attentional focus). The authors proposed that if the cause of skill breakdown is due to the imposition of a general load on attention, then providing both the external and internal groups with an equivalent *amount* of excessive information to process should result in both groups' performances degrading under secondary task loading. If, however, only the content of internally focused information is crucial to skill breakdown, then the provision of a large amount of externally focused information should not result in skill breakdown. This was investigated in the second experiment, in which healthy volunteers performed the same golf putting task under either external or internally focussed conditions – with both groups being given a set of six rules (either external or internally focussed) to follow. Both groups demonstrated a uniform improvement throughout practice, with no differences between groups at follow up, and no differences under secondary task load. These findings provide some evidence that it is not just the focus of attention derived from instructions that is important, but also the demands that the quantity of instructions place on working memory.

This is supported by evidence within healthy individuals that has specifically compared different how quantities of feedback influence motor learning. These studies have demonstrated that reducing the proportion of trials for which feedback is presented can result in more effective learning than presenting feedback after every trial (Weeks and Kordus, 1998, Winstein and Schmidt, 1990a, Lai and Shea, 1998). Typically, these studies compare feedback after every practice trial (100% feedback) to feedback after every third trial (33% feedback). Similar benefits of reduced frequency feedback have also been shown in patients with traumatic brain injury learning a novel upper limb sequence (Croce et al., 1996). Croce et al (1996) found that during acquisition trials subjects receiving feedback on every trial were the most accurate and the most consistent in their responses (i.e. higher performance); however, subjects in groups receiving summary and average feedback were the most accurate during immediate retention, with the group receiving summary feedback being the most accurate during longer retention (i.e. greater learning) (Croce et al., 1996). In all of the aforementioned studies comparing different frequencies of feedback, participants receive “knowledge of performance” feedback – i.e. internally focussed feedback relating to the nature of their movement pattern. Therefore, it is unclear whether the beneficial effects are due to a reduction in the amount of feedback, or due to the effect of reducing the degree to which an internal focus of attention is reinforced. In addition, no studies include a control condition, so it is not possible to conclude the beneficial effects of 33% feedback over and above no feedback.

However, Wulf and colleagues (2010) have provided evidence to challenge the presumption that reducing the amount of feedback is always beneficial. In their experiment to investigate both frequency and focus of attention of feedback, participants (aged 10-12 years old) practiced a soccer throw whilst receiving either internal or external focussed feedback of varying frequencies. They demonstrated that learning was enhanced under 100% external focus feedback, relative to 33% external focus feedback and both 100 and 33% internal focus feedback. Therefore, whilst there is evidence to support a reduction in quantity of internally focussed feedback by two thirds , (Winstein and Schmidt, 1990b, Weeks and Kordus, 1998, Lai and Shea, 1998), the opposite may be true for externally focussed feedback, where higher frequencies could be beneficial (Wulf et al., 2010a). Further research is required to determine whether these findings are transferable to adult learners, and different motor tasks.

The mechanisms underlying the observed beneficial effect of reduced frequency feedback are not entirely clear. One reason that concurrent and instantaneous feedback might have detrimental effects is that they prevent spontaneous error estimations, based on the processing of intrinsic feedback, that might occur during or after the movement (van Vliet and Wulf, 2006). In line with the Constrained Action Hypothesis (see 3.11.2), allowing an individual the ability to adjust their movement according to their own intrinsic feedback mechanisms is important for implicit learning to take place. Delaying feedback, if only for a few seconds, may therefore encourage those error estimations from the performer. Thus, concurrent feedback may create dependency, such that the feedback may become a part of what the person has learned and they cannot perform efficiently without it. It has also been proposed that frequent feedback results in excessive variability in performance, preventing the individual from learning a stable movement pattern (Wulf et al., 2010a). Indeed, regular feedback may keep the environment more explicit, and may therefore reduce the ability for implicit learning to occur.

Within a therapeutic setting, frequent and concurrent verbal feedback or instruction from a therapist may therefore degrade carry-over and subsequent motor learning. This could be a result of creating bias towards explicit learning. The balance between giving an optimal quantity and *type* of feedback and at the right time is therefore important. Reducing or delaying feedback delivery may encourage the patient to find their own means of feedback, and may promote more implicit processes of learning.

3.14 Current Physiotherapy Practice

Despite the growing body of evidence relating to the use of instructions and feedback during motor learning, very little is known about what therapists actually do within clinical practice.

Utilising observational methods, a small number of studies (n=3) have examined current physiotherapy practice with regards to the conversation that takes place during stroke rehabilitation (Talvitie, 2000, Talvitie and Reunanen, 2002, Durham et al., 2008). Talvitie and colleagues examined the characteristics of the manual, visual and verbal feedback provided by Finnish physiotherapists during rehabilitation. They report the frequent use of verbal guidance during therapy, but describe this feedback as being motivational and reinforcing; seldom involving specific or targeted information feedback (Talvitie, 2000). Visual and verbal feedback was typically provided alongside concurrent verbal instruction. In a later study, the same authors found that physiotherapists frequently used oral communication to organise and guide physical exercises. They noted an unequal distribution in conversation, describing therapist's approach as being "authoritarian", with little space for patients to initiate conversation.

Only one previous study considered communication in terms of attentional focus. Durham et al (2008), video recorded and analysed 74 physiotherapy sessions focussed on the hemiplegic upper limb. Statements of "instruction" and "feedback" were identified, and categorised according to their attentional focus. 13% consisted of feedback statements, compared to 54% for instruction and 33% for motivation. Furthermore, internally focussed statements occurred significantly more frequently than those with an external focus. One major limitation of this study was that treating therapists were told that the purpose was to examine the use of internal and external focus feedback, and were given definitions of these terms. This knowledge could have altered the therapists' behaviour. Furthermore, as the study involved a small number of therapists (n=8) and only considered upper limb rehabilitation, it is not known whether the findings are generalisable to physical therapy practice as a whole.

3.15 GAPS IN LITERATURE

This chapter has introduced the concepts of explicit and implicit learning as the overarching process by which motor skill learning takes place. Whilst the existence of these forms of learning is widely accepted, there are a number of limitations to the presently available research on the neural bases of explicit and implicit processes. Firstly, the type of task used to examine skill learning experimentally, for example serial reaction time tasks, do not involve functional actions and do not require the organisation of truly novel movements. They are typically controlled to exclude the multiple sources of feedback that are available in natural settings, and primarily involve healthy young adult participants. Further research is therefore required to examine the concepts of implicit and explicit learning within functional motor tasks, and with different study populations – including those with neurological pathology. In order to do this, research first needs to consider how implicit and explicit strategies might be delivered outside of a laboratory setting.

The issue of terminology is the second limitation of the current evidence base; the notions of explicit and implicit learning are not always clearly defined. Rarely are these concepts anchored to specific motor control functions (Gentile, 1998), and terminology within the evidence base is unclear. The examples given in section 3.8 (e.g. errorless learning, trial and error learning etc) highlight a lack of consistency within the field of rehabilitation with regard to how the structure of practice is defined, described and interpreted across the existing evidence base. In many ways, this abundance of terms and definitions overcomplicates the evidence base, as it is challenging to directly compare studies that use the same terms to mean different things, or different terms to mean the same thing. There is common theoretical ground linking evidence from studies examining concepts such as focus of attention and attentional capacity/dual tasking, however these concepts are rarely considered collectively (i.e. as factors that may influence each other) and are rarely associated to the broader constructs of implicit and explicit learning. This lack of clarity has been recognised by researchers in the Netherlands, who are currently conducting a Delphi study with the aim of achieving consensus on the definitions, descriptions, and taxonomy of terms related to motor learning, using the distinction of implicit and explicit forms of learning as a conceptual basis (Kleynen et al., 2013a). If all learning encompasses either explicit or implicit processes (or a combination of the two), then a simpler view would be to develop clear definitions within the context of rehabilitation so that they can be used and investigated consistently. This is particularly pertinent within stroke rehabilitation as explicit and implicit processes are not likely to be discrete and cannot therefore be applied in their purist form during a complex intervention such as gait rehabilitation. Further work is also required here.

Given the complexity of motor learning, there are many factors relating to a practice environment that may be altered in order to created bias towards implicit or explicit learning. The literature has identified information provision, both in terms of quantity and focus of attention, to be important factors in motor learning. Whilst there is considerable evidence linking these factors to learning within healthy individuals, particularly in the fields of sports science and psychology, there is little evidence in stroke rehabilitation and the transferability of findings is unknown. The current evidence base is not conclusive, and does not provide sufficient knowledge to guide the optimal delivery of rehabilitation interventions. Equally, whilst a few small studies have reported the frequent use of instructions and feedback during rehabilitation, there is little analysis of the exact nature and content of these interactions; and again, no association made to the impact this may have on the processes underlying learning. How best to optimise implicit motor learning by manipulating the use of instructions and feedback is therefore unknown. The use of instructions and feedback, including the amount, timing and focus of attention, will therefore be the focus for the remainder of this research.

3.16 CONFOUNDING VARIABLES

With regards to practice conditions, this research will primarily focus on the impact that instructions and feedback have on attention and learning. However, there are multiple variables that may affect learning and/or attention; controlling for which may be challenging in a clinical setting. Nevertheless, it must be acknowledged that instructions and feedback will not be the only source of knowledge, and other factors relating to practice conditions may also be important in the distinction between explicit and implicit learning. It is not within the scope of this thesis to discuss these practice conditions in depth, but as potential confounding variables, they are described below.

3.16.1 Structure of the Learning Experience

Practice can be described broadly in terms of how it is structured. In a therapeutic setting, these variables or practice conditions may be used to create bias towards either the explicit or the implicit learning system. Three main variables relating to the structure of a learning experience are outlined in Table 6.

Table 6 Structure of the Learning Experience
Overview of the various ways in which motor task practice may be structured.

Structure of the Learning Experience		
Scheduling Practice	**Organisation of Practice**	**Organisation of the Task**
a) Intensity and Repetition b) Massed versus Distributed Practice	a) Blocked versus Random Practice	a) Whole versus Part Practice

3.16.1.1 Scheduling practice

There is very little empirical evidence relating to the optimal "dosage" of any given rehabilitation activity. Clearly this will be individualised and based on many factors including the individuals' tolerance and levels of fatigue. In their comprehensive review, Teasell et al (2011) conclude that although there is strong evidence that greater intensities of therapy result in improved functional outcomes, the overall beneficial effect is modest and the positive benefits associated with greater treatment intensities are not maintained over time (Teasell et al., 2011). So whilst intensity and repetition does appear to be important, the content of that therapy is likely to be of equal significance.

Depending on the relative amounts of practice and rest periods, the scheduling of performance-rest ratios within treatment sessions can be defined as either massed or distributed in nature (Schmidt and Wrisberg, 2000). During massed practice, the amount of rest between practice attempts or between practice sessions is relatively shorter than the amount of time spent practising; whereas during distributed practice, the amount of rest between practice attempts or practice sessions is relatively longer than the amount of time spent practising. However, there is no consensus within the literature as to which form of practice has most benefit to learning. Whilst some suggest that distributed practice improves performance and learning in healthy individuals (see Krakauer, 2006 for a review), there is little evidence to guide practice in people with stroke, where a more massed approach with high levels of repetition may be important for recovery.

3.16.1.2 Organisation of practice

The terms blocked practice and random practice refer to the variation of tasks employed within a training session. During blocked practice, the learner repeatedly practices one discrete task, before moving onto the next. In contrast, during random practice the learner performs a number of different tasks in no particular order, thus minimising or avoiding consecutive repetitions of any single task (Schmidt and Wrisberg, 2000). When compared to blocked practice, random practice has been shown to have a much stronger, positive influence on learning in healthy populations, despite having a temporary degrading influence during acquisition performance (Sherwood and Lee, 2003, Schmidt and Wrisberg, 2000). No studies specifically compare blocked and random practice in individuals with stroke.

3.16.1.3 Organisation of the task

When designing rehabilitation interventions, skills can be practised in their entirety (whole practice) or in component parts (part practice). The decision to practice a skill as a whole or in parts can be based on the complexity and organisation characteristics of the skill (Naylor and Briggs, 1963). Complexity refers to the number of parts and the attentional demands of the task, and organisation refers to the spatial and temporal relationship between these parts. It is important to note that in this definition, the term complexity relates to the level of processing demands on the human performer, and not the difficulty of the task. Naylor and Briggs (1963) suggest that for tasks in which complexity is low and organisation is high, for example kicking a ball, whole practice is preferable. Whereas, in tasks where complexity is high and organisation is low, for example performance of a dance routine, a part practice strategy is preferable, at least initially. Based on Naylor and Briggs definition, it is difficult to define the complexity of rehabilitation activities such as walking or reach to grasp. In a healthy individual, these would certainly be low in complexity (they are automatic tasks that are low in attentional demand); however, this may change in the presence of neurological deficit. In particular, the attentional demand associated with previously automatic tasks may be increased in the presence of neurological pathology. It is clear that rehabilitation tasks such as walking are high in organisation, and therefore if level of complexity can be kept low, whole task practice is likely to be most effective.

3.16.2 Intrinsic Feedback

Intrinsic feedback is inherent to any motor action and includes kinaesthetic, visual, cutaneous, vestibular and auditory signals, collectively termed “response produced feedback” (Winstein and Schmidt, 1990a). For example, if the learner is attempting to throw a ball at a target, their own sensory systems (visual and auditory) will give them feedback about whether or not this has been achieved. This type of feedback is likely to be used during implicit learning.

Verbal instruction, particularly if it is internally focussed, may distract attention away from the processing of more important information sources, such as kinaesthetic or visual information that may be integral to task execution (Hodges and Lee, 1999). However, after stroke, intrinsic feedback systems may be impaired, making it difficult for the person to determine what needs to be done to improve performance (van Vliet and Wulf, 2006) and extrinsic (augmented) feedback of some form may therefore be more necessary (van Vliet and Wulf, 2006). In these circumstances, extrinsic feedback is supplemental to the intrinsic sources, and will typically seek to enhance or focus attention on existing intrinsic systems. Enhancing the use of intrinsic mechanisms through therapeutic handing and the visual system are two examples of this, common to neurological physiotherapy practice.

3.16.2.1 Handling

There is little research evidence directly evaluating the impact of therapeutic handling within stroke rehabilitation. Handling techniques may be used with the intention of providing sensory or proprioceptive feedback, or may be manual in order to allow a movement to be performed. These different factors are difficult to delineate and therefore objective analysis is challenging.

Research relating to handling within neurological physiotherapy tends to evaluate approaches to physiotherapy as a whole, of which handling may be an integral part. For example, approaches based on neurophysiological principles (Bobath) primarily involve physiotherapist handling; moving the patient through patterns of movement, with the therapist acting as problem solver and decision maker and the patient being a relatively passive recipient (Lennon, 1996). Conversely, motor learning approaches stress the importance of active involvement by the patient (Carr and Shepard, 1982). Despite these broad depictions, the evaluation of research evidence is often difficult owing to poor description and documentation of the approaches investigated (Pollock et al., 2007); isolating the impact of the physiotherapist's handling on performance or learning is extremely difficult. In their Cochrane systematic review comparing such different physiotherapy approaches for lower limb rehabilitation, Pollock and colleagues (2007) concluded that there is insufficient evidence that any one physiotherapy approach is more effective in promoting recovery of lower limb function or postural control after stroke than any other approach.

However, therapeutic handing is an important consideration since it is integral to neurophysiotherapy, yet the evidence base behind it is so sparse. It has been observed that when therapists give tactile cues or manual guidance, they typically coincide with verbal guidance (Talvitie and Reunanen, 2002). One could argue that therapeutic handling without such verbal communication may promote implicit learning, as it enables the person to move through the required movement pattern repetitively, until they begin to learn that pattern themselves. However, it has also been suggested that the frequent use of handling techniques prevents patients from making mistakes and does not let them evaluate their own performance and learn from their errors (Lettinga, 1999), thus potentially inhibiting the use of implicit learning pathways. Gentile (1998) goes further to suggest that when handling techniques or active guidance is used, the therapist becomes part of the regulatory environmental conditions, altering the performance context and intrinsic feedback. Movement imposed by the therapist does not reflect the patient's own generative processes, and does not help the patient to derive the required motor plan (Gentile, 1998). Since there is no robust research to support or refute these theories, the effectiveness of such manual guidance in facilitating motor learning, and the link to implicit or explicit learning, remains unclear.

3.16.2.2 Visual Demonstration and Feedback

Demonstration is one of the most common means of communicating how to perform a skill (Magill, 2010), however, it is not less commonly employed by neurological physiotherapists (Talvitie and Reunanen, 2002). Demonstration can support motor skill learning in healthy populations, particularly when the skill being learnt requires the acquisition of a new pattern of coordination (Magill, 2010). Consideration needs to be given to the specific individual characteristics of the person with stroke; for example, they may or may not have the physical ability to perform the skill in the way in which it had been demonstrated, which could in turn affect motivation. If perception is impaired, or indeed if sensory and proprioceptive pathways are impaired, then the patient may not be able to translate what they perceive they have observed into their own performance of the activity. However, demonstration of an activity by a physiotherapist is one way in which therapists can provide instruction without giving internally focussed information, and may therefore be a useful tool for promoting implicit learning.

Visual feedback can be delivered by means of an environmental aid, for example by using a mirror (extrinsic) for a patient to assess their own standing posture. Such methods may supplement the patient's own visual systems, and account for any loss of postural awareness resulting from impairments to the sensory or proprioceptive systems. However, there is little evidence to support the use of visual feedback. In their systematic review, van Peppen and colleagues analysed eight trials involving a total of 214 subjects in which visual feedback was compared to conventional care for the postural control and gait training post stroke (van Peppen et al., 2006). Meta-analysis demonstrated no significant effect sizes in favour of visual feedback for weight distribution, postural sway or balance, and that this did not generalise to better balance control during gait or gait related activities. Therefore, the additional value of using visual feedback is questionable.

3.17 Modelling the Characteristics of Explicit and Implicit Learning

3.17.1 Modelling

Modelling is a broad term used to describe any preliminary work that may provide important information about the complex intervention itself, or the processes used for evaluation (MRC, 2008). At this stage of the current research, modelling was used to pull together the findings from existing theory and evidence in order understand all of the factors that may play a role in creating an explicit or an implicit learning environment.

3.17.2 Definition of Explicit and Implicit Learning

Based on the review of the literature, the following definitions of explicit and implicit learning were applied:

i) Explicit learning is defined as learning that takes place in the presence of declarative task relevant knowledge relating to the task being performed. Individuals are likely to be learning explicitly if they are encouraged to adopt an internal focus by *thinking about* how to perform the task.

ii) Implicit learning is defined as learning that takes place without task relevant knowledge relating to the task being performed. Individuals are likely to be learning implicitly if they are practising activities without consciously thinking about *how* to perform the task (i.e. by adopting an external focus).

3.17.3 Mapping the Variables that may affect Motor Learning

Throughout the literature review, a number of different variables that may affect motor learning have been introduced. These relate to the individual learner, the structure of the learning environment, and the task being learnt. Mind mapping was used to visually capture and organise this information. Figure 4 provides a visual representation of this, but does not attempt to analyse or make associations between them. Variables that may be influenced by a therapist are shown in black text; those that cannot be directly influenced by the therapist are shaded in grey. These variables, and their relationship to explicit and implicit learning, are used to inform the initial analysis of data during the observational study (Chapter 4).

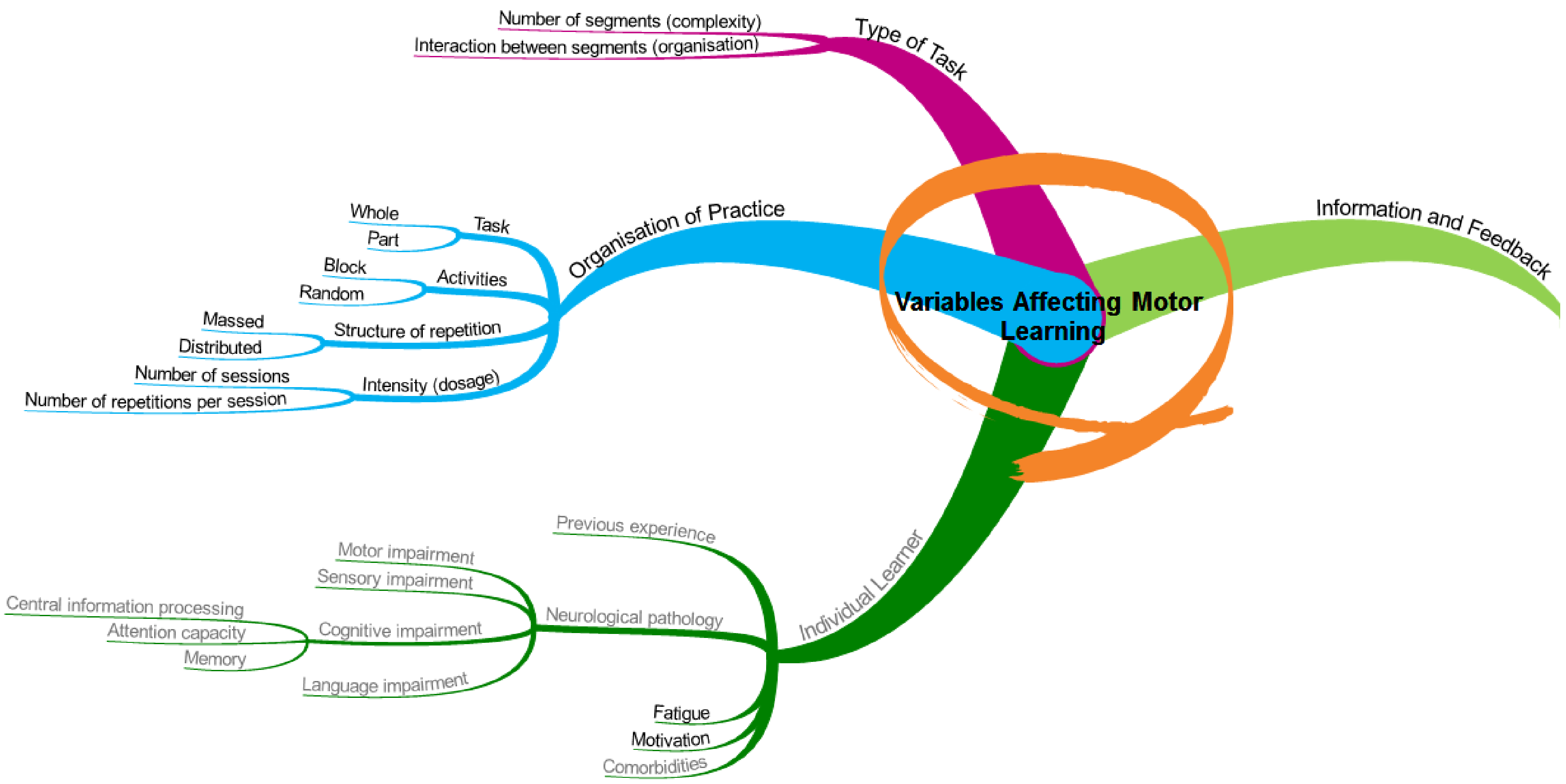
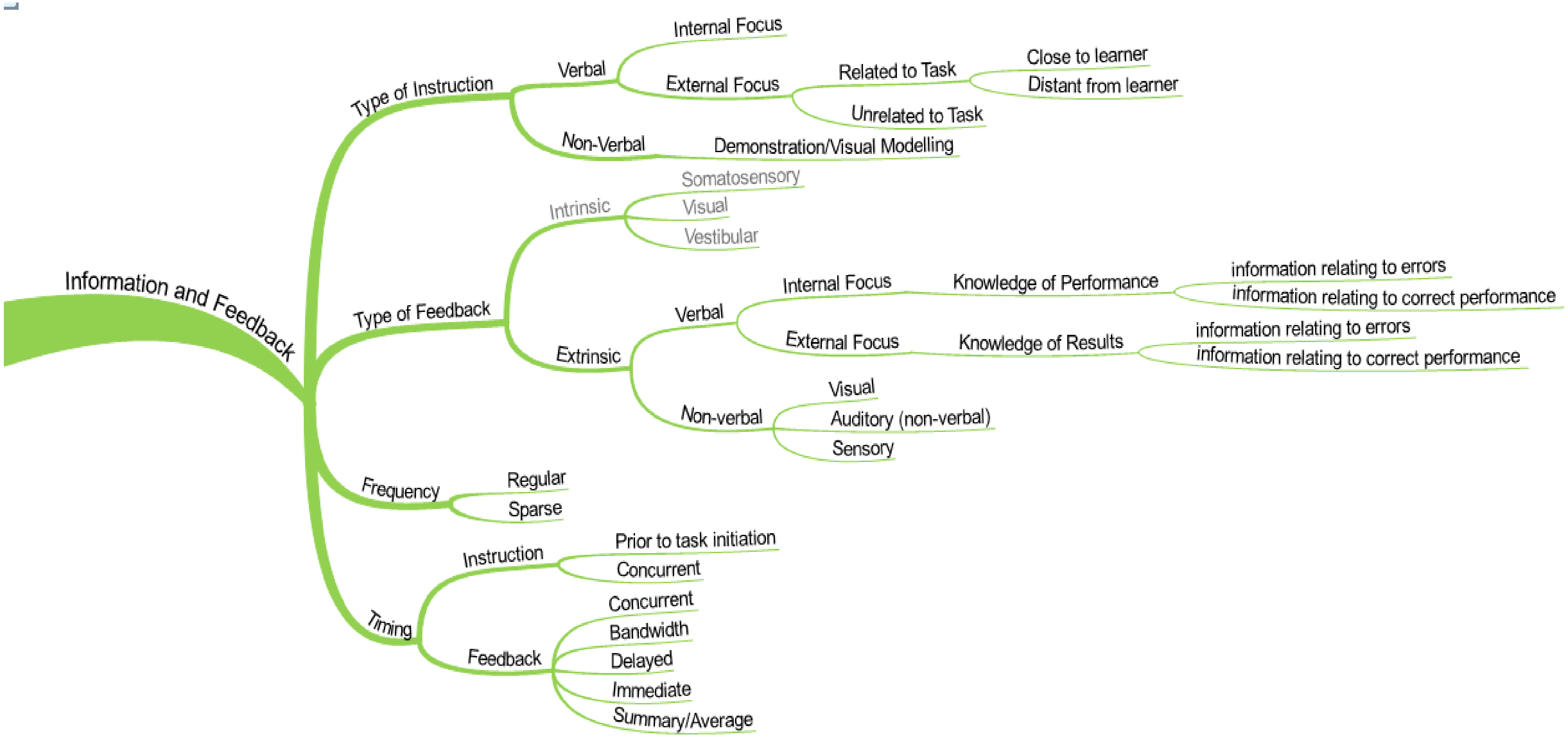


Figure 4 Variables Affecting Motor Learning

Figure to summarise the various practice conditions and variables that may affect motor learning, based on variables discussed in the literature and those observed in practice. Variables that cannot be influenced by changing the structure of practice are shaded in grey. NB – this figure spans 2 pages.



Information and Feedback
Type of Instruction
Verbal
Internal Focus
External Focus
Related to Task
Close to learner
Distant from learner
Unrelated to Task
Non-Verbal
Demonstration/Visual Modelling
Type of Feedback
Intrinsic
Somatosensory
Visual
Vestibular
Extrinsic
Verbal
Internal Focus
Knowledge of Performance
information relating to errors
information relating to correct performance
External Focus
Knowledge of Results
information relating to errors
information relating to correct performance
Non-verbal
Visual
Auditory (non-verbal)
Sensory
Frequency
Regular
Sparse
Timing
Instruction
Prior to task initiation
Concurrent
Feedback
Concurrent
Bandwidth
Delayed
Immediate
Summary/Average

3.18 SUMMARY

Learning can broadly be divided into two categories – explicit and implicit. The mechanisms for each at a neurophysiological level are similar; the difference lies at a neuroanatomical level. However, explicit and implicit learning are not mutually exclusive, and may occur, to varying degrees, in parallel.

An understanding of motor learning is fundamental to the delivery of rehabilitation, yet the concepts of explicit and implicit learning are rarely referred to in the stroke rehabilitation literature. Whilst numerous behavioural models for the delivery of rehabilitation are described in the literature, terminology and definitions are inconsistent. The concepts of explicit and implicit learning are therefore not well understood or defined in the context of neurological rehabilitation; and their importance to rehabilitation outcomes is unknown.

Despite this, evidence from healthy populations suggests that skills learnt implicitly are a) more likely to be retained, and b) more robust under secondary task load. However, the majority of studies investigating explicit and implicit learning utilise controlled laboratory based tasks, principally the Serial Reaction Time task. It is not known whether the same benefits of implicit learning would be observed during true motor learning of a more complex task. Furthermore, there is limited evidence specifically examining explicit and implicit learning within patients with stroke, although the few studies that do exist replicate the findings from those conducted with healthy populations.

Existing evidence relating to attentional capacity and attentional focus during learning in both healthy and neurologically impaired individuals has been discussed. Although there is a significant body of evidence within the former, it is clear that research within the stroke population is limited. It is argued that both attentional capacity and attentional focus are important concepts when considering explicit and implicit learning. Theories propose that focussing on specific movements (internal focus) may actually constrain or interfere with automatic control processes that would normally regulate movement, whereas if attention is focussed towards the movement effect (external focus) the motor system is able to more naturally self-organize, resulting in more effective performance, and learning. High quantities of instruction or feedback will place demands on working memory; and if internally focused, will provide the learner with specific task relevant knowledge. This is therefore associated with the explicit learning paradigm. Conversely, fewer instructions and an external focus of attention will promote automatic and self regulated performance, which is allied to implicit learning.

Whilst explicit and implicit learning are the overarching concepts under investigation in this programme of research, the next stage (development study) specifically considers the individual elements of clinical practice that may promote either type of learning.

4. DEVELOPMENT STUDY

4.1 INTRODUCTION

Prior to designing a clinically relevant experimental study, it is important to have a clear understanding of the concept of implicit and explicit learning within the context of stroke rehabilitation, and be able to recognise and distinguish between implicit and explicit elements within a physiotherapy gait re-education session. In line with the MRC Framework (MRC, 2008), this development phase sought to examine current physiotherapy practice, and describe the elements of rehabilitation that may bias either explicit or implicit learning; with particular reference to the timing, frequency and attentional focus of instructions and feedback. In particular, the study sought to understand whether the bias toward the use of internally focused statements, as reported by Durham and colleagues (2008), also applied within a gait rehabilitation setting.

The findings from this phase have directly informed the development of the interventions to be trialled in the next stage of this research, in which the feasibility of delivering explicit and implicit learning strategies during gait rehabilitation post stroke is examined. This current chapter reports the developmental phase and discusses the implications both for clinical practice and for the remainder of this research.

4.2 Aim

To identify current practice amongst neurological physiotherapists in relation to the learning strategies used in post-stroke gait rehabilitation, with particular reference to the use of instructions and feedback.

4.3 Objectives:

- To describe the types of activities or interventions commonly employed during gait rehabilitation post stroke.
- To investigate and report the frequency, type, content and attentional focus of instruction and feedback that is delivered to patients during gait rehabilitation post stroke.

- To develop an analysis matrix for identifying the presence of explicit/implicit behaviours in clinical practice (to be used as a means of monitoring the content of interventions provided during the main study).
- To formulate and agree two sets of guidelines, one each for explicit and implicit learning, which will later be applied and compared in the experimental study.

4.4 METHODOLOGY

This phase of the study utilised fundamental qualitative description (Sandelowski, 2000) to describe, analyse and interpret the content of observational data collected through video recording physiotherapy treatment sessions.

4.4.1 Methods for describing healthcare practice

> "The qualitative researcher systematically watches people and events to find out about behaviours and interactions in natural settings – describing and analysing what has been seen."
>
> (Mays and Pope, 1995)

In attempting to describe and define the content of physiotherapy within specific contexts, previous researchers have chosen a range of qualitative methodologies, such as surveys, interviews and focus groups (e.g. Tyson and Selley, 2006). Such methods offer several benefits, such as the ability to feasibly collect data from a large or broad sample, and the opportunity to gain insight into therapists' perceptions regarding therapy interventions. However, they also present limitations, such as a potential discrepancy between what people say and what they actually do, and they may not allow for depth of analysis – particularly regarding the interaction between different aspects of therapy content.

When considering the "talk" that takes place during therapy sessions, as in this present study, it is quite feasible that therapists may not be fully aware of the frequency and content of what they say; their perception of how they use instructions and feedback may not be truly representative of what they actually do. Since communication is so embedded in the culture of healthcare professionals, there may be elements or details of communication that only an external observer would consider noteworthy – interviews or focus groups alone would be unlikely to elicit such detailed insights into these patterns of behaviour.

Audio recording has been used in a small number of physiotherapy studies seeking to analyse and illustrate therapist and patient interaction (Schoeb, 2009, Slujis et al., 1993, Baker et al., 2001). Such studies typically use pre-determined assessment instruments to identify and record the conversational behaviours of interest. Schoeb (2009), included analysis of physiotherapist and patient interaction with regards to turn taking, how talk was organised, what vocabulary is used and how participants responded to each others' utterances. However, audio recording alone has obvious limitations. Significant elements of the interaction may be missed, since the verbal communication from an audio recording cannot be fully analysed in relation to the context in which it is taking place, and interpretation of the meaning or significance of the participant's communicative actions is limited since the researcher cannot see the response, or the consequence of the communication. This is particularly true when the talk is intended to elicit an action. Therefore, since verbal communication and physical actions are likely to be closely entwined in physiotherapy, they need to be analysed concurrently.

4.4.2 Non-participant observation

Non-participant observation methods have been used in numerous studies examining activities and interactions in hospital settings, however, their use within physiotherapy is limited. Within stroke rehabilitation, studies using non-participant observational methods have typically sought to investigate the activities and interactions that take place within a ward setting, and generally used time sampling methods to provide a convenient method of managing the potentially massive amounts of data generated (e.g. Dowswell et al., 2000, De Wit et al., 2005, De Wit et al., 2006). Since the observer has the task of recording what they see, these sampling methods are usually combined with structured documentation of predetermined, mutually exclusive, activity/ interaction category codes. This deductive approach is necessary for observations to be recorded quickly and achieves a higher degree of inter-rater reliability than less structured methods (Dowswell et al., 2000). Due to the nature of the data collected, these studies give an overview of the quantity of communication and interaction, and insights into the general types of activity that patients are exposed to but do not provide insight into the content of the communication.

A number of studies have used video recording as a means of researching the activities and interventions that take place within physiotherapy, and several of these have specifically described elements relating to the communication that takes place. Such studies may examine the prevalence and content of verbal conversation (e.g. Roberts and Bucksey, 2007, Talvitie and Reunanen, 2002, Durham et al., 2008), whilst others provide more detailed insights into non-verbal behaviour and social interaction (Parry, 2004, Parry, 2005, Talvitie, 2000).

Using the sociological method of conversation analysis, Parry (2004, 2005) provided insightful and detailed reports relating to physiotherapists' and stroke patients' communication practices in relation to both goal setting (Parry, 2004) and problems or errors in performance (Parry, 2005). Both studies used video recording as a means of data collection, and utilised detailed conversation analytic methods to describe and draw inferences about the practices and constraints relating to communication for these purposes. This method not only elicited information on the technical content of what therapists say, but also examined the detailed structure of communication patterns, and reflected on the observed social interactions that occur between patient and therapist. Similar research into physiotherapist –patient interaction using video recording has been carried out by Talvitie et al (2000, 2002). In these studies, a systematic observation method was used to depict verbal and physical communications; a form of discourse analysis was used to analyse content.

Due to the potential complexity of the behaviours being investigated during the current study, it was important that data collection allowed for the behaviours and interactions of patients and therapists to be captured, both audibly and visually, and in a natural setting; non-participant observation through video recording was used to achieve this.

4.4.3 Use of Video Recording

The use of video recording as a means of collecting observations has long been used within healthcare research, becoming increasingly prevalent due to the easy access and relatively low cost of video technology (Haidet et al., 2009, Elder, 1999). Video recording presents a number of advantages, including the ability to: replay and review observational data in detail; control observer fatigue and drift; and achieve levels of analysis not offered by real-time observations (Haidet et al., 2009). Thus, using video to record clinical practice enables the collection of rich data, and detailed analysis of the content of the observed behaviours and interactions, including both verbal and non-verbal actions.

4.4.4 Limitations of Non-Participant Observation

Despite these benefits, there are a number of limitations relating to the reliability of collecting data through direct observation. These have been categorised as: participant reactivity; environmental extraneous variables; ambiguous behavioural definitions; and low inter-rater agreement in video tape interpretation (Elder, 1999). Descriptions of these potential limitations are given in Table 7. Strategies used to minimise their effects are outlined in the relevant part of the methods (4.4) and analysis (4.5) sections.

Table 7 Limitations of Direct Observation

Limitation	Description
Participant Reactivity	The response between researcher and participant during data collection that affects the natural course of behaviour as a result of being observed (Patterson, 1994). Also known as observer effect or Hawthorne Effect. In addition, observation may cause self questioning or introspection among those being researched (Mays and Pope, 1995)
Environmental Extraneous Variables	Unrelated environmental factors such as noise from surrounding areas or the presence of individuals other than the research subjects that may threaten the internal validity of the data collected (Elder, 1999).
Ambiguous Behavioural Definitions	Analysis of data based on poorly defined targeted behaviours. It is critical that the observer can recognise when the behaviour of interest begins and ends, and exactly what constitutes that behaviour. Ambiguous behavioural definitions present a threat to construct validity: the assessment instruments' ability to measure the constructs of interest (Elder, 1999).
Low Inter-Rater Agreement in Video Tape Interpretation	A reliable instrument for analysis should repeatedly produce the same results (Elder, 1999). Inter-rater agreement refers to the degree of agreement between individuals when analysing the content of the video tapes; it is an important measure of reproducibility and indicates uniformity in their interpretation.

4.5 DATA ANALYSIS METHODS

4.5.1 Qualitative description and content analysis

Fundamental qualitative descriptive methods were utilised for data analysis, drawing on the general tenants of naturalistic enquiry. Naturalistic enquiry implies only a commitment to studying something in its natural state, to the extent that this is possible in any research enterprise (Sandelowski, 2000). Since the study objectives were to investigate and report what happens in clinical practice, in relation to the use of explicit and implicit learning strategies, qualitative content analysis was deemed both feasible and appropriate.

Researchers conducting qualitative descriptive studies seek descriptive and interpretive validity. Descriptive validity refers to producing an account of events that most people (including researchers and participants) observing the same event would agree is accurate, and interpretive validity refers to an accurate account of the meanings that participants attributed to those events, that those participants would agree is accurate (Sandelowski, 2000). The validity of observational accounts therefore relies on the truthful and systematic representation of the research (Mays and Pope, 1995).

For this phase of the study, data analysis had two aims:

i) to identify, categorise and count incidences of instruction and feedback, using quantitative methods; and

ii) to describe, in-depth, how instruction and feedback were provided, using thematic analysis, and to relate this back to the concepts of explicit and implicit learning.

4.5.2 Quantitative analysis using an analysis matrix

Analysis sought to identify both the physiotherapists' and patients' physical and verbal actions relating to instruction and feedback, categorising observations with regard to their content, attentional focus and frequency. An analysis matrix (Pope et al., 2000, Sandelowski, 2000) was used to achieve this. Such classification and counting approaches have been utilised previously in various physiotherapy studies, typically focussing on the actions of the therapist (e.g. Baker et al., 2001, Slujis et al., 1993, Jones et al., 1998). As no apriori definitions existed by which to classify explicit and implicit behaviours, an iterative process as outlined by Haidet et al (2009) was adopted. This process broadly involved defining target behaviours, applying these definitions to the data using the analysis matrix, testing for inter-rater agreement, refining definitions and re-testing.

4.5.3 Qualitative thematic analysis

Verbal dialogue from each video was transcribed verbatim. The content of the transcripts was thematically analysed in order to describe behaviours and to provide examples of the interactions observed. Thematic analysis, broadly based on the approach described by Pope et al (2000) was used. Initial familiarisation occurred during development of the analysis matrix, as described in section 4.10.1. Statements of instruction, feedback or general information were identified and coded according to their attentional focus. Information of the same code type was then considered i) within each transcript and then ii) between the different transcripts. Data were synthesised into charts relating to each code. These charts were then analysed to define concepts and draw associations and interpretations relating to attentional focus.

These processes are described in further detail in sections 4.10.1 and 4.10.3.

Both forms of data analysis (analysis matrix and thematic analysis) were then considered and interpreted collectively in order to draw relevant conclusions about the data, and to present a comprehensive descriptive record of the learning approaches used in the recorded treatment sessions.

Although no description is free of interpretation, this form of basic or fundamental qualitative description entails low-inference interpretation, which is likely to result in easier consensus among researchers; that is, with low-inference descriptions, researchers will agree more readily on the "facts" of the case, even if they may not feature the same facts in their descriptions (Sandelowski, 2000). Considering that one primary purpose of this phase of the research was to guide the interventions applied during the main study, and given that these interventions must be feasible for therapists to deliver, remaining close to the data in this way was essential. For this reason, more detailed methods of qualitative analysis, such as conversation analysis (e.g. Parry, 2004), were not considered appropriate to this study.

4.6 ETHICAL CONSIDERATIONS

4.6.1 Recruitment of Physiotherapists

Potential physiotherapists were identified via the appropriate Head of Service, and contact with individual physiotherapists was made initially via letter. Therapists were asked to complete and return a reply slip if they are interested in taking part or receiving further information. Those that expressed an interest were then contacted via either telephone or email.

All patients taking part in the study were already receiving physiotherapy for gait rehabilitation. Potential participants were identified and approached initially by their treating physiotherapist, who provided a letter of invitation, a copy of the Participant Information Sheet, and an opt-in reply slip. Patients who were interested in taking part or in finding out more were asked to return the reply slip to their physiotherapist, who passed this on to the researcher. The researcher then arranged to visit the ward/outpatient department in order to meet with the patient and discuss their potential involvement further. Physiotherapists (and other clinicians) were briefed regarding the inclusion criteria and general purpose of each phase of the research.

In all instances, participants were given a minimum of 24 hours between receiving the relevant information sheet and deciding whether or not to take part, and had the opportunity to ask questions and discuss their involvement at every stage. As detailed on the information sheets, it was emphasised that participants (both patients and therapists) could choose to withdraw at any time, without prejudice, and without patient care being affected in any way.

4.6.2 Maintaining Participant Confidentiality

All electronic data was stored on a password protected computer. All paper data was stored in a locked filing cabinet in a locked office. Patient confidentiality was ensured by allocation of a unique identification number (ID). All data that linked patient personal information with the ID was kept in a separate locked filing cabinet. Institutional Guidelines for Research Governance procedures for good clinical practice in research were be followed.

4.6.3 Use and storage of audio visual data

Video and audio recordings will be retained in a secure place in line with University of Southampton policy.

Both patients and therapists were asked to provide separate consent as to whether they agreed for their videos to be used for the purpose of teaching and /or research presentations, in line with individual policies for each Trust. The therapist/patient was offered the opportunity to view their video recording before providing this consent. Only if both therapist and patient agree will videos be used for either of these purposes.

4.6.4 Specific ethical considerations relating to video recording

Observation of clinical practice and the use of video recording may feel intrusive. For the purpose of this research, observation was overt, with both physiotherapist and patient being fully aware of the presence of the observer, of the recording equipment, and of the general purpose of the observation. Both therapists and patients were made aware that they can request for the recording to stop at any stage.

Although the overt nature of this observation does create observer bias, whereby both therapist and patient may alter their behaviour in response to being observed, this was minimised in several ways:

- The observer endeavoured to remain as discreet as possible throughout the observation, and will not intervene or participate in the session in any other way.
- Recording took place within the familiar environment of the therapy gym, and between therapists and patients who were well-known to each other.
- Both patients and therapists were informed of the general purpose of the video recording, and were reassured that the researcher was interested in the overall content of therapy, rather than individual behaviours.

4.7 Ethical Approval

The study was approved by the Southampton and South West Hampshire Research Ethics Committee (B) [Reference 09/H0504/80] (appendix 4). Sponsorship was provided by the University of Southampton, and Research Governance approval was gained from each of the participating NHS Trusts (appendix 5).

4.8 METHOD

4.8.1 Study Design

This development study consisted of direct non-participation observation of physiotherapy treatment sessions, with data being collected through video recording.

4.8.2 Participants

Physiotherapists were recruited based on the following inclusion criteria:

- currently working within a neurological rehabilitation setting;
- at least one years experience working in neurology at a senior level;
- treats patients with stroke on a regular basis (at least fortnightly).

Therapists who agreed to participate in the observational study were asked to identify potential patients from their caseload, based on the following inclusion criteria:

- has suffered a stroke;
- is currently receiving active rehabilitation that includes gait rehabilitation;
- is able to provide informed consent.

To ensure that the observations gave insight into a range of clinical scenarios, there were no specific criteria relating to participant's level of walking ability, other than that the therapist considered their intervention to include "gait rehabilitation". This included working towards standing and stepping in the early stages of recovery.

Two NHS Trusts (one acute and one primary care) were used in order to ensure sufficient numbers of therapists with a range of experience were recruited, and also to account for possible local bias or practice trends.

4.8.3 Recruitment of Therapists

Letters of invitation, including a Participant Information Sheet and a reply slip (appendix 1), were sent to all eligible therapists within the two Trusts (n = 16). On receiving a completed reply slip, the researcher made contact with the therapist to discuss their involvement, and, if appropriate, to arrange for completion of the consent form (appendix 1).

4.8.4 Recruitment of Patients

Potential patient participants were initially approached by their treating therapist, who gave a brief explanation of the nature of the research, and provided the patient with the relevant Participant Information Sheet (appendix 2). Those interested in being involved were asked to sign a reply slip giving permission for the researcher to meet with them. Following a meeting with the researcher, those that were willing to proceed were asked to sign a consent form (appendix 2).

4.8.5 Information and Consent

Careful consideration was given to the information provided to participants regarding the purpose of the research. All participants (patients and physiotherapists) were told that the aim of the observation was to gain insights into how therapists worked with their patients to rehabilitate gait. This was kept broad to avoid changes in practice behaviour resulting from knowledge of the specific study objectives.

Both patients and therapists were asked to provide additional consent as to whether they agreed for their videos to be used for the purpose of teaching and /or research presentations, in line with individual policies for each Trust. All participants were offered the opportunity to view the video recording before providing this consent.

Once consent was obtained from a physiotherapist-patient pair, a mutually convenient time was arranged for the researcher to attend and video record a treatment session.

4.9 Data Collection

Routine treatment sessions in which gait rehabilitation was taking place were observed and video recorded. Each patient-therapist dyad were videoed once. The following demographic data were collected from the patient's medical record on the day of observation in order to aid sample description: age; gender; date of stroke; type of stroke, Modified Rivermead Mobility Score (Johnson and Sheila, 2000, Collen et al., 1991) (appendix 3).

Observation and videoing took place within the physiotherapists' usual clinical environment (e.g. therapy gym) and with a patient whom they had assessed and treated previously. Therapists were not given any instruction regarding the duration or specific content of the session, except that it must include physiotherapy for the rehabilitation of gait. They were asked to conduct the session as they normally would, and as far as possible, to ignore the presence of the researcher.

4.9.1 Minimising Participant Reactivity

The greatest limitation of direct observation is that of participant reactivity (Hawthorne Effect), whereby those being observed, may consciously or sub-consciously alter their behaviour in the presence of the observer.

Generally accepted "good practice" strategies for observational research were adopted: building good rapport with participants; carrying out observations in a familiar and natural environment; and minimising distractions (including avoiding the presence of other patients or professionals) (Haidet et al., 2009, Elder, 1999). In order to remain discreet, the researcher was positioned several metres away from the participants and outside of their main line of vision. The researcher did not intervene in the session in any way, avoided unnecessary movements and eye contact and did not speak during the observation.

Data were collected using a small and unobtrusive video recorder mounted on a tripod and operated by the researcher.   For patients who were working on activities within a small space, for example practicing sit to stand, this was sufficient and the researcher was able to remain discreet. For those practicing walking activities, or who were using different areas of the gym, the tripod and camera had to be repositioned during treatment. Whilst this is clearly more obtrusive, it did not appear to have a detrimental effect on the flow of the treatment session. Only on two brief occasions did a therapist acknowledge the presence of the researcher during recording; patients did not acknowledge the researcher at all.

Participant reactivity can also be reduced by exposing participants to longer periods of observation, helping to acclimatise them to the presence of the observer (Haidet et al., 2009). When only short one-off periods of clinical practice are being recorded, this can be achieved by analysing data in a predetermined "middle" segment of the session, for example after the first 3-5 minutes (Haidet et al., 2009). The sessions observed during this research were recorded from the very beginning to the very end. Although exact timings were not predetermined, the first 5-10 minutes of each session was invariably spent performing activities that were not directly relevant to the research question, and were not therefore intended for inclusion in the analysis – for example getting the patient ready for treatment by transferring onto a plinth, removing clothing and having a general chat. Therefore, by default, participants had an opportunity to become habituated to the presence of the video equipment and the researcher.

4.10 DATA ANALYSIS

The verbal dialogue from each video tape was transcribed verbatim. An iterative process was then used to analyse the data collected during the observations: the written transcripts and videos were analysed concurrently. Analysis of each video was broadly approached in two ways, as outlined in 4.5. For clarity, these processes are described separately below. However, in practice, both approaches to considering the data took place simultaneously, such that they concurrently informed the development and modification of themes and patterns relating to the data in an iterative manner.

4.10.1 Development of the Analysis matrix

An **analysis matrix** was used in order to count episodes of target behaviours. Although this approach reflects the original accounts and observations of the people studied (i.e. it is "grounded"), it starts deductively from pre-set aims and objectives (Pope, 2000). As part of the analysis matrix, simple counts were used to provide a summary of the frequency of certain behaviours. Data were not normally distributed, and therefore non-parametric descriptive statistics were used to summarise the findings.

A thorough method for the development of the matrix, based on expert consensus, was employed. This process ensured that the behavioural definitions were developed in a robust way. In addition to ensuring a systematic process for analysing the videos at this stage, the same matrix is also used during the main experimental study as a valid and reliable means of monitoring the content of the interventions under investigation (i.e. ensuring content validity).

4.10.1.1 Identifying Relevant Behavioural Criteria

Although the observed treatment sessions focussed primarily on gait rehabilitation, this was invariably not the focus of the entire session. In order to collect only the pertinent data from the videos, it was important that only relevant segments were analysed. Selection of these segments was guided by conceptually relevant behavioural criteria, as recommended in the literature (Haidet et al., 2009). Behavioural criteria were identified by the researcher as the types of activity most commonly employed that relate to gait rehabilitation, and were divided into broad categories. Video data was only analysed when these were taking place.

Three broad behavioural units relating to early gait rehabilitation were identified. These were: sit to stand; activities in standing; and walking. They are defined in Table 8.

Table 8 Behavioural Criteria and their Definitions

Sit to Stand Sit to stand when performed as an exercise/therapeutically. For example: sit to stand performed repetitively; asymmetrical sit to stand; sit to stand performed with specific instructions from the therapist (e.g. regarding foot position, alignment or weight bearing). Single episodes of sit to stand were not counted.
Activities in Standing Any exercise performed in upright standing that is equal to or less than one gait cycle (initial contact on one foot to initial contact on the **same** foot). For example: stepping back and forth; stepping onto a block; squatting; weight transfer exercises.
Walking Any activity in which the patient continuously performs **more than** one full gait cycle (moving forwards only). For example: practicing walking by a plinth/table; walking with equipment/an aid; walking with assistance from the therapist; walking independently.

The types of activities that were not analysed either focussed on the upper limb in lying/sitting, or included passive or active assisted exercises carried out in supine. Whilst such exercises may contribute to recovery of walking, the focus of this study is towards motor task learning, and therefore non-functional exercises were excluded from the analysis. Furthermore, for the purpose of developing treatment protocols for the main study, it was important not to introduce too many variables, or interventions that may be difficult to replicate with a variety of patients and a variety of therapists.

Likewise, time units that involved preparation for an activity, for example when the therapist was setting up a task by organising equipment, or when the patient was removing footwear, were only analysed if the therapist was giving an instruction or piece of feedback that directly related to the task that had just been, or was just about to be, performed. Whilst these sections were excluded from the analysis using the matrix, the entire transcript was included in the qualitative thematic analysis.

4.10.2 Structure of the Matrix

The analysis matrix was based on a timeline, divided into 30 second intervals (units). Time was plotted horizontally across a grid, with each of the identified categories/codes listed vertically on the left hand side. During each of the behavioural activities, instances of instruction or feedback were identified, and marked on the grid under the appropriate time slot and category. Since their occurrence was high, and so that important information relating to frequency was not lost, verbal behaviours, such as the use of instructions, were recorded within each unit as a tally of each occurrence. Non-verbal behaviours, such as the use of handling or external cues, were simply recorded once for each unit in which they occurred.

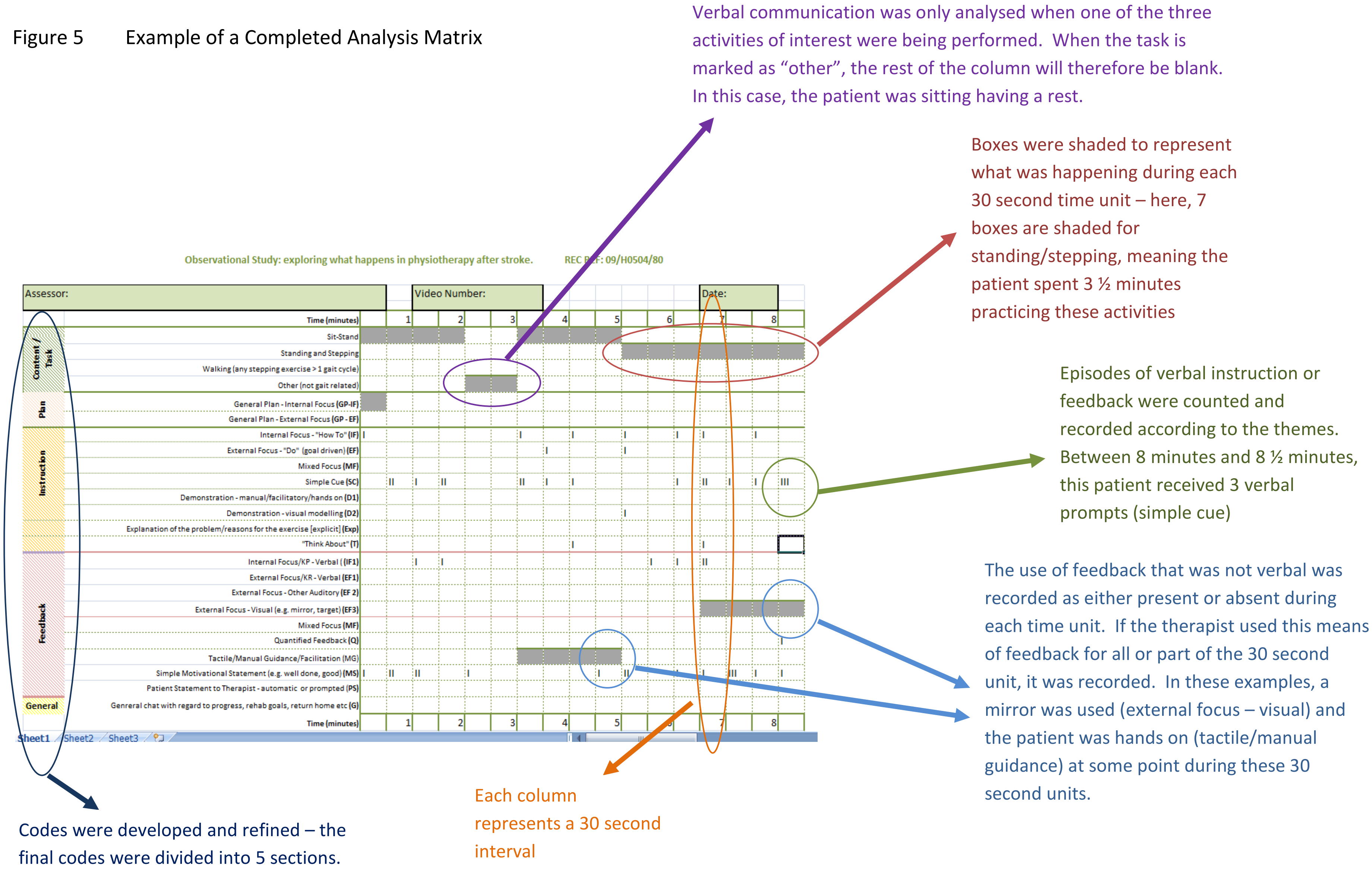
This matrix allowed the recording of the frequency and pattern of occurrence for each target behaviour. Since the categories are not mutually exclusive, this format also allowed for the recording of interventions that occurred simultaneously in order to demonstrate how behaviours may be used together, for example when a verbal instruction is accompanied by a visual demonstration**.** An annotated example of a coding matrix is shown in Figure 5.

4.10.2.1 Developing Codes for the Matrix

Identification of themes relating to instances of instruction or feedback was initially carried out by the primary researcher. Pope (2000) suggests that analysis begins with the researcher immersing themselves in the raw data – i.e. watching and re-watching the videos. Based on this, and on the objectives of the study, a deductive approach was initially used to begin to form categories and themes. These were based on pre-determined codes developed through the literature review and initial modelling phase (see Figure 4).

Following this, an inductive approach for the further development and refinement of these codes was adopted. Videos were viewed by the primary researcher to further define categories for the types and content of intervention and task. In line with the concept of constant comparison, this process was inclusive – keeping in mind the objectives of the study, categories were added and expanded to reflect as many of the nuances of the data as possible. A record of each category, along with a definition and examples, was kept and constantly refined (see appendix 6).

Figure 5 Example of a Completed Analysis Matrix



4.10.2.2 Refining and Testing the Matrix

Once drafted, the matrix underwent a process of testing and further refinement, as outlined by Haidet et al (2009). Development sessions were held with two additional clinical researchers, both experienced neurological physiotherapists, who had not been study participants. The purpose of these sessions was to i) develop and agree the matrix and the definitions within it and ii) test its feasibility and inter-rater agreement. During the initial process this triad worked together to analyse clips from the videos. This resulted in changes to the matrix including clarification of certain definitions and merging of some categories. For example, the initial draft matrix included two sub-categories relating to "hands-on" feedback: i) tactile feedback –defined as sensory or proprioceptive feedback given by the therapist (e.g. muscle tapping and joint approximation)and ii) facilitatory feedback, when the therapist manually helped the patient to perform a movement correctly (e.g. lifting the foot to allow dorsiflexion during stepping). Through discussions it became clear that it was difficult to conclusively differentiate between these using the video alone. They were therefore combined to form one category relating to whether or not the therapist was "hands on". Therefore, the initial categories, which had been expanded and inclusive, were collapsed and refined through this process of testing and consensus.

The two additional researchers then applied the matrix in order to examine its inter-rater reliability. They independently analysed purposively selected sub-sections of video using the matrix. These sections were selected to contain a range of scenarios and high volumes of verbal communication. Results from each researcher were compared using Cohen's Kappa, and percentage point agreement for each behaviour was calculated to highlight the areas where agreement was poor. Such categories were re-considered and refined, either by clarifying their definitions or combining categories together. This was discussed with the independent raters, who then applied the revised version to a further sub-section of video, with the process being repeated until an acceptable level of agreement (set at $k > 0.60$) was achieved. An example of a completed matrix from the testing phase and analysis using Cohen's Kappa can be found in appendix 7.

In total, 5 different sections of video were analysed by the additional researchers, with modification of the matrix after each round of testing (Table 9). The process of refinement led to fewer, broader categories – it was evident that analysing extreme detail within the video at this stage would not be feasible without making assumptions about the nature of some activities.

Comparison of results using Cohen's Kappa consistently showed only fair agreement between the two raters for each video clip. Further examination of the completed matrices revealed that although the independent raters were clearly identifying internal focus versus external focus statements, they were disagreeing as to the classification of 'instruction' versus 'feedback'. For example, the phrase "*you need to bend your knee more next time*" could be interpreted as both an instruction (telling the patient what to do next) and feedback (implying that the knee was not bent enough on the last attempt). Therefore the subsections of "instruction" and "feedback" were removed from the matrix, and Cohen's Kappa reapplied to the combined categories that were relabelled as "statements". For example, results for "internally focussed instruction" and "internally focussed feedback" were combined to form a single category – "internally focussed statement". Re-analysing the modified matrix revealed substantial agreement between raters (k – 0.61; k – 0.68), providing clear evidence that the lack of agreement resulted from poor clarity regarding what should be regarded as instruction and what should be regarded as feedback. This is discussed further in section (4.11.3).

Table 9 Kappa Statistics
Agreement between two independent raters who analysed sub-sections of video using the analysis matrix; calculated using Cohen's Kappa.

Test #	Video Number	Agreement Between Raters (Cohen's Kappa)	Interpretation of Cohen's Kappa (κ)
#1	1	0.37	< 0 = poor agreement 0.0 – 0.20 = slight agreement 0.21 – 0.40 = fair agreement 0.41 – 0.60 = moderate agreement 0.61 – 0.80 = substantial agreement 0.81 – 1.00 = almost perfect agreement
#2	4	0.41	
#3	5	0.57	
#4	2	0.37	
#5	7	0.38	
Results with Instruction and Feedback Categories Combined			
#6	2	0.61	
#7	7	0.68	

4.10.2.3 Final Matrix

As there was no consistent agreement with regards to whether statements were categorised as instruction or feedback, the two were combined in order to enhance reliability. This reliability was particularly important because the analysis matrix is used later in the experimental phase of the research to confirm whether treatment sessions are appropriate to the participant's group allocation (internal or external). The distinction between instruction and feedback is not vital for this purpose. Observations were, therefore, grouped and categorised solely as internal or externally focussed *statements*.

However, for the purpose of describing current practice, it is useful to report use of instruction and feedback separately. In her description of fundamental qualitative description, Sandelowski (2000) states that with low-inference descriptions, researchers may agree more readily on the "facts" of the case, even if they may not feature the same facts in their descriptions. Therefore, whilst interpretation of what is instruction and what is feedback may have differed between the researchers, all agreed on what was internal focus and what was external focus, and all reported a similar number of statements overall.

During the qualitative analysis (section 5.9.3), the primary researcher analysed the videos and the transcripts concurrently. At this stage, the primary researcher continued to distinguish between instruction and feedback in order to give a picture of how these were used in the videos. Consequently, despite the potential uncertainty regarding the categorisation of instructions and feedback, detailed analysis of the videos and the transcripts allowed for the general balance between the two to be estimated. Whilst this is clearly the primary researcher's interpretation of events, equivocating fully between the two categories was not necessary since the most important factor for this research is the attentional focus that is inferred by the statement, and the frequency and timing of statements, since these factors relate to whether the learning environment is primarily explicit or primarily implicit. Hence there are two versions of the final matrix – one which does differentiate between instruction and feedback (used during the analysis in this study) and one which does not (used for monitoring interventions in the feasibility study) (see appendix 8).

4.10.2.4 Final Analysis

Once agreed and tested, this final matrix was then applied to each video, in its entirety, by the main researcher. This provided an overview of what was happening in each session, including a count of the incidence of the various behaviours. Non-parametric descriptive statistics were used to summarise the findings, including the relative frequency of internally focussed versus externally focussed statements.

4.10.3 Qualitative Thematic Analysis

Alongside the application of this matrix, the transcripts and videos were thematically analysed by the primary researcher in order to provide a more descriptive and rich report of the interactions and behaviours observed, and also to further explore discrepancies relating to the distinction between instruction and feedback. This part of the analysis aimed to build on the findings from applying the analysis matrix by providing a detailed account of the observations, identifying key themes and patterns, and making inferences about the relevance and meaning of these. Key issues, concepts and themes were therefore identified in more detail, and associations and links between them were considered.

Thematic analysis, broadly based on the approach described by Pope et al (2000) was used to structure the analysis. This approach has been described as having 5 stages:

1. **Familiarisation –** immersion in the raw data (or typically a pragmatic selection from the data) by listening to tapes, reading transcripts, studying notes and so on, in order to list key ideas and recurrent themes.
2. **Identifying a thematic model** – identifying all the key issues, concepts, and themes by which the data can be examined and referenced. The end product of this stage is a detailed index of the data, which labels the data into manageable chunks for subsequent retrieval and exploration.
3. **Indexing** – applying the thematic model or index systematically to all the data in textual form by annotating the transcripts with numerical codes from the index, usually supported by short text descriptors to elaborate the index heading.
4. **Charting** – rearranging the data according to the appropriate part of the thematic model to which they relate, and forming charts. Each chart contains distilled summaries of views and experiences, thus the charting process involves a considerable amount of abstraction and synthesis.
5. **Mapping and interpretation** – using the charts to define concepts, map the range and nature of phenomena, create typologies and find associations between themes with a view to providing explanations for the findings. The process of mapping and

> interpretation is influenced by the original research objectives as well as by the themes that have emerged from the data themselves.
>
> (Pope et al., 2000)

Familiarisation occurred largely during the development of the analysis matrix already described. Furthermore, since the researcher was present during collection of the original data and independently transcribed the verbal dialogue, they were already acquainted with the raw data, and had begun to generate ideas regarding key themes.

In applying this process of indexing, charting, mapping and interpreting, data from the 8 transcripts and videos were then considered collectively; summary data were recorded and overall themes and observations drawn together.

These themes are discussed in the subsequent sections. Each section presents both quantitative and qualitative findings related to a specific theme.

4.10.3.1 Definition of Instruction and Feedback

Verbal instructions and verbal feedback were used frequently throughout all of the observed treatment sessions. Thematic analysis was based on the following definitions:

> **Instruction -** statements directed at the patient regarding a desired action or how to perform a desired action/skill.
>
> **Feedback -** statements that provide information based on previously observed movement attempts; intended to influence or modify further attempts.

Clearly differentiating between instruction and feedback was not straightforward, and it became evident that the two are often entwined, with subtle differences in how information is delivered. For example – *"bend your knee"* is an instruction, whereas *"you are not bending your knee enough"* is feedback. However, "*next time, bend your knee more"* could be either; it is a piece of feedback given as a further instruction. For the purpose of thematic analysis, statements such as this were categorised as an instruction since they are first and foremost telling the patient what to do next; they are directive and do not allow for the patient to make the association about how to modify their movement for themselves. This approach was applied consistently throughout this stage of the analysis.

4.10.3.2 Defining a 'Statement'

Irrespective of the difference between an instruction and a piece of feedback, it is important to define what is meant by a "statement"; particularly as they are counted during the analysis in order to determine their frequency. Given the nature of verbal communication, it may not always be clear where one statement ends and another begins. For the purpose of this research, a statement was counted every time a single piece of information (be it instruction or feedback) was given to the patient; one sentence may therefore be made up of several statements. For example, "bend your knee" was counted as one internally focussed statement. A sentence such as *"bend your knee, go on, that's it, and now straighten that knee"* was counted as two internally focussed statements and two unfocussed statements:

> *"Bend your knee [internally focussed statement], go on [unfocussed statement], that's it [unfocussed statement], and now straighten that knee [internally focussed statement].*

Likewise, repetition of the same statement were counted separately, for example *"squeeze your bottom, that's it, squeeze your bottom"* was counted as two internally focussed instruction [*squeeze your bottom*], and one unfocussed statement [*that's it*]. All dialogue was consistently analysed in this way. Breaking prose down in this was allowed for a more accurate reflection and comparison of the amount of verbal communication across the various videos analysed.

4.11 RESULTS

4.11.1 Participants

Eight therapists responded to the initial letter of invitation, and all agreed to participate. This represents a response rate of 50%. The sample was therefore a convenience sample. All therapists were female (there were no male therapists working in either department). Level of post-graduate experience ranged from 3 to 12 years ($\bar{x}$ = 7.2 years) and all were working in senior clinical posts. Each therapist identified an appropriate patient from their caseload, all of whom agreed to take part after meeting with the researcher.

Of the eight patient participants, 5 were male and 3 female. Time since stroke varied from 7 to 216 days ($\bar{x}$ = 90.25 days; σ = 83.13). Four presented with left sided and four with right sided hemiplegia. Four patients were able to mobilise without physical assistance, three were able to mobilise with some assistance, and one was not yet able to walk, but could practise activities in standing with support. Modified Rivermead Mobility Index scores reflect this varying level of function, with a range between 15 - 38 out of 40. The duration of the recorded treatment sessions ranged from 27 to 50 minutes ($\bar{x}$ = 38.5 minutes), with a total of 308 minutes of video available for analysis. Five sessions took place in an inpatient setting, and 3 within an outpatient setting. Participant characteristics are displayed in Table 10.

Table 10 Participant Characteristics for Phase I

Video	Setting	Total Duration of Session (mins)	Therapist			Patient					
			M/F	Years Working in Neuro Rehab	AfC Band	M/F	Age	Time Since CVA - days	L or R Hemiplegia	Type of CVA	mRMI Score /40
1	ASU	45	F	9	6	M	56	7	L	PACS	23
2	SRU	34	F	5	6	M	85	52	R	PACS	31
3	ASU	37	F	10	6	M	72	17	R	PACS	20
4	NOP	50	F	5	6	F	70	201	L	ICH	19
5	NOP	27	F	12	7	M	62	135	R	ICH	38
6	SRU	32	F	3	6	F	62	27	R	PACS	15
7	NOP	44	F	3	6	F	59	216	L	ICH	20
8	SRU	39	F	10	7	M	36	67	L	PACS	20

ASU = Acute Stroke Unit; **SRU** – Stroke Rehabilitation Unit; **NOP** = Neuro Outpatients

PACS = Partial Anterior Circulatory Stroke; **ICH** = Intra-Cerebral Haemorrhage

L = left; **R** = right

mRMI = Modified Rivermead Mobility Index

4.11.2 Activities

Figure 6 shows the distribution of the three types of activity across the eight videos. The relative division of time between activities carried out in standing and in walking is partly dependent on the functional level of the patient. The highest functioning patient was in video 5, and a significant proportion of time here was spent carrying out standing and walking activities. In contrast, the lowest functioning patient appeared in video 6, where no actual walking took place.

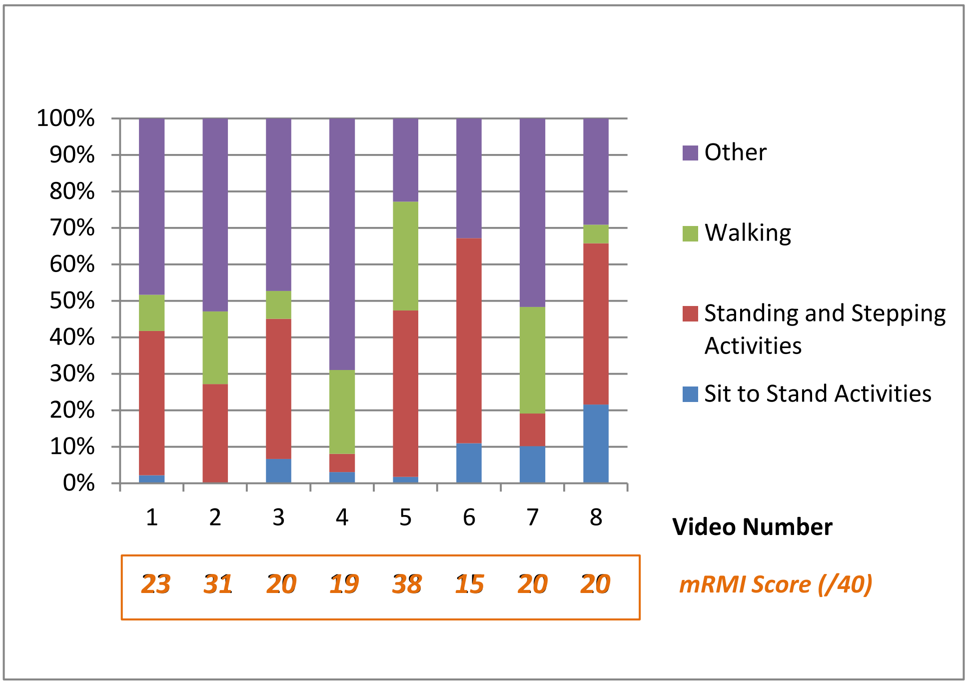


Figure 6 **Distribution of Activities as a Percentage of Overall Session Time**

4.11.3 Instruction and Feedback

By applying the analysis matrix, incidences of instruction/feedback were identified, counted, and categorised according to their attentional focus. Additional codes relating to the use of unfocussed statements were also identified. The thematic analysis of both the transcripts and the videos revealed a number of further themes that whilst not directly related to instruction/feedback, may have an indirect bearing on attentional focus, self consciousness, and explicit learning. These themes are discussed in the following sections.

4.11.4 Frequency and Timing of Instructions and Feedback

By applying the analysis matrix and counting incidences of different behaviours, it is possible to give a picture of the frequency of occurrence. Overall it appeared that instructions were used far more commonly than true feedback; that is feedback that is specific and targeted, and that does not direct the patient with regards to what to do next. On average 22 (IQR 16-25.5) feedback statements were delivered per treatment session, compared to an average of 76 (IQR 65.5 – 79.5) instructions. Overall, this equated to **approximately one instruction or piece of**

feedback being given every 14 seconds, and does not account for unfocussed prompts or motivational statements which are considered separately and are discussed below.

Often a sequence of instructions would be used, successively prompting attention towards a number of different components of the movement, as highlighted in the example below. Text is coloured, according to the codes in Table 11.

Table 11 Colour codes used in quotations

Internal Focus = **blue**	Mixed Focus = **orange**
External Focus = **red**	Unfocussed = **purple**
Overt Observation = **green**	
Text that does not fit any of the above themes is left in **black**.	

Video 5 (patient is practicing walking):

"Step back with your right foot, good. Wait, don't lose....wait. Grow tall, step forwards, good. Step back. And step forwards. Good. So just keeping both heels on the floor there, ok, that's quite tricky for you....just want you to just let your hips come back so your weight comes to your back foot, now let your weight go forwards to your front foot....."

In addition, instructions were commonly repeated by the therapist several times within a very short space of time. This tended to occur concurrently as the patient attempted to perform the movement. Similarly, therapists regularly corrected or passed comment on a patient's movement after they had performed just one attempt, and this again may be repeated with subsequent attempts. Feedback immediately following completion of a task, delayed feedback and summary feedback (Winstein et al., 1999) were infrequent.

4.11.5 Attentional Focus

Statements of instruction/feedback were considered with regards to the attentional focus that they created. Statements were categorised as being either primarily internally focussed or primarily externally focussed. Internally focussed statements tell the patient "how to" move, whereas externally focussed statements encourage the patient to "do". All physiotherapists used a combination of internal and external focus statements. The following sections use examples from the videos to highlight these themes.

The example below includes both feedback and instruction, and is given to a patient who is practicing sit to stand.

Video 1

"Now – just a little point. When you're standing up, your knees tend to come together. So if, when you're standing up, try and think about your knees coming over your toes."

This example clearly infers an internal focus; it gives feedback about the movement problem, and encourages the patient to think about what is happening at their knees as they repeat the task. It therefore promotes an explicit bias to learning. This style of statement was extremely common across all of the observed treatment sessions.

In contrast, the following example from video 2 promotes an external focus, whereby attention is directed toward the effects or functional purpose of the movement. The patient is not told "how" to move.

Video 2

"So if you want to stand up [patient stands from wheelchair]. Much better, lovely. OK. And then if you want to come over to the mirror."

Statements of this kind were less common. Where externally focussed statements were used, they were typically inexact, as in this example. There were no clear examples of externally focussed statements deemed likely to enhance movement accuracy.

Some statements, categorised as having a mixed focus of attention, included both internal and external focussed information, for example: *"Bring your tummy [internal focus] towards the plinth [external focus].* The frequency of such mixed statements was relatively low (11%).

By and large, therapists favoured internally focussed statements. Figure 7 highlights the distribution between internal, external and mixed focus statements for each of the recorded sessions. On average, 67% of the statements delivered by therapists were internally focussed, 22% were externally focussed, and 11% were of mixed focus. Only one therapist (video 2) used externally focussed statements more frequently than internally focussed statements.

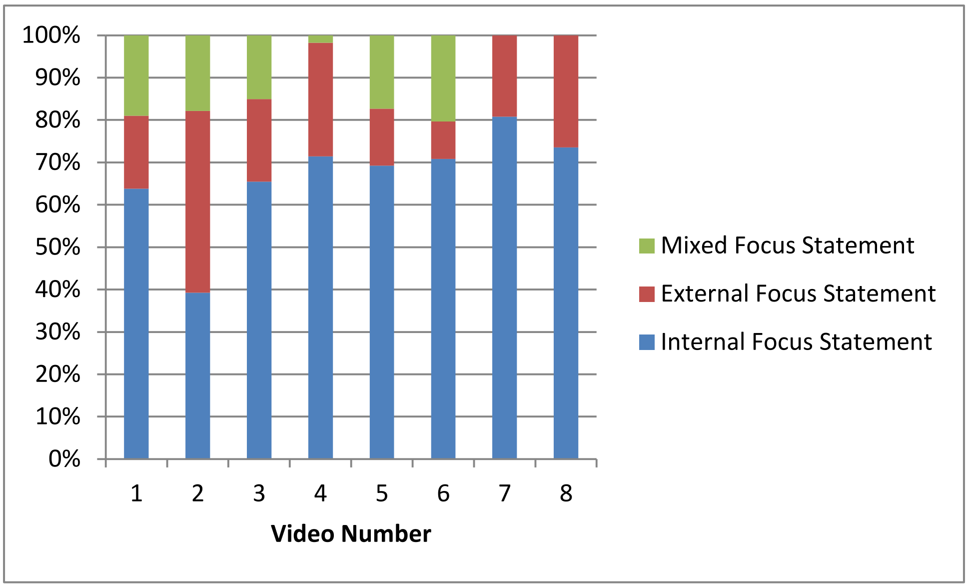


Figure 7 Attentional Focus of Statements (Instruction and Feedback)

When considering the difference between the focus of attention created for instructions and feedback separately, it is clear that whilst therapists regularly used elements of both external and internal *instructions* (Figure 8), the delivery of external focus feedback was proportionally low in all but one video (Figure 9). Indeed, Figure 9 shows that the therapists in videos 4, 5 and 6 only used feedback that inferred an internal focus of attention.

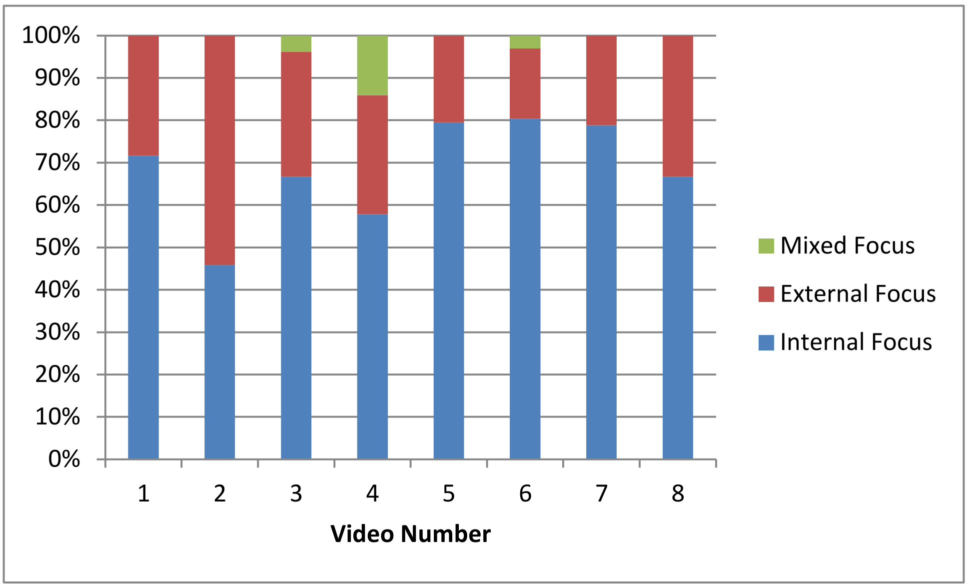


Figure 8 Attentional Focus of Instructional Statements

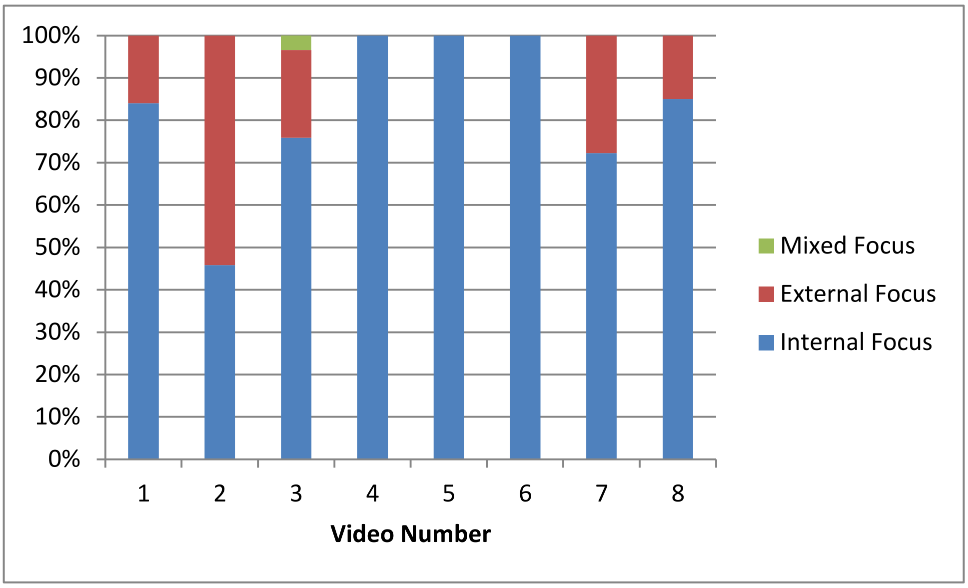


Figure 9 Attentional Focus of Feedback Statements

4.11.6 Unfocussed Statements

Some statements did not elicit any particular focus of attention, and were therefore categorised separately as ***unfocussed statements.*** These were defined as short, concise phrases that served to prompt or encourage an action *(e.g. "and again" "keep going"),* or provide encouragement *(e.g. "good" "well done"),* but that did not refer to any specific aspect of performance.

The incidence of such statements was high, generally occurring concurrently with activity and often in clusters, meaning that a patient would receive a succession of prompts/ encouragement as they practised an activity. The following short abstract from video 6 highlights this. The patient is practising stepping alongside a table; the therapist is providing assistance and uses regular unfocussed statements, in addition to instruction, continuously throughout the task.

> *"So you ready – know what you're doing? So that leg's going forward, and back. OK. That's it, right, hold it there, and step. A bit straighter, and step straighter. You're just loosing it a bit, on the back bit. So it's not staying too straight this time, just coming a little bit bent. That's it, and then step. Good, keep it straight, and then step. Squeeze your bottom, and step. And step."*

Unfocussed statements were also considered in relation to their general nature, with two sub-categories being identified. Some unfocussed statements were clearly motivational in nature, for example the use of words such as "good" or "well done". These were classed as unfocussed feedback (motivational statements). Other unfocussed statements appeared to serve more as prompts to elicit an action – for example, to prompt continuation of a task by saying "keep going". Whilst such prompts may also be motivational in nature, depending on the way in which they are used, they are different in that they are more instructional; these statements were therefore classed as unfocussed instructions (or verbal prompts).

Figure 12 presents' data about instructional statements including unfocussed statements that were categorised as verbal prompts; whilst Figure 11 presents data about feedback statements including unfocussed statements that were categorised as motivational. When considering feedback in particular, Figure 11 highlights that use of unfocussed feedback was much more common than specific or directed feedback statements.

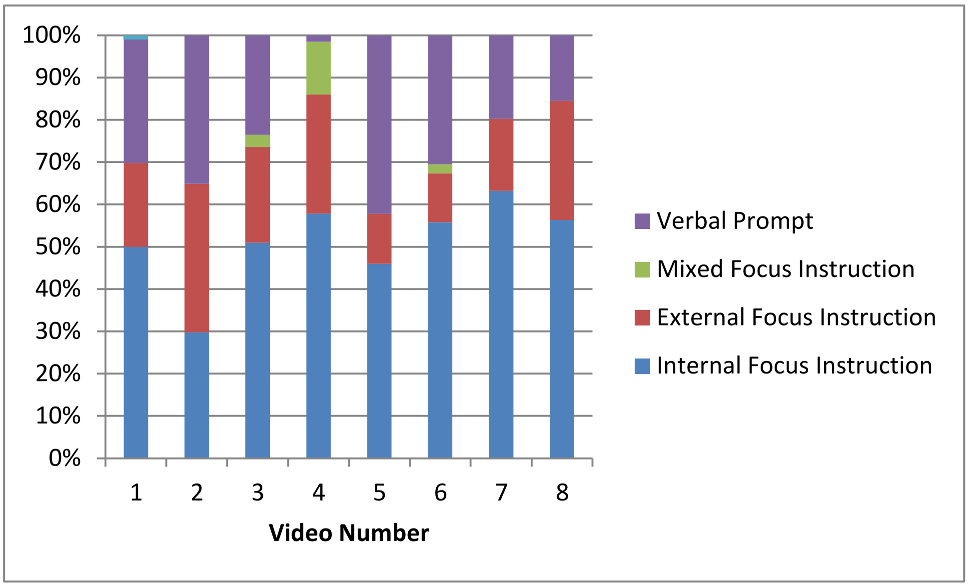


Figure 10 Attentional Focus of Statements and Verbal Prompts

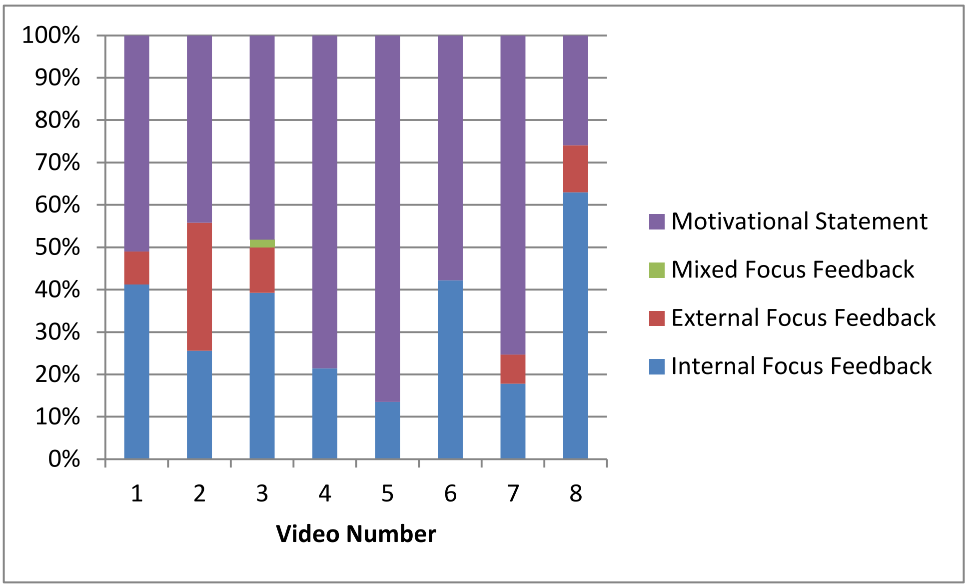


Figure 11 Attentional Focus of Feedback and Motivational Statements

4.11.7 Explanatory Information

Therapists also delivered explanations regarding what they were observing, or why they were asking patients to perform certain tasks. These statements are important because although they are neither instruction nor feedback, they infer an internal focus of attention, and may reinforce the explicit learning process. Such statements were identified in all eight videos; examples are given below.

"That wobbling is just showing me that you're trying to work that knee – which is good." (video 1)

"I've taken the weight off this leg a bit. So this one's got to work harder" (video 6)

"Because you go into what we call extensor tone – so your muscles are really tight in that extended position, so it's really hard for you to bend your knee through" (video 7)

4.11.8 Increasing patient awareness through overt observation

In all but one of the observed treatment sessions, therapists stated to the patient that they wanted to observe and analyse how they moving. This was often followed by internally focussed comments about those observations. Typically, this would occur at the beginning of the treatment session, or at the beginning of a new activity. Some examples are given below. In each of these, the therapist states that she wants to "look at" or "see" what is happening.

"I'd like to have a look at your transfer round to the plinth first, so if you can show me that, then we'll take it from there." (Video 2)

"I'm just going to roll your leg up, your trouser leg up a little bit, just so I can keep an eye on what's happening with this foot." (Video 4)

"So just without your socks and shoes and your splint on, let's just see, sort of like, what's happening with your walking." (Video 5)

4.11.9 Encouraging conscious thought in relation to performance.

Asking a patient to "think about" their performance also arose in all but two of the recorded sessions. These statements occurred in varying contexts, sometimes in relation to how the patient was generally performing a movement; and sometimes focussed towards a specific component of that movement. This example from video 1 is a typical example relating to an overall movement: *".....if you want to stand up again – but **think about** how you're standing up."*; whereas the following example, also from video 1, highlights how a patient may be encouraged to think about a more specific component of their movement: *"….**thinking about** controlling that knee, I'm gonna get you to step your other foot up".*

Another common occasion when therapists actively encouraged the patient to consciously think about their performance related to weight transfer during standing or stepping activities, either by directly asking the patient to "think", or indirectly by using the word "feel".

> *"So actually consciously, trying to think about moving your weight over onto your right leg."* (video 3)

> *"Can you get your weight through this leg? Can you feel, can you feel any more through this right leg?"* (video 8)

Similar phrases were also used in order to bring the elements of the movement together, again prompting conscious thought. This often occurred towards the end of an activity, or the end of a treatment session.

> *"Try to remember the elements that I've said to you. Keep your foot on the floor and stand up. So think about what you're doing" (video 4)*

> *"Right, OK, so try and remember all those things. So push off with that leg"* (video 3)

Interestingly, on a few separate occasions, therapists acknowledged the explicit nature of the task, stating that there was *"lots to think about"* (video 1) or that *"we've got to the stage where you're thinking about too much at once"* (video 8).

4.11.10 Analogy Learning

In one treatment session, the therapist used an analogy to prompt correct performance. In video 5, the patient was repeatedly prompted to imagine that they were kicking a ball in order to encourage the swing phase of gait.

> *"Release the knee, not hitching the hip, kick the ball. Better good. Wait, don't lose it as you turn, step back, good. And step, step back. Good. And step, good. Excellent. Now step forwards, step. Release the knee as you step. Kick the ball through. That's better."*

This was the only observed example of analogy learning. Although externally focussed, such analogies are abstract in relation to the task being performed.

4.11.11 General Feedback

On occasions, general, non-specific feedback was given. Such feedback is neither internally nor externally focussed, and was typically related to how someone was improving overall, rather than in relation to a specific task. These examples both refer to the patients overall progress with their walking, *"it's much better than it was"* (video 8) and "*I see definite improvements*" (video 1). Such statements were generally used at the end of the treatment session.

4.11.12 Non Verbal Instruction

Although the frequency of verbal instructions was clearly high, the use of non-verbal methods in instructing patients was low. Six of the eight therapists used visual modelling (demonstration) at some point, although the actual number of occurrences was very low ($\overline{x} =$ 1.75 occurrences per treatment session). This was always used prior the patient attempting the task, and was always combined with a verbal instruction. No other themes relating the non-verbal instruction were identified.

4.11.13 Non Verbal Feedback

Two types of non-verbal feedback were identified: external cues and physical handling. External cues were used by 4 therapists; these included markers on the floor (targets during a stepping activity), a mirror being used for visual feedback, and the use of another person or a plinth as a reference point to encourage weight transfer. Such external cues were again combined with verbal dialogue, prompting the patient to utilise the feedback given by the cue.

Therapists used physical handling to some degree in all of the observed sessions. From analysing videos alone, it is not possible to establish the role that handling may play in directing movement, delivering feedback, or directing focus of attention. However, it was evident that when physical therapists were "hands on", this was typically accompanied by verbal instruction/feedback of some form.

4.12 LIMITATIONS

One obvious limitation of this study is the small number of observed treatment sessions. Although the observations were analysed in detail, the actual number of treatment sessions that were recorded was relatively small (n=8). Alongside this, therapists were only recruited from two sites, which were geographically close. It is possible that the observations made result from local practice trends, and may not be generalisable to wider neurological physiotherapy practice across the UK. Furthermore, all participants were working on gait rehabilitation activities. It is therefore not possible to conclude whether the observations are reflective of neurological physiotherapy as a whole, or solely to gait rehabilitation – i.e. do therapists use similar levels of verbal instruction and feedback when training other tasks, such as reach to grasp. Evidence from similar studies suggests that perhaps they do (Durham et al., 2008).

There was considerable variance among the small study population in terms of number of days post stroke, level of function and experience of the treating therapist. In addition, observations took place in both inpatient and outpatient rehabilitation settings. The small sample size meant that it is not possible to analyse the relationship between any of these factors and the use of strategies that may promote implicit or explicit learning. There was however much similarity across the 8 videos, suggesting that a bias towards explicit learning is evident regardless of stroke severity or time post stroke. Therefore, although the lack of homogeneity in the observed sample means that this group are not directly comparable to those that will be under investigation in the second phase of this research, the similarities observed mean that the interventions to be applied are clinically applicable and relevant.

The limitations relating to direct observation and video recording have been discussed in section 4.4.4. Whilst every effort was made to reduce the impact of these, they can never be completely eliminated. There is always the possibility that the physiotherapists and patients being observed in this study altered their behaviour in the presence of the researcher. For example, the use of verbal communication may have been exaggerated as a result of physiotherapists inadvertently attempting to demonstrate to the researcher what they were doing and why. One way of accounting for this would be to interview participants post video recording to determine how they perceive the influence of the video camera; an approach that has been described by others (Roberts and Bucksey, 2007).

Analysis of the videos primarily considered the content of the verbal dialogue that took place. Whilst this enables the primary aims to be met, it does not take account of other verbal and non-verbal aspects of communication – such as intonation or gesture. Given that the primary purpose of this phase was to inform the interventions that would be compared in the main study, excluding these factors from the analysis is justifiable; it would not be feasible to influence these more tacit behaviours when asking physiotherapists to alter their interactions in the main study. However, such factors are arguably important aspects of communication, and inclusion in any further analysis of the raw data would provide interesting and more detailed insights into the patient-therapist interaction, and the relationship to explicit and implicit learning.

Furthermore, whilst non-verbal aspects of instruction and feedback were included in the analysis (e.g. the use of a mirror as a means of feedback), there was no detailed analysis of the exact content of the activities being performed, and how practice was structured. Such factors may be important in creating bias towards either implicit or explicit learning. Analysis of such factors would be valuable in future research, and would help to build a more comprehensive picture of how physiotherapy can be made more implicit.

In order to increase reliability of the results, video data was analysed using both matrix and thematic analysis approaches. Whilst other researchers were involved in the development of the analysis methods, the final matrix was only applied by the primary researcher. One limitation of observational research such as this is that analysis relies on the researcher's interpretation of events, which is a potential source of bias. The involvement of independent researchers in the development of the analysis matrix reduces the likelihood of this, but the final reporting is reliant on the researcher's perception of events; particularly with regards to the distinction between instructions and feedback. Further analysis using the independent researchers would be one way of improving robustness of the data analysis methods, but this was not logistically possible at this stage.

By utilising direct observation alone as a means of data collection, interpretation of the data is limited to a fairly descriptive approach. Understanding of why therapists behaved as they did is therefore limited. In future work, it would be useful to explore the therapists (and possibly the patients) perceptions of the treatment sessions alongside the videos in order to gain different perspectives of observed behaviours, and the reason that they are employed.

4.13 DISCUSSION

This phase of the study sought to examine the use of instructions and feedback during early gait rehabilitation post stroke. Physiotherapists used verbal communication frequently throughout the observed treatment sessions, typically *during* the practice of rehabilitation tasks. **On average, verbal instruction or feedback statements were delivered to patients every 14 seconds throughout the observed treatment sessions.** Although the difference between them was not definitive, it appeared that instructional statements were particularly frequent, with feedback statements being less common. **Of all identified statements, 67% were internally focussed.** These statements prompted patients to think about *how* they were moving, therefore promoting explicit learning. Unfocussed statements (e.g. "good", "and again") were also used regularly, and patients were frequently encouraged to "think about" their performance, again, promoting explicit processes. Similarities across the eight videos in terms of the use of internally focussed statements suggest that such behaviours are inherent to physiotherapy practice. Similar trends toward the use of high quantities of instruction and feedback during physiotherapy practice have been reported elsewhere in the literature (Talvitie, 2000, Talvitie and Reunanen, 2002, Durham et al., 2008).

Much of the talk that took place during the observed treatment sessions could be categorised as either instruction or feedback – thus therapists frequently and consistently made requests or delivered information to patients during rehabilitation. This high volume of dialogue typically took place concurrently with activity. On many occasions, the same statement was delivered repeatedly throughout the practice of an activity, or throughout a session. It has been suggested that the amount of verbal communication from therapists means that patients are rarely given the opportunity to demonstrate what they can achieve themselves (i.e. in a more implicit way), and they often find the amount of information given confusing (Talvitie and Reunanen, 2002). It is, therefore, not clear whether such repetition is useful in reinforcing improvements to performance, or whether it interferes with performance or learning.

The therapists who took part in this study showed a distinct preference for using internally focussed information and feedback. Even when externally focussed statements were used, they were frequently either preceded or followed by instructions with more of an internal focus. It could be argued that once an internally focussed statement is given, the patient has explicit information and awareness; such that even if part of the statement is then delivered in a more functional or externally focussed way, it has already been influenced by the internally focussed information. It is hypothesised that when internally focussed statements are used, they may potentially override any other instruction or feedback that holds a more external focus.

In addition to instructions and feedback, unfocussed statements were also particularly frequent. These types of statement were often repeated throughout and at the end of a task. Although they were typically motivational or positive in nature, such statements did not always appear to coincide with particularly good aspects of performance; they were not specifically targeted. These statements of “good” and “well done” appeared to be inherent to the “talk” given by the therapist. The value of such statements in actually improving performance or maintaining motivation is unclear.

Prompts to complete an action were also used frequently and repetitively; typically concurrent with task practice – for example, *“and again”, “keep going”.* Such statements may be motivational to a degree, depending on the way in which they are used. However, how necessary such prompts are in enabling performance is questionable. It is not clear how unfocussed statements fit with explicit and implicit models. Whilst they may not represent any significant cognitive burden to the patient, it is feasible that they represent a background of “noise” that is not specifically helpful to learning, and does not allow the patient to lead their own adjustments and movement patterns.

Whilst this current study focussed primarily on attentional focus, the relationship to attentional capacity also requires consideration. Not only did physical therapists tend to use internally focussed statements, but they were used in high quantities. Patients were therefore given a large amount of information to process whilst practising activities. Attention capacity limits may be reduced in people with neurological damage, meaning that this volume of information may be problematic: dual tasking studies have repeatedly shown that performance efficacy may decreases under dual task when compared to single task conditions (Plummer-D'Amato et al., 2008, Hyndman and Ashburn, 2004, Bowen et al., 2001). Due to the demands placed on working memory, excessive information during rehabilitation may, therefore, be detrimental to learning.

Aside from the cognitive and attentional demands that result from frequent instruction/feedback, it is possible that such practices also increase an individual’s self-consciousness by drawing attention to performance. Examples of this are given elsewhere in the literature (Parry, 2004), and were observed on a number of occasions in this research – sometimes overtly, and sometimes more subtly. It has been hypothesised that increased self consciousness is associated with an increased tendency for individuals to consciously control movement, and that this occurs where evaluation of performance is likely (Baumeister, 1984). This increased awareness of movement may be initiated or exacerbated by therapists who are seen to stand back and evaluate a person's movement, pass comment on the quality of movement, or draw attention to specific impairments; which may reinforce explicit learning. If such evaluation does increase self consciousness, then it may inadvertently result in skill breakdown (Masters, 1992) or hinder learning.

Overall, the evidence to support the benefits of an external focus of attention amongst healthy populations is compelling, raising questions about the impact of an internal focus of attention amongst any population. However, there are significant gaps in current knowledge and understanding relating to focus of attention and learning within stroke rehabilitation. Despite this, the findings of this current study and that of Durham et al indicate that stroke physiotherapy treatment is biased toward an internal focus of attention, and this may account for the often cited lack of carry over amongst patients with stroke (Winstein and Schmidt, 1990a).

If the findings from healthy populations were to be replicated within stroke rehabilitation, it would have important implications for how rehabilitation is delivered, highlighting the need for changes to communicational practices in order to improve retention of functional skills. Therefore, thought must be given to whether instructing patients "how to" move (i.e. explicit learning), as observed during this study, is conducive to learning (van Vliet and Wulf, 2006). It is possible that skills are more likely to be retained if patients are given greater opportunity to find their own solutions to motor problems through trial and error (i.e. in an implicit manner). Strategies involving modification of the environment, the task, the use of instruction and feedback, and level of repetition may enhance this (Gentile, 1998), particularly if they result in a more external attentional focus.

The need for empirical research with this population is evident. In particular, clinically relevant studies are required to examine how focus of attention can be directed during rehabilitation, and the impact this has on both performance and learning during commonly strived for functional tasks such as walking and reach to grasp.

4.14 Development of guidance for explicit and implicit learning during gait rehabilitation

The characteristics of explicit and implicit learning, in relation to neurological therapy, have been described based on the existing evidence base, and the observations made during the initial phase of this research. Development of guidance for delivering rehabilitation interventions with a bias towards either an explicit or implicit approach forms the next part of this research.

In section 3.17 (page 89), the range of variables that may affect motor learning were presented. This formed part of the initial modelling exercise; scoping the elements of the therapeutic environment that could potentially be altered in order to create more of an explicit or implicit bias. Four main elements were proposed. These were - factors relating to the:

- individual learner – previous experience, pathology/impairments (intrinsic feedback), fatigue, motivation and co-morbidities.
- organisation of practice – task, activities, repetition and intensity
- type of task – complexity, organisation
- use of instructions and feedback – type, frequency and timing

The observational study aimed to identify behaviours within clinical practice that may support either explicit or implicit processes, in line with these factors. Therapists' use of verbal instruction and feedback was observed to be the primary way in which patients were guided; the high frequency of instructions/feedback was so apparent, that this is assumed to be the primary way in which patients gained task relevant knowledge. The remainder of this research programme will therefore focus on the last element – the use of instructions and feedback. Given that evidence from studies within healthy populations consistently demonstrates that verbal communication has an important influence on motor learning, this was a justified focus for the feasibility study. Equally, for the sake of this early research, it was important not to change multiple factors relating to the delivery of therapy, and therefore the focus of this research has primarily been on altering the therapist's communication.

The observational study demonstrated relative homogeneity in the types of intervention that different therapists provided for gait rehabilitation. In the feasibility trial, it was intended that therapists would therefore be allowed to design and deliver a treatment programme using their own clinical judgement and matched to the needs of the patient; however that programme would be **delivered with a bias towards explicit or implicit learning dependent on the assigned group for that participant**. Therefore, the type of activities that were practised were left to the discretion of the therapists, but the learning style would be dictated by the study arm (either explicit or implicit). This bias was primarily created by manipulating the verbal communication from the therapist (i.e. the frequency, content and timing of instructions and feedback) – in order to promote either explicit or implicit processes.

Table 12 Characteristics of Explicit and Implicit Learning
Guidance for therapists on the delivery of an explicit or implicit bias during gait rehabilitation. This guidance is based on the collective review of relevant theory, empirical evidence, and observation of clinical practice.

	EXPLICIT LEARNING GROUP	**IMPLICIT LEARNING GROUP**
Duration of treatment session	Aim for 30-45 minutes	Aim for 30-45 minutes
Task	Break activities down and practice component parts. Ensure the patient is thinking about how they are moving; readily correct poor performance.	Ensure the activity is functional; practice "whole" activities/ tasks. Use the environment or other non-verbal cues to elicit the desired movement. Promote automacity; allow self modification.
Instructions	Internally focussed and detailed – encourage patient to think about how to move. Given at the beginning and throughout the activity. May be accompanied by demonstration.	Externally focussed and simple – goal orientated. Given at the beginning of the activity. May be accompanied by demonstration
Feedback	Give frequently – at least once for every 5 repetitions of any task. Can be given before, during and after the activity. Keep internally focussed.	Keep to a minimum. Avoid giving during the task. Keep externally focussed.
Handling	Keep to a minimum	Keep to a minimum
Demonstration	Can use demonstration; combine with related instruction and feedback to draw attention towards what the patient is seeing [e.g. "look at how I am doing it…..see how I am bending my knee"]	Can use demonstration; but keep associated verbal instruction/feedback to a minimum [e.g. "like this…..”]

Visual Feedback	Can use visual feedback (e.g. mirrors); combine with related instruction and feedback to draw attention towards what the patient is seeing [e.g. "look at yourself in the mirror…..look at the position of your hips…"	Can use visual feedback (e.g. mirrors); but keep associated verbal instruction/feedback to a minimum [e.g. I'm going to put a mirror here for you to look in……]
Repetition	Providing that the activity is being performed safely, allow high numbers of repetitions. If the patient is not performing the activity well, correct them immediately following the first few repetitions. Continue to give instruction and feedback (as outlined above) frequently. If they continue to struggle, **move on to a new task**.	Providing that the activity is being performed safely, allow high numbers of repetitions. If the patient is not performing the activity well, allow them to practice. This will be dependent on ability/fatigue, but try to allow at least 3 sets of 5-10 repetitions (more if able). Give instructions and feedback only as outlined above. If they continue to struggle then **modify the task** if in order to make it more achievable.

4.15 Descriptors of Explicit and Implicit Learning Groups

4.15.1 Explicit Learning Group

Based on what had been learnt from routine clinical practice and research evidence it was determined that the **explicit learners** would be instructed on ***how*** to perform the various activities; being readily corrected if they went wrong and receiving regular feedback about their performance and how to improve. In essence, this information would serve to encourage the learner to think not just about what they were doing, but also about how they were doing it. They would be given verbal prompts and feedback to draw their attention to the kinematic features of how to perform the activity. For example, if the patient was practising sit to stand, the therapist may prompt them to think about their starting posture, to reposition their feet, and to straighten their hips and knees as they come to stand. Therapists were asked to give feedback at least once for every 5 repetitions of any given task. This level of feedback was common during routine clinical practice – as shown in the observational study.

4.15.2 Implicit Learning Group

In contrast, it was determined that instructions and feedback for the **implicit learners** would be kept to a minimum and be goal orientated. Patients should not receive additional information or feedback throughout the task and should not be encouraged to think about how they were performing. Instead, learners in this group were allowed to practice and to modify their movements independently. If they repeatedly made mistakes, then the task should be modified to ensure that it was achievable. For example, when practicing sit to stand, the therapist may have altered the height of the plinth to make the task easier, or may put a marker on the floor to encourage correct foot placement. Participants could be given externally focussed feedback and encouragement following completion of each activity, but this should was not excessive.

Examples of activities and the variation between the explicit and implicit learning group are given in (appendix 9). Examples of the types of wording for therapist instructions are given in speech marks. These were intended to highlight the difference between the two treatment approaches; activities applied during the study were not directed in this way and therapists were not expected to follow scripts.

4.16 Dissemination

The findings from the observational study have been presented orally at the UK Stroke Forum in Glasgow in 2011 (appendix 10) and have been published in Physical Therapy (Johnson et al., 2013) (appendix 11).

4.17 CONCLUSION

The use of video as a means of data collection has allowed for detailed reporting of the use of instruction and feedback across 8 physiotherapy treatment sessions. Physiotherapy practice tends toward an explicit learning environment where the patient is encouraged to be consciously aware of their performance. This may reduce automaticity of movement and hinder learning and retention. Greater consideration of the attentional focus and timing of instructions/feedback may optimise motor learning post stroke.

5. FEASIBILITY STUDY

5.1 Introduction

Based on the findings from the literature review and the observational study, the characteristics of explicit and implicit learning, relevant to gait rehabilitation post stroke, have been described (see 4.15) and guidelines for their application have been drafted (Table 12). Using observation of current practice to derive these descriptions ensures their clinical relevance and clinical applicability. This second phase of the research will test the feasibility of applying these guidelines within a clinical research setting. This phase therefore represents the second (experimental) stage of the MRC Framework (MRC, 2008).

5.2 Purpose

The primary purpose of this phase was to test the feasibility of delivering the explicit and implicit approaches within a clinical setting. The primary analysis therefore focused on the actions and behaviours of the therapists who were delivering the intervention.

A secondary purpose was to test elements of the overall research design, in order to inform the development of a future experimental trial, as outlined in 5.4 below. The study was therefore conducted as a small scale experimental study, in which baseline measures were taken and outcome was recorded. As this was a feasibility trial, we did not intend to examine outcomes relative to the type of learning strategy employed and the study was not sufficiently powered for this. However, data was used to estimate future sample size requirements.

5.3 Aim

To assess the feasibility of applying explicit and implicit conditions during gait rehabilitation in the early phase post stroke.

5.4 Objectives

i. To comprehensively define the nature of explicit and implicit interventions for early gait rehabilitation, in preparation for any future experimental trial
ii. To investigate and report the feasibility of applying explicit and implicit approaches in clinical practice by:

a. Using the evaluation matrix (appendix 8) to determine how well therapists could deliver explicit and implicit approaches in a standardised manner (practicality), establishing the level of training required for a Phase II randomised controlled trial
b. Comparing patient participants' recollections of explicit knowledge ("rules") in relation to the activities they have practiced (with the expectation that those in the implicit group would report fewer rules than those in the explicit group)

iii. To evaluate the appropriateness of the chosen outcome measures by assessing their sensitivity to detecting change within this patient group
iv. To establish whether there were any differences between the treatment groups in terms of the individual patients' perceptions of their walking ability and/or motivation (acceptability)
v. To establish likely rates of recruitment and retention
vi. To estimate sample size requirements for a future trial

5.5 BACKGROUND AND RATIONALE

5.5.1 Background

This was a randomised, double blind, feasibility trial using a matched pairs design. This methodology was deemed appropriate for an exploratory trial of this scale, and allowed for control of the key confounding variables. Participants were randomised, using a random numbers table, into either an explicit learning or an implicit learning group (see section 5.8.7). They received interventions for gait rehabilitation over three consecutive days, which were delivered in line with their group of randomisation. The interventions provided to each group were based on the treatment guidance that arose from the earlier development study (see section 3.17). This phase tested the ability of therapists to deliver that guidance.

5.5.2 Rationale for Chosen Design - Matched Pairs Design

This trial intended to recruit 20 patient participants. As the content of the treatment sessions would be analysed in detail, this number was felt to be sufficient to establish the physiotherapists' compliance with delivery of the explicit and implicit treatment approaches; thus meeting the primary objective of the study.

Participants were randomised into either an explicit or implicit treatment arm. Given that clinical presentation varies widely post stroke, simple randomisation may not have given balanced intervention groups for this small number of participants. Furthermore, the broad inclusion criteria chosen for the study (section 5.8.3), which were considered important for ensuring external validity, would invariably result in a further reduction of homogeneity within the sample. Stratifying participants according to certain characteristics can account for such variability. Therefore, the matched pairs design was chosen as it is the simplest form of stratification. In a matched pairs study, participants are matched for any important characteristics that may affect outcome. In doing so, between group differences are minimised. Random assignment, within the pairs, then accounts for any remaining differences between subjects – ensuring internal validity. This form of stratification is useful when the stratifying factors are fairly strongly related to outcome (Ukoummune et al., 1999).

This current study did not intend to analyse outcome in relation to the type of learning strategy used, and stratifying participants was therefore not necessary for this purpose. However, the way in which a patient performs and responds during a treatment session may affect how therapists subsequently deliver interventions, which is particularly pertinent given the pragmatic nature of this research. Accounting for confounding variables was therefore important when assessing the feasibility of delivering explicit and implicit approaches in clinical practice. Matching pairs during the randomisation process would ensure that treatment groups were equal in terms of the chosen key characteristics, and that the ability of therapists to deliver explicit and implicit approaches would therefore be tested equally within the broad spectrum of patients recruited to the trial.

Matched pairs designs have some limitations. Caution is advised when using matched pairs designs as the range of appropriate analytical methods may be limited (when compared to unrestricted or stratified designs) (Klar and Donner, 1997), and because when the number of clusters is small, the study may have less statistical power (Martin et al., 1993). However, these critiques relate to large studies in which outcome is analysed. Given that the primary objective of this current research related to analysis of the physiotherapists' behaviours (and not the outcome of the patient participants), and that the analysis was appropriate only for a small sample, a matched pairs design was considered a sufficient methodology to account for variability in patient characteristics, and was deemed realistic for a small scale feasibility trial of this nature.

5.5.3 Criteria and Assessments for Matched Pairs

Pairs were matched on three criteria; age, baseline Berg Balance Score and presence or absence of an attentional deficit. These were considered to be the most important confounding variables when considering the ability to learn using the treatment approaches being compared. Justification for each is given below.

5.5.3.1 Age

Age is known to be an important variable when considering recovery post stroke. Studies have shown that age in inversely related to recovery, in terms of both the speed (Kugler et al., 2003) and overall completeness of recovery (Kugler et al., 2003, Bagg et al., 2002). In addition, age is likely to have a direct effect on the processes underlying motor learning and retention. Although the ability of older adults to (re)learn motor skills had not been studied extensively, research has shown that the processes underlying learning, particularly for skills that involve complex motor sequences, are slower in older adults (Shea et al., 2006, Smith et al., 2005).

As there is no specific data to guide the exact criteria for matching participants on age, the researchers opted to match participants who were within 10 years of each other's age.

5.5.3.2 Berg Balance Scale

Recovery is also known to occur more quickly in patients who have a smaller lesion/milder clinical presentation (Jorgensen et al., 1995). It was therefore important to ensure that matched pairs were of a similar level of functional ability at baseline. As well as accounting for rate of recovery, this would also ensure that matched participants were working on comparable functional activities during their therapy. As it was also the primary outcome measure, the Berg Balance Scale (BBS) (Berg et al., 1989) was used to match individuals for functional level. The total maximum score for the BBS is 56 (with a score of 56 indicating the highest level of function); each individual subsection is scored out of 4. Rather than using a cut off value, which would be arbitrary and could prevent participants with very similar scores being paired (i.e. those who score around the value of the cut off), participants were matched if they scored within 8 points of each other. This represents two sub categories on the scale, ensuring that matched pairs would be similar in terms of their functional ability.

5.5.3.3 Attentional deficit

Given the importance of attentional capacity in learning, and the potential impact that explicit and implicit approaches have on attention, it was also important to match patients based on the presence or absence of an attentional deficit. Therefore, participants were matched according to whether their attention was classified as impaired or normal using the Test for Everyday Attention (TEA) (Robertson et al., 1996) [Pearson Education Limited].

The TEA is a broad measure of attention that was principally designed as a clinically valid assessment for adults with acquired neurological insult. It includes a number of sub-tests that are validated for independent use, the results of which can be compared against norm-referenced scores. For the purpose of defining categories for the matched pairs, two subsections from the TEA were used. These subsections assess **auditory sustained attention** and **auditory selective attention.** The first of these (elevator counting) involves counting strings of tones presented on audiocassette. There are seven strings, and a score of less than 6 is considered impaired. The second (elevator counting with distraction) involves counting strings of auditory tones whilst ignoring high pitched distractor tones. A score of 1 is given for each correctly counted string, with a maximum score of 10. Subjects are classified as scoring in the impaired or normal range according to their age; cut off figures are given in the test manual. These subsections were chosen as they are most relevant to the tasks being compared (i.e. performing a task under explicit conditions with frequent instruction and feedback requires auditory attention), and have been used by others investigating the impact of attention on balance (Stapleton et al., 2001). The full TEA takes between 60 and 90 minutes to complete, and was considered an unnecessary burden on participants in this study.

Participants completed both tests and were matched according to whether they are classed as "impaired" or "normal". Those that only demonstrated impairment in one of the tests were categorised as "impaired" overall. The standardised TEA protocol can be found in appendix 12.

5.5.4 Participants

Treatment sessions were delivered by selected members of the clinical team at the recruitment site. As the main objective was to study the behaviour of these therapists in relation to their ability to deliver the two interventions being compared, they were classed as research participants.

The study aimed to recruit between 2 and 4 physiotherapists. This number was deemed to be sufficient to deliver the required interventions, and to account for staff being away, for example on annual or sick leave (by ensuring that there was always at least one therapist available). It also gave therapists sufficient opportunity to become familiar with applying the interventions; a larger pool of therapy participants would make this difficult for a study of this size.

In terms of patient participants, the study aimed to recruit 20 hospitalised patients (10 pairs) with sub-acute stroke, who were receiving early gait rehabilitation. Participants were recruited as early as possible during their inpatient stay in order to minimise the impact of existing explicit knowledge relating to their gait. Early gait rehabilitation was defined as the point at which patients were beginning to work in standing, with assistance from a physiotherapist as required. Patients who were only able to weight bear with the assistance of equipment or an aid, such as a standing hoist or standing frame, were not considered eligible. However, patients did not need to be actually stepping or walking to be included. Full inclusion and exclusion criteria are given in the methods section (5.8).

5.5.5 Intervention

Data collection and treatment sessions took place in the patients' usual therapy setting. From the point of inclusion, patients were involved in the study for 5 days. Participants in each group received three training sessions; one session per day over 3 consecutive days. The short intervention length of 3 days was largely due to the confines of a part time PhD. Given that the primary objective was concerned with the ability of the therapists to deliver the interventions, then any potential lack of treatment effect as a result of this relatively short intervention was accepted as a limitation at this stage. Longer periods of intervention would arguably be needed in any future definitive trial. Limitations are discussed further in section 5.18.

The guidance for delivering treatment in a more explicit or implicit way was derived from the earlier observational study (see 4.14). Therapists were encouraged to provide exercise and functional practice based around three primary activities: sit to stand; standing (incorporating activities for both the stance and swing phases of gait); and stepping/walking. Since the treatment interventions provided during each approach were intended to be rooted in clinical practice, the content was largely pragmatic. However, therapists were asked to deliver their chosen interventions with a bias towards either explicit or implicit learning. This was done primarily by changing the amount, timing and attentional focus of their verbal communication with the patient.

Following the retention tests, participants in both groups underwent a short interview in which they were asked to report what they were thinking about (any rules, methods or techniques) during the previous three days of physiotherapy. Similar methods for ascertaining participants task relevant knowledge have been used by other researchers, albeit within healthy populations (Poolton et al., 2006b). It was anticipated that those in the explicit group would report more task relevant knowledge (rules), in relation to their gait rehabilitation, than those in the implicit group.

5.5.6 Choice of Outcome Measures

A battery of six outcome measures were chosen in order to evaluate the most appropriate and useful measures for detecting change in this patient group; this was intended to inform any future experimental trial.

5.5.6.1 Berg Balance Score

The primary outcome measure was the Berg Balance Scale (BBS) (Berg et al., 1989, Berg et al., 1995, Wood-Dauphinee et al., 1997).

The BBS has been investigated and used extensively within stroke research, and also has widespread use within clinical practice. Each item is graded between 0 and 4 based on specific measurable performance guidelines; the maximum score of 56 indicates balance ability within normal range. The scale includes 14 observable balance tasks that are commonly performed in everyday life (appendix 13). Since this scale includes tasks in both sitting and standing, it is a relevant measure for the functional level of the participants included within this study.

A systematic review of 21 studies examining the BBS concludes that it is a psychometrically sound measure of balance impairment for use in post-stroke assessment with high levels of validity and reliability (Blum and Korner-Bitensky, 2008). In the acute setting, the BBS is shown to have excellent interrater (Mao et al., 2002, Berg et al., 1995) (ICC = 0.95 and 0.98 respectively) and intrarater (Wood-Dauphinee et al., 1997) (ICC = 0.97) reliability. It is also known to have reasonable responsiveness in the acute phase post stroke (Wood-Dauphinee et al., 1997, Chou et al., 2006) (effect size = 0.66 and 0.85 respectively); however, several studies have indicated poor floor effects at 14 (Mao et al., 2002, Chou et al., 2006) and 38 (Salbach et al., 2001) days post stroke. These floor effects were unlikely to impact on the use of the BBS in this current trial as participants were required to be able to stand in order to meet the inclusion criteria; therefore those with a very low level of function post stroke were not considered for inclusion.

The BBS was taken at baseline and again at follow up. It takes less than 20 minutes to complete.

5.5.6.2 2 Minute Walk Test

Timed walk tests over a set distance, typically 5 or 10 metres, are commonly used to evaluate walking ability in people with stroke. However, during the early rehabilitation phase many patients may not be able to walk 5 or 10 metres, and are therefore not testable. This floor effect can be overcome by using 2-, 6- or 12- minute walk tests, which focus on distance walked in a pre-determined time rather than time taken to walk a pre-determined distance. These walking tests have all been shown to be valid and reliable in patients with stroke (Kosak and Smith, 2005). Given the functional level of those recruited to this study, a 2 minute walk test was used to evaluate changes in overall walking performance.

A standardised procedure was used, as outlined in the literature (Kosak and Smith, 2005). A linear walking course was measured in a quiet corridor within the hospital. Patients were asked to walk at a comfortable pace and were allowed to use aids (e.g. walking stick or frame) if necessary. They were given standby supervision but not assistance. The timing of 2 minutes was initiated from the point at which the participant was standing and was ready to begin walking. Patients were advised that they could stop to rest at any point (a wheelchair was provided), and could then continue when ready. Distance walked in 2 minutes was recorded, as was the number of rest breaks taken, and the number of steps taken (in order to calculate cadence). The 2 minute walk test was videoed with the intention that walking quality would also be assessed (see 5.5.6.5 below). Patients who were not yet able to mobilise without assistance scored 0 metres.

5.5.6.3 Hauser Ambulation Index

The level of assistance required for walking was recorded using the Hauser Ambulation Index (Hauser et al., 1983) (appendix 14). This is a simple standardised 10 point ordinal scale that rates the level of support required for walking. It was completed for all patient participants. Those that were not able to complete a 2 minute walk (i.e. could not walk without assistance) but could take some steps with assistance, were asked to attempt to mobilise a distance of 25 feet (7.62 metres), with assistance as required. This allowed for scoring on the Hauser Ambulation Index.

5.5.6.4 Step Test

The identification of small changes in performance may be limited when using ordinal scales such as the BBS; particularly given the potential floor effects identified in section 5.5.6.1. Similarly, the 2 minute walk test provides a useful means of evaluating gait and balance performance, but requires the individual to be able to walk independently, which could limit its use in this population who are in the early stages of becoming mobile.

Therefore, the Step Test (Hill, 1996) was also used. This simple, clinically practical test measures dynamic balance in single leg stance. The standardised procedure is outlined by Hill et al (1996); the individual is asked to step on and off a 7.5 cm block, placed 5 cm in front of their feet, as many times as possible in 15 seconds. The test is repeated with both the paretic and the non-paretic limb.

Test re-test reliability of the Step Test is shown to be high in the stroke population (ICC>0.88) (Hill, 1996). Performance on the Step Test also correlates significantly with functional reach, gait velocity and stride length ($p<0.001$) (Hill, 1996, Bernhardt et al., 1998), with the gait sub-section of the Motor Assessment Scale (Bernhardt et al., 1998), and with the knee extension component of the Upright Motor Control Test (as a measure of paretic limb loading) and the Repetitive Reach Test (as a measure of weight transfer) (Stemmons Mercer et al., 2009). The Step Test has also been shown to be sensitive to detecting change over a 4 week period in patients with sub-acute stroke ($p<0.0036$) (Bernhardt et al., 1998).

The Step Test was therefore used as an additional measure of balance improvement in this feasibility trial.

5.5.6.5 Wisconsin Gait Scale

The 2 minute walk provides an overall measure of walking ability, speed and cadence. However, one criticism of timed walking tests is that they do not assess “quality” of walking. Although it is likely that good quality is associated with greater speed, this may not always be the case. Therefore, it was intended that quality of walking would be measured using an observational gait analysis tool called the Wisconsin Gait Scale (WGS) (Rodriquez et al., 1996). The WGS is a visual gait analysis system that examines 14 observable variables related to hemiplegic gait deviations (appendix 15). It has been shown to be a useful framework for rating qualitative gait alterations of post-stroke hemiplegic subjects and to assess changes over time during rehabilitation training (Turani et al., 2004). There is, however, minimal data to support the psychometric properties of the WGS, in particular, there is little published data relating to its reliability. In terms of validity, Wisconsin Gait Scale scores are shown to correlate to Barthel Index scores and gait velocity, but not to Functional Independence Measures or the Adapted Patient Evaluation Conference System (Turani et al., 2004). Accepting these limitations, each 2 minute walk was video recorded, with the intention that these videos would then be analysed using the WGS as a means of assessing gait quality in a standardised way.

5.5.6.6 Patient Reported Confidence with Walking Pattern

A simple patient reported measure was used to assess how patients felt about the way in which they were stepping/walking. Using a standard question pre and post treatment, patients were asked to rate on a 11 point numerical rating scale (NRS) from 0-10, how confident they felt about the way in which they were stepping/walking (appendix 16). Numerical rating scales are widely used in healthcare practice and research, commonly for the quantification of perceived pain (e.g. Williamson and Hoggart, 2005). Within stroke rehabilitation, numerical rating scales have been used to assess quality of life outcomes (e.g. Wood-Dauphinee et al., 1988, Jones et al., 2008). The value of using a NRS in the stroke population, particularly within the acute phase, is revisited in the discussion section of this chapter.

5.6 Training for Therapists

Therapists were briefed about the nature of the research prior to giving consent. Once recruited, they each met with the CI to receive training on the explicit and implicit learning approaches, and to go through the written guide to each treatment approach (appendix 17). The guide was kept purposively broad as it was intended that therapists would change the amount, content and timing of the instructions and feedback that they give, without otherwise making significant changes to their practice. The CI provided each therapist with a 60 minute training session on the concept and principles of explicit and implicit learning, and the objectives of the current research. They then discussed the treatment guidelines with each therapist, using clinical examples to highlight differences between explicit and implicit learning in a practical way. Physiotherapists were encouraged to ask questions and discuss/debate the guidelines to ensure that they had a thorough understanding of what they were being asked to deliver (training materials can be found in appendix 18).

During the main trial, the Chief Investigator was available throughout the data collection period to support the therapists and to discuss the delivery of treatment programmes and using explicit and implicit learning approaches. Prior to a patient commencing treatment, the CI emailed the treating therapist with the patients group of randomisation, and briefly reinforced the key principles of the learning approach that they were due to deliver, encouraging the therapist to refer back to the treatment guidelines (appendix 17). The CI did not otherwise directly influence or participate in the treatment sessions.

5.6.1 Blinding

This was a double blind trial. Patient participants were blinded as to which intervention group they were in. In the first phase of recruitment (first 8 patients), primary outcome measures were completed by the CI, who was not blinded but for whom each assessment was video recorded and later verified by an independent (and blind) research colleague. In the second phase of recruitment (patients 9- 21), all outcome measures were completed by a physiotherapy research practitioner, who was blinded as to which intervention group the participant was in. This change primarily occurred due to a change in staffing at the study site, and the opportunity arising to use a research assistant for this role. This was deemed to be a positive addition to strengthen the validity of the research. Therapists were delivering the intervention, and were therefore not able to be blind.

5.7 ETHICAL CONSIDERATIONS

5.7.1 Recruitment of Physiotherapists

Potential physiotherapists were identified via the Therapy Services Manager. Initial contact with individual physiotherapists was made via email, which included the appropriate Participant Information Sheet. Therapists were asked to complete and return a reply slip if they were interested in taking part or receiving further information. Those that expressed an interest were then contacted via either telephone or email. The researcher then arranged a time to meet with the therapist to discuss in detail what involvement would consist of. This recruitment processes ensured that therapists did not feel and pressure, and were not coerced, into taking part.

5.7.2 Recruitment of Patients

All patients taking part in the study were in-patients on a stroke unit. Potential participants were identified and approached initially by their treating physiotherapist, who provided them with a letter of invitation, a copy of the Participant Information Sheet, and a reply slip. If the patient was interested in taking part, or in finding out more, they were asked to return the reply slip to their physiotherapist, who then passed this onto the researcher. The researcher then arranged to meet with the patient and discuss their potential involvement further. Physiotherapists (and other clinicians) were briefed regarding the inclusion criteria and general purpose of the research.

In all instances, participants were given a minimum of 24 hours between receiving the relevant information sheet and deciding whether or not to take part, and had the opportunity to ask questions and discuss their involvement at every stage.

As detailed on the information sheets, it was emphasised that participants (both patients and therapists) could choose to withdraw at any time, without prejudice, and without patient care being affected in any way.

5.7.3 Maintaining Participant Confidentiality

All electronic data was stored on a password protected computer. All paper data was stored in a locked filing cabinet in a locked office. Patient confidentiality was ensured by allocation of a unique identification number (ID). All data that linked patient personal information with the ID was kept in a separate locked filing cabinet. Institutional Guidelines for Research Governance and procedures for good clinical practice in research were followed.

5.7.4 Use and storage of audio and audio visual data

Audio and video recordings are retained in a secure place in line with University of Southampton policy. Audio and video recordings were primarily required for direct study purposes (i.e. verifying outcome measures and monitoring interventions). It was therefore a requirement of participating that both patients and therapists provided consent for video and audio recording to take place.

Both patients and therapists were asked to provide separate consent as to whether they agreed for their videos/audio recordings to be used for dissemination purposes (e.g. teaching or conference presentations). This was not an essential requirement, and patients/therapists were not excluded if they choose not to give this consent. This was made clear during the recruitment process.

5.7.5 Intervention

Participation required a commitment from the patient to be available for a series of treatment sessions on three consecutive days. However, as this replaced the physiotherapy sessions for mobility that the patient would have otherwise received, it was not considered to represent any significant additional burden. Flexibility allowed these sessions to fit around any other activity that was due to take place for that patient; and the intervention provided as part of this study did not therefore interfere with the patient's ongoing care or rehabilitation.

Throughout the study, participants were seen within their usual therapy setting and in the presence of one of their treating therapists, creating a familiar and comfortable atmosphere. Treatment sessions were restricted in length to around 45 minutes and participants were allowed adequate rest periods during this time (as judged by the treating physiotherapist). The content of the session was intended to be pragmatic and guided by the physiotherapist, since this is reflective of clinical practice. During balance and mobility tests, stand-by supervision was given at all times, regardless of patient ability.

On each day that a patient received a treatment session as part of this study, that session replaced any treatment that they would have otherwise received specifically *for general mobility* on that day. A 45 minute physiotherapy session focussing on mobility is generally reflective of what would otherwise be provided during this time (see De Wit et al., 2005, De Wit et al., 2006) and is in line with National Clinical Guidelines (RCP, 2008). Throughout their involvement in the study, all patients continued to receive all other therapies and intervention as they normally would, including following any prescribed exercise or stretching programmes, splinting regimes, upper limb rehabilitation, and input from therapists/other healthcare staff for functional rehabilitation and general walking or balance practice on the ward. Therefore patients participating in the study did not "lose out" in terms of therapy input or intensity. Since the content of each session was based on guidance developed through observation of current practice and expert consensus, it is unlikely that this varied greatly from what would have been provided during routine clinical practice, although it was delivered in a different way (dependent on the use of explicit and implicit strategies). Thus the study did not investigate any "new" or experimental approaches used in therapy; rather it separated and compared two approaches already in use. Wherever possible, each individual patient received treatment from the same therapist for the duration of the study.

In order to minimise the disruption or inconvenience caused to the therapy teams involved in this study, a maximum of two patients were actively involved in the study any given time. This also ensured adequate flexibility to fit all sessions for each patient into the desired timeframes/sequence. Sessions took place on the ward or in the therapy gym, in line with usual practice at the recruitment site. For the duration of the treatment session, other patients were not allowed to be treated in the gym, as this may have created distraction and potentially provided contamination (for example if another therapist was treating a patient in a very explicit way). The recruitment site had other treatment areas available that staff not involved in the study would be able to use during these times. This was discussed and agreed with relevant service leads prior to the study commencing.

5.7.6 Ethical Approval

The study was approved by the Yorkshire and the Humber Research Ethics Committee [Reference 11/YH/0111] (appendix 21). Sponsorship was provided by the University of Southampton, and Research Governance approval was gained from the participating NHS Trust (appendix 22).

5.8 METHOD

5.8.1 Design

This was a double blind, randomised trial using a matched pairs design.

5.8.2 Setting

The study took place on an inpatient stroke unit at a district general hospital.

5.8.3 Participants

The study involved both physiotherapist and patient participants.

Therapists were eligible to take part if they were currently working within the stroke service and had at least one years experience working within neurology at a senior level.

Patients were selected based on the following inclusion and exclusion criteria.

5.8.3.1 Inclusion criteria

- Patients receiving rehabilitation for their first episode of stroke which resulted in hemiplegia
- Able to give informed consent to take part in the study.
- Currently receiving physiotherapy for the rehabilitation of gait (at minimum is able to stand and weight bear, with physical assistance from one physiotherapist if necessary).

5.8.3.2 Exclusion Criteria

- Patients with a history of:
    - any other neurological conditions
    - previous stroke with residual impairments
    - any pre-stroke musculoskeletal condition that either:
        1. limited walking to less than 100 metres and/or
        2. resulted in a noticeable gait abnormality and/or
        3. required use of a bilateral walking aid (e.g. 2 walking sticks or a walking frame)
- Patients with marked receptive dysphasia (not able to follow 3-stage commands) - confirmed through liaison with multi-disciplinary team, including Speech and Language Therapists where necessary

5.8.4 Recruitment Process

5.8.4.1 Recruitment of Physiotherapists

All eligible therapists, as identified by the Therapy Services Manager, were sent a letter of invitation and a copy of the relevant Participant Information Sheet (appendix 19). They were asked to consider this information, and to return a reply slip if they were interested in knowing more. The researcher then arranged a time to meet with them to talk through what their involvement would consist of. Those that wished to continue were asked to sign a consent form (appendix 19). Therapists remained enrolled in the study throughout the data collection period, although they were only required to provide treatment when there was a patient actively involved in the trial. Therapists were made aware that they were free to withdraw from the study at any time. If a therapist did choose to withdraw, then a decision was made as to whether or not they should be replaced, dependent on the timing of the withdrawal and how many further patients needed to be recruited.

For the purposes of measurement and monitoring, video recording was used throughout the study. Therapists delivering the interventions were made aware of this requirement prior to giving consent (see section 5.7.4 for ethical considerations relating to video recording).

5.8.4.2 Training for Therapists

Once recruited to the study, therapists underwent a 60 minute training session with the Chief Investigator, during which they were briefed on the treatment guidance for the implicit and explicit approaches. They were provided with written copies of this guidance for future reference.

5.8.4.3 Recruitment of Patients

Patient participants were recruited from the inpatient stroke unit. Patients who were able to stand with assistance were screened by their treating physiotherapist for inclusion into the study based on the criteria set out in 5.8.3.1, and were subsequently approached by that physiotherapist to gain permission for the Chief Investigator (LJ) or the Research Practitioner (ER) to meet with them. The physiotherapist provided the potential participant with a copy of the relevant PIS, a covering letter, and a reply slip giving agreement for the researcher to meet with them (appendix 20). Patients were made aware that agreeing to meet with the research team did not, in any way, commit them to taking part.

The Chief Investigator or Research Practitioner then met with the patient to explain the nature of the study further and talk through the Participant Information Sheet. Patients were given at least 24 hours to consider this information. Those that agreed to participate were then asked to sign a consent form (appendix 20). The recruitment and randomisation process is outlined in Figure 12.

5.8.5 Collection of Patient Demographic Data

Once consent was obtained, background information was collected from the patient's medical records, including: age, gender, time since stroke onset (days), type of stroke, relevant past medical history and drug history.

5.8.6 Outcome Measures

The following outcome measures were recorded pre-treatment (at baseline) and post-treatment (24 hours after the final treatment session). With the exception of the numerical rating scale, all outcome measures were video recorded to allow for verification of scores by an independent assessor if necessary.

- Berg Balance Scale (Berg et al., 1989)
- Step Test (Hill et al., 1996)
- Hauser Mobility Index (Hauser et al., 1983)
- 2 minute walk test (Kosak and Smith, 2005)
- Numerical Rating Scale

In addition, the Test for Everyday Attention was completed at baseline, in order to allow for randomisation in line with the matched pairs process outlined below.

5.8.7 Randomisation

The first participant was assessed against the following matched pair criteria and then randomised, using a random numbers table, into either the explicit or the implicit learning group. Participants were required to match on all three criteria, in order to be matched as a pair.

1. Age – participants were matched if they were within 10 years in age
2. Berg Balance Score – participants were matched if they scored within 8 points of each other
3. Presence or absence of an attentional deficit.

Each subsequent participant completed the same assessments. If they matched an existing participant's criterion, they were assigned to the opposite group. If they did not match an existing participant's criterion, they were randomised. This process for recruitment continued until a sufficient number of matched pairs had been found, and had completed data collection.

Where one participant from an already matched pair withdrew before completing data collection, they were replaced with the next matching participant. All data from drop-outs was retained, including reasons for withdrawal, and this is reported in order to ensure that the approach has not introduced bias.

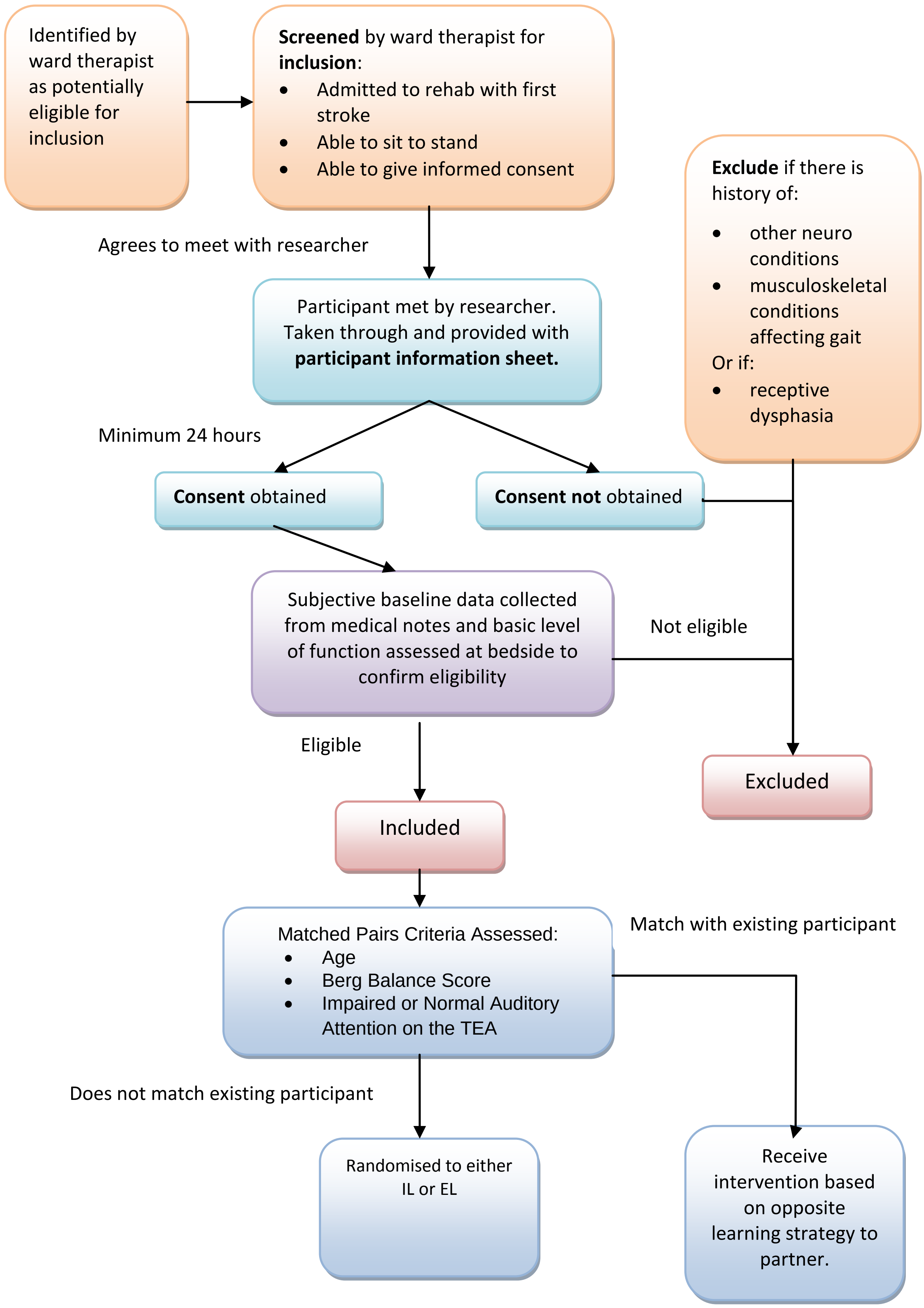


Figure 12 Recruitment Process

5.8.8 Intervention - Acquisition (learning) Phase.

Both groups received three consecutive days of training based on their assigned group. Training was delivered in line with the guidance developed in the earlier phase of this research programme. Therapists were asked to keep a log of the activities completed during each session. A copy of the activity log form can be found in appendix 26.

One treatment session for each patient was video recorded. To allow the therapist to become accustomed with the individual patient and to formulate a treatment plan, only session 2 or 3 was recorded. The treating physiotherapist was asked to set up the video camera in an appropriate position within the treatment area, and to record the session in its entirety. The absence of any involvement or presence by the researcher helped to reduce any observer bias, resulting in a truer reflection of how the therapy was delivered.

5.8.9 Follow Up Measures – Retention Phase

The BBS, 2 minute walk test, Step Test and Hauser Mobility Index were repeated 24 hours after the final treatment session in order to assess retention (learning). Participants were also asked to repeat the NRS. The assessment and intervention process is summarised in Figure 13.

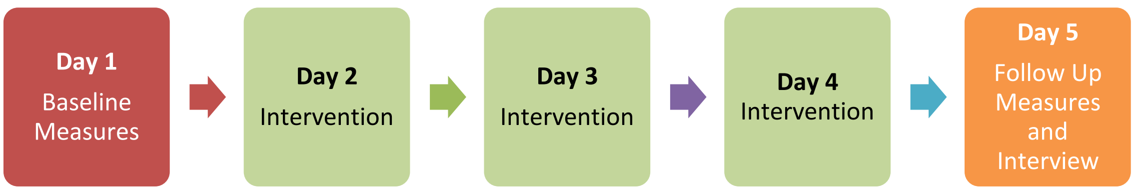


Figure 13 Assessment and Intervention Procedure
Summary of the assessment and intervention process across the 5 days of participant involvement in the study

5.8.10 Patient Interviews

Following the retention tests, patient participants in both groups underwent a short interview in which they were asked to report what they were thinking about (any rules, methods or techniques) during the previous three days of physiotherapy. The interviews were audio taped, and later transcribed verbatim. The interview guide can be found in appendix 24.

5.8.11 Physiotherapist Interviews

After all data collection had been completed, the participating therapists also underwent a semi-structured interview in order to gain insight into their experience of delivering the explicit and implicit treatment approaches, and their thoughts on the relative benefits or disadvantages of each. Interviews were conducted by the Chief Investigator (LJ), were digitally recorded, and later transcribed verbatim. The interview guide can be found in appendix 25.

5.9 Data Analysis Plan

The primary purpose of the data analysis was to assess the feasibility of delivering explicit and implicit approaches – i.e. to understand how well the physiotherapists were able to deliver the intervention in line with the explicit and implicit treatment guidelines. The methods used to establish this compliance are outlined in the following sections.

All data was stored and analysed using SPSS software (Statistical Package for the Social Sciences; version 21). Statistical support was provided by the supervisory team and Dr Sean Ewings (Senior Research Fellow – Statistics) from the School of Health Sciences at the University of Southampton.

5.9.1 Data Extraction and Statistical Analysis

In order to report the ability of therapists to deliver each approach, one treatment session was video recorded for each participant. Using the analysis matrix, the content of these treatment sessions was analysed. Statements of instruction or feedback were identified, counted and coded according to their attentional focus; using the process and definitions developed through Phase 1 (Chapter 5). Data was considered in various ways, as outlined below.

5.9.1.1 Physiotherapists delivery of the treatment guidelines

The total number of statements for each video was counted, and then normalised (number of statements per minute) to account for the differences in length of treatment session; this is reported using descriptive statistics.

Data was found to be normally distributed, and therefore comparison was made between the explicit and implicit treatment groups using a linear regression model (univariate analysis of variance). The total number of statements was compared using the intervention (implicit or explicit) as a dependent variable, and the duration of the treatment session (minutes) as a covariate. Similarly, separate analysis took place to compare the number of internal focus statements, external focus statements and unfocussed statements. Again, the intervention was the dependent variable, with the duration of the treatment session (minutes) and the total number of statements acting as covariates.

Compliance with the intervention guidelines would broadly be achieved if patients in the implicit group received:

a) proportionally fewer statements of instruction/feedback than those in the explicit learning group; and
b) a higher proportion of internally focussed statements, when compared to those in the explicit learning group.

5.9.1.2 Measuring the amount of silence

In order to analyse the quantity of information, statements of instruction or feedback were counted, as described above. However, since a single statement could be lengthy, or could be relatively short, data was also analysed to assess the overall amount of "talk" in comparison to the amount of "silence"; providing an estimation of how much opportunity patients had to practice tasks without any concurrent verbal instruction/feedback. This part of the analysis was therefore limited to the periods of time during which the patient was actually practising a task, such as sit to stand, stepping or walking (periods of rest were excluded).

Estimating the amount of silence during the practise of tasks requires a definition of the parameters associated with a period of "silence"; i.e. what is the threshold for labelling a period of time without speech as "silence", and would this be meaningful in the context of this research. There is very little published literature, relevant to the purpose of this study, to guide this analysis.

For example, the topic of "silence" is widely debated within the qualitative research literature, particularly in the field of conversation analysis. In particular, many researchers have considered the role of silence in relation to turn taking during conversation, and have proposed various definitions for different forms of silence. Whilst there appears to be no consistent terminology, researchers have distinguished three types of acoustic silence which occur during conversation: pauses; gaps and lapses (Sacks et al., 1974). Pauses occur when there is a period of silence during speech by the same person, gaps occur when there is a period of silence between one conversation partner and the other, and lapses are longer periods of silence. Schegioff (2000) has quantified a gap as "just a bit of space", equivalent to roughly one syllable, or 150-250 microseconds.

The purpose of such detailed conversation analysis is very different to the purpose of recording silence within the context of this research; and the definitions and thresholds described in the aforementioned literature are therefore not directly applicable to the analysis of data in this study. Not least because the verbal dialogue analysed during this research is less of a conversation, and more the one way delivery of information (from therapist to patient). It is not directly about the verbal *interaction* between two people, and more about one person's (the patient's) physical response to verbal information from another person (the therapist). However, it does raise the question as to how long a gap in verbal talk needs to be in order to be counted as a meaningful period of silence for this current research. This is likely to be significantly longer than those described by conversation analysts, and closer to the "lapses" described by Sacks (1974).

Since one key factor in implicit learning is the opportunity for the learner to self-correct and modify their behaviour based on their own intrinsic feedback mechanisms, a meaningful period of silence would need to be sufficient enough to allow the patient to practice repetitions of a task without any verbal input from their therapist. Therefore, a period of time during practice was labelled as a period of silence only if there was no verbal talk (from either the patient or the therapist) for 30 seconds. Whilst this is a significantly long period of time compared to those definitions of silence given in the conversation analysis literature, it was deemed to be a reasonable period of time for patients with this level of ability to practice an estimated 1 to 5 repetitions of a given task without any verbal input. For example, in a 30 second time period, a patient may only be observed to practice 1-2 repetitions of a sit to stand exercise, or 4-5 steps onto a block. As all patients within this study were in the early stage of recovery, this is a reasonable estimation of what could be achieved in 30 seconds, and was deemed an appropriate cut off for counting a period of silence as meaningful. The analysis matrix was therefore used to count the number of blocks of time during which the patient was practicing a task, and was not receiving any verbal information (i.e. there was complete silence). The proportion of silent units (given as a percentage) was calculated for each individual. Data were described using descriptive statistics and displayed visually using bar charts. Due to the nature of the data (see results section), statistical tests were not performed.

5.10 Qualitative Data Analysis

5.10.1 Patients recollection of "rules"

The term "rules" refers to the patient's recollection of explicit, declarative knowledge about how to perform the tasks they had been practising. For example, *"I have to try and control my knee",* or *"I have to really think about lifting my foot up".* Twenty-four hours after the last treatment session, patients were interviewed and asked about what they had been practising during their physiotherapy sessions, and what they usually think about when practising such activities. Interviews were digitally recorded and then transcribed verbatim. Transcripts were then analysed to identify and count the number of "rules" reported by each patient.

5.10.2 Physiotherapist interviews

The physiotherapist interviews were also transcribed verbatim, and were analysed to identify key points that may inform the development of the main study. As the number of therapist interviews was small (n=2), full thematic analysis was not considered appropriate, however, inferences are made about any common or potentially useful insights that arose.

5.11 Clinical Outcome Measures

This study did not intend to test any hypotheses relating to clinical outcome, and was therefore not powered to do so. The use of outcome measures allowed their appropriateness to be evaluated in the context of this study; thus informing the design of any future trial. Therefore, data relating to the clinical outcome measures was not analysed for statistical differences, but the results are reported and discussed using descriptive statistics and where appropriate, graphical representation.

Data from the primary outcome measure (the Berg Balance Score) was used to perform a sample size calculation for the next phase of the research.

5.12 RESULTS

The results are presented in three difference sections. Firstly, data relating to the content of the recorded physiotherapy sessions is presented. This data was generated using the analysis matrix to record and describe the content of each recorded treatment session. Comparison is made between the explicit and implicit groups using statistical testing. Data from this feasibility stage is also compared with that collected through the initial observational study to determine how the interventions applied during this feasibility trial compare to 'standard care'. Secondly, qualitative data from the analysis of the patient and therapist interviews is presented. Finally, data relating to patient outcome is presented. This was not analysed using statistical methods, but is presented using descriptive statistics.

5.12.1 Demographic Data

5.12.1.1 Physiotherapist Participants

Two physiotherapists were initially recruited into the study. Both were senior therapists who worked on the inpatient stroke unit at the study site. Therapist A had over 15 years of experience working in neurology at a senior level, and therapist B had more than 5 years of experience. Both had been involved in the initial observational study.

Therapist A retired from clinical practice part way through the study, and a third therapist was therefore recruited. Therapist C had 1 year of experience working in neurology at a senior level, and previous senior experience working in a general rehabilitation environment.

All therapists provided informed consent to take part in the study.

The number of patients treated by each therapist in each treatment arm is shown in Table 13.

Therapist	Number Treated in IMPLICIT GROUP	Number Treated in EXPLICIT GROUP	Total Number Treated During Study
A	2	1	3
B	4	8	12
C	5	1	6

Table 13 Number of patients treated per therapist
The number of patients treated by each participating therapist (A, B and C) during the study, divided in terms of group of randomisation (implicit or explicit).

5.12.2 Patient Participants

Participant characteristics are shown in Table 14.

Of the 21 participants recruited to the study, 9 were male and 12 were female. The mean age of participants was 74 years (range from 48 – 91 years; σ 14.00). Time since stroke ranged from 1 to 47 days ($\bar{x}$ = 18.9 days; σ = 12.99). Eight participants presented with left sided hemiplegia and 13 with right sided hemiplegia. 62% of participants were diagnosed clinically with a partial anterior circulatory stroke, 24% with an intracerebral haemorrhage, 5% with a total anterior circulatory stroke, 5% with a posterior circulation stroke and 5% with a lacunar stroke. The mean Berg Balance Score at baseline was 12.29 (out of a possible maximum of 56), indicating that patients were at a fairly low level in terms of function (range 2 to 24; σ 8.24). Only 3 participants (14%) demonstrated normal auditory attention on the TEA, with the remaining 18 participants (86%) demonstrating deficits in at least one of the TEA subtests, and therefore impaired auditory attention overall. Table 14 shows the baseline characteristics of participants according to group. As would be expected with a matched pairs design, the groups were similar at baseline in terms of key characteristics.

	Implicit Group	**Explicit Group**
Age ($\bar{x}$ and σ)	76.91 years (σ = 13.61)	71.11 years (σ = 13.54)
Berg Balance at Baseline ($\bar{x}$ and σ)	12/56 (σ = 7.66)	13.56/56 (σ = 9.28)
Test for Everyday Attention	Normal in one participant; impaired in all others	Normal in two participants; impaired in all others

Table 14 Baseline Characteristics of Participants
Baseline characteristics of participants according to treatment group; groups were similar at baseline.

					Matched Pairs Criteria					
Participant Number	Therapist	Type of Stroke	Time Since Stroke (days)	Gender	Age	Initial BBS	Auditory Attention	Randomised or Matched	Intervention Group	Participant Matched To
1	A	Left PACS	47	F	79	4	Impaired	Randomised	Explicit	Withdrawn*
2	B	Right PACS	14	F	83	13	Impaired	Randomised	Explicit	14
3	A	Left PACS	14	M	65	5	Impaired	Randomised	Implicit	Not matched
4	A	Right ICH	19	M	78	14	Normal	Randomised	Implicit	6
5	B	Left PACS	24	F	79	23	Impaired	Randomised	Explicit	8
6	B	Right PACS	15	F	80	6	Normal	Randomised	Implicit	4
7	B	Right TACS	29	F	89	4	Impaired	Randomised	Implicit	Withdrawn[†]
8	C	Left PACS	1	F	89	17	Impaired	Matched	Implicit	5
9	B	Right ICH	15	F	48	24	Impaired	Randomised	Explicit	Withdrawn[†]
10	B	Left PACS	36	F	85	5	Impaired	Randomised	Implicit	Withdrawn*
11	C	Left PACS	16	M	63	24	Impaired	Matched	Explicit	13
12	B	Right PACS	9	M	78	2	Normal	Randomised	Explicit	Not matched

13	B	Left PACS	10	M	59	20	Impaired	Matched	Explicit	11
14	C	Left ICH	15	M	86	13	Impaired	Matched	Implicit	2
15	B	Left PACS	18	M	55	24	Impaired	Randomised	Explicit	19
16	C	Right PACS	6	M	49	13	Impaired	Randomised	Implicit	Not matched
17	B	Left ICH	43	F	73	4	Impaired	Randomised	Explicit	20
18	B	Left Cerebellar Haemorrhage	37	F	86	8	Impaired	Randomised	Implicit	21
19	C	Left PACS	5	M	55	25	Impaired	Matched	Implicit	15
20	C	Left POCS	22	F	91	4	Impaired	Matched	Implicit	17
21	B	Right LACS	2	F	85	6	Impaired	Matched	Explicit	18

* participant was withdrawn from the study due to being medically unwell and therefore not fit for therapy

✝ participant was withdrawn from the study due to being discharged from hospital

Table 15 Experimental Study - Participant Characteristics

Characteristics of the 21 patients who took part in the study, including their treatment group and whether they were randomised or matched.

5.12.3 Drop Outs

Twenty one participants were recruited to the study, and were assigned to one of the treatment groups (either by randomisation or being matched). One patient was withdrawn from the study before completing the full course of intervention as a result of having unstable blood pressure. All other participants completed the baseline assessments and all three days of training. However, one further participant was withdrawn before the final measures were taken as they were unwell with a urinary tract infection. Two further patients were lost to follow up due to being discharged from hospital before follow up outcome measures were collected. Therefore, there were 17 participants for whom a full data set was available. Figure 14 shows the Consort Diagram. Data from drop outs was retained and is used in the reporting of findings. The video recorded treatment sessions from those that withdrew, where available, are included in the analysis.

5.12.4 Consort Diagram

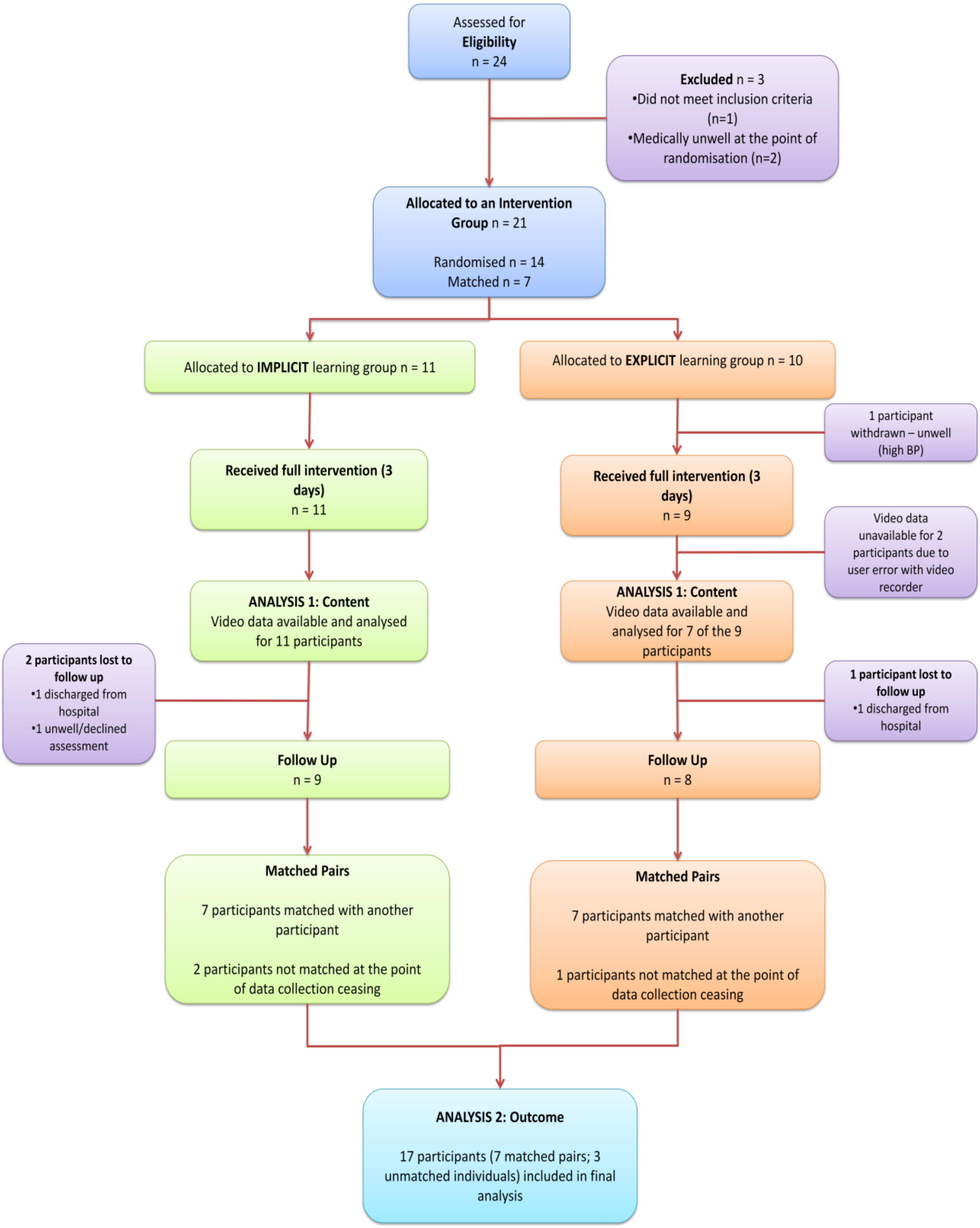


Figure 14 Consort Diagram

5.13 Content Analysis - Results

5.13.1 Physiotherapists compliance with the treatment guidelines

In order to evaluate the physiotherapist's compliance with the treatment guidelines, one treatment session was video recorded for each patient. This video data was available for 18 of the 21 patients recruited. Recordings were missing for patients 1 and 6 due to user error, and patient 9 who withdrew from the study due to being unwell.

Table 16 summarises the data collected using the analysis matrix for each video recording. The total number of identified statements for each category is shown, alongside normalised data (number of statements per minute) to account for the differences in length of treatment session. The number of silent units is also shown as both a total, and as a percentage of overall time (see 5.13.1.2).

5.13.1.1 Quantity of Information

Verbal communication was more frequent among patients in the explicit learning group. The average number of statements per minute for a patient in the implicit learning group was 2.24; and for a patient in the explicit learning group was 7.07. This equates to one verbal statement every 26.8 seconds for those in the implicit learning group; compared to one verbal statement every 8.4 seconds for those in the explicit learning group.

Results between groups were compared using ANCOVA (univariate analysis of variance model). The dependent variable, total number of statements delivered, was found to be significantly related to the intervention group (implicit or explicit) after controlling for the overall length of treatment session (minutes) [$F(1, 15) = 49.71$, $p<0.01$, $r^2 = 0.777$]. Therefore, we can conclude that physiotherapists successfully managed to alter the amount of information that they delivered to patients in line with the group of randomisation; with patients in the implicit learning group receiving statistically fewer statements of instruction and feedback than those in the explicit group. This is evident on Figure 15, which shows the average number of verbal statements per minute for each patient; those in the implicit group are shown in blue, and the explicit group are shown in orange.

Table 16 Analysis of Treatment Videos

Summary of data from each treatment video, the content of which was recorded using the analysis matrix. Statements of instruction and feedback were identified and categorised according to their focus of attention. These are summarised in terms of overall quantity (per video), but are also normalised to account for differing lengths of video (number per minute).

Participant Number	Treatment Group	Amount of Video Analysed (mins)	Total Number of Statements Identified	Internally Focussed Statements		Externally Focussed Statements		Mixed Focus Statements		Unfocussed Statements		Average number of statements per minute (overall)	Number of Silent Units	% of silent units
				Total	Average per Minute	Total	Average per Minute	Total	Average per Minute	Total	Average per Minute			
1	Data not collected due to user error with video recorder.													
2	EXPLICIT	18	195	97	5.39	45	2.5	2	0.11	51	2.83	10.83	0	0
3	IMPLICIT	54	125	47	0.87	53	0.98	3	0.16	22	1.22	2.91	45	42
4	IMPLICIT	15	39	14	0.93	16	1.07	0	0	9	0.5	3.25	2	7
5	EXPLICIT	27	170	134	4.96	10	0.37	0	0	26	1.44	8.71	0	0
6	Data not collected due to user error with video recorder.													
7	IMPLICIT	24	31	4	0.17	24	1	0	0	3	0.16	2.38	7	15
8	IMPLICIT	38	95	30	0.79	40	1.05	0	0	25	1.39	3.73	10	13
9	Participant withdrew before data collected due to illness unrelated to the study.													
10	IMPLICIT	13	52	4	0.31	33	2.54	6	0.46	9	0.51	4	3	12
11	IMPLICIT	18	36	1	0.06	20	1.11	5	0.28	9	0.51	1.94	12	33
12	EXPLICIT	17.50	118	86	4.91	13	0.74	2	0.11	17	0.97	6.74	0	0
13	EXPLICIT	26	122	82	3.15	8	0.31	2	0.08	30	1.15	4.69	0	0
14	IMPLICIT	36	30	0	0.00	25	0.69	0	0	5	0.14	0.83	16	22.22

15	EXPLICIT	18.50	139	53	2.86	20	1.08	1	0	65	3.51	7.51	0	0.00
16	IMPLICIT	18	20	2	0.11	9	0.50	1	0	7	0.39	1.06	8	22.22
17	EXPLICIT	13	131	79	6.08	7	0.54	0	0	45	3.46	10.08	0	0.00
18	IMPLICIT	12	29	0	0.00	22	1.91	0	0.00	7	0.61	2.52	5	21.74
19	IMPLICIT	15	59	9	0.60	21	1.40	0	0.00	29	1.93	3.93	4	13.33
20	IMPLICIT	13	57	8	0.64	31	2.48	0	0.00	18	1.44	4.56	0	0.00
21	EXPLICIT	18.50	104	52	2.81	21	1.14	0	0.00	31	1.68	5.62	2	5.41

Totals	**EXPLICIT**	**138.5**	**979**	**583**	**4.21**	**124**	**0.90**	**7**	**0.05**	**265**	**1.91**	**7.07**	**2**	**0.72**
	IMPLICIT	**255**	**573**	**119**	**0.47**	**294**	**1.15**	**15**	**0.06**	**143**	**0.56**	**2.24**	**112**	**21.96**

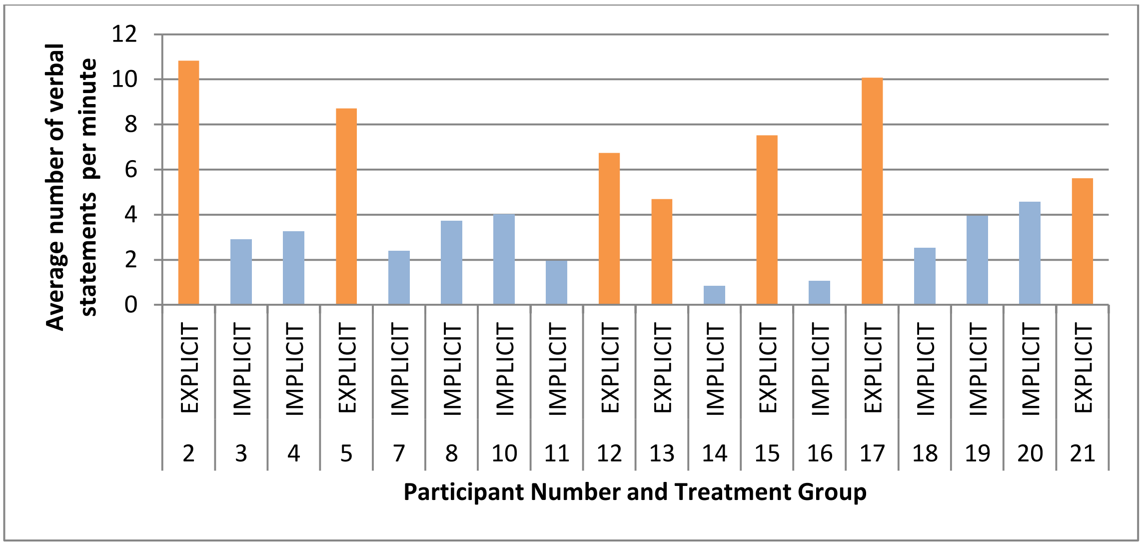


Figure 15 Average number of verbal statements for each participant
The total number of statements (instruction and feedback) was recorded for each video, and then normalised to account for the differing lengths of treatment session. This graph shows the normalised figure (number of statements/number of minutes) for each participant for whom there was a video available.

5.13.1.2 Proportion of "silence"

The analysis matrix recorded communication activity in 30 second units of time. The number of units in which there was no verbal communication (i.e. silence) was calculated as a percentage of the overall number of units for each individual participant. For example, participant 3 received 54 minutes of therapy, which translates to 108 (30 second) units of time. In 45 of these units, the therapists did not use any verbal communication, which equates to 42% of the total number of units.

For those in the implicit learning group, the proportion of silent units averaged 22%, whereas for those in the explicit group it was considerably less, with an average of 0.7%. All patients in the implicit learning group had some time during the observed session in which they were allowed to practice, for a period of at least 30 seconds, without receiving any verbal communication from the therapist (see Figure 19). Conversely, only one patient in the explicit group had a period of time in which there was complete silence. Given that the difference between groups with regards to the number of silent units was so distinct, statistical analysis was not performed. We can clearly conclude that patients who were randomised to the implicit group had greater opportunity to practise activities without receiving verbal input from the therapist.

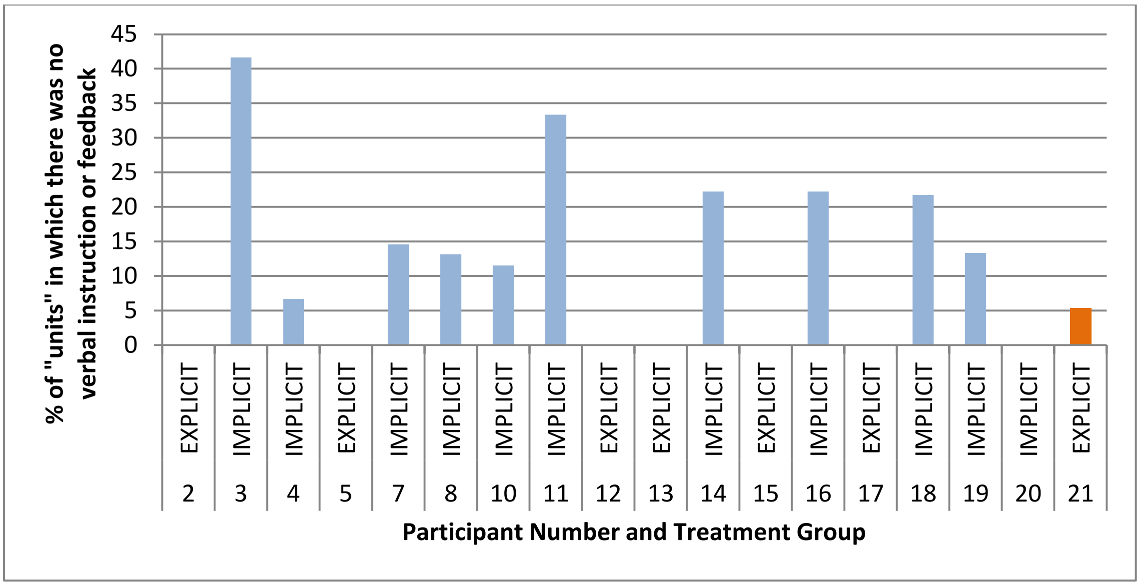


Figure 16 Graph showing the % of silent units per patient
The proportion of units in which there was no verbal communication, shown as a percentage of the overall number units in the treatment session (1 unit = 30 seconds of treatment).

5.13.1.3 Focus of Attention

In addition to counting the number of statements delivered to each participant, the focus of attention derived from those statements was also recorded. Table 17 and Figure 17/Figure 18 show the overall proportion of internal, external and mixed focus statements for each treatment group.

Type of Statement	IMPLICIT LEARNING GROUP	EXPLICIT LEARNING GROUP
Internal Focus	28%	82%
External Focus	69%	17%
Mixed Focus	4%	1%

Table 17 Distribution statements according to focus
The overall proportion of internal versus external focus statements for all participants, across the two treatment groups.

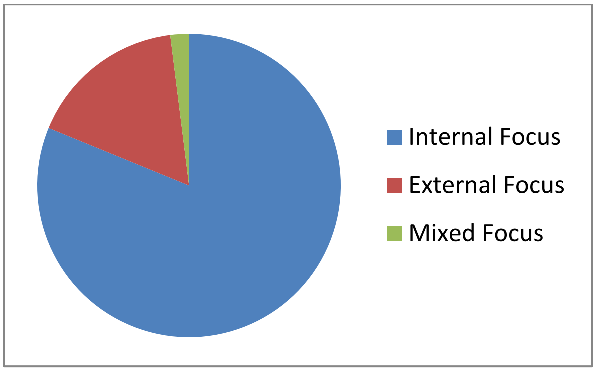


Figure 17 Explicit Group - % of statements according to focus
Proportion of internal, external and mixed focus statements delivered to patients in the explicit learning arm (all participants combined)

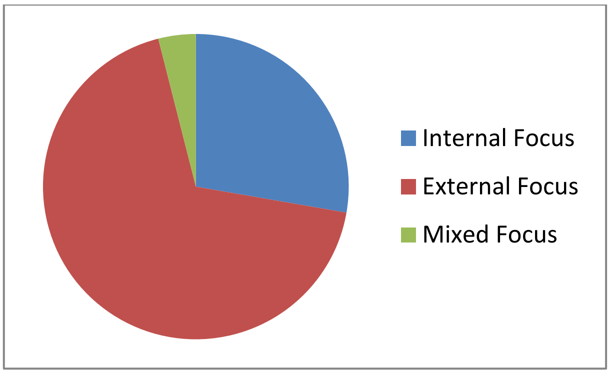


Figure 18 Implicit Group – % of statements according to focus
Proportion of internal, external and mixed focus statements delivered to patients in the implicit learning arm (all participants combined)

Treatment groups were compared with regard to the use of internal, external and unfocussed statements using ANCOVA; with both the length of treatment session and the total number of statements as covariates. The number of mixed focus statements was so low (an average of 0.05 statements per minute), that these were excluded from the analysis.

There was a clear association between the incidence of internal focus statements and external focus statements and intervention group. Participants in the explicit learning group received statistically higher numbers of internally focussed statements [$F(2, 14) = 6.09$, $p<0.05$, $r^2 = 0.0901$] and statistically fewer external focus statements [$F(2, 14) = 16.73$, $p<0.01$, $r^2 = 0.663$] than participants in the implicit learning group. Therefore, the therapists successfully adhered to the treatment guidelines, and we can conclude that there was a true difference in the focus of attention derived from instructions and feedback according to treatment intervention.

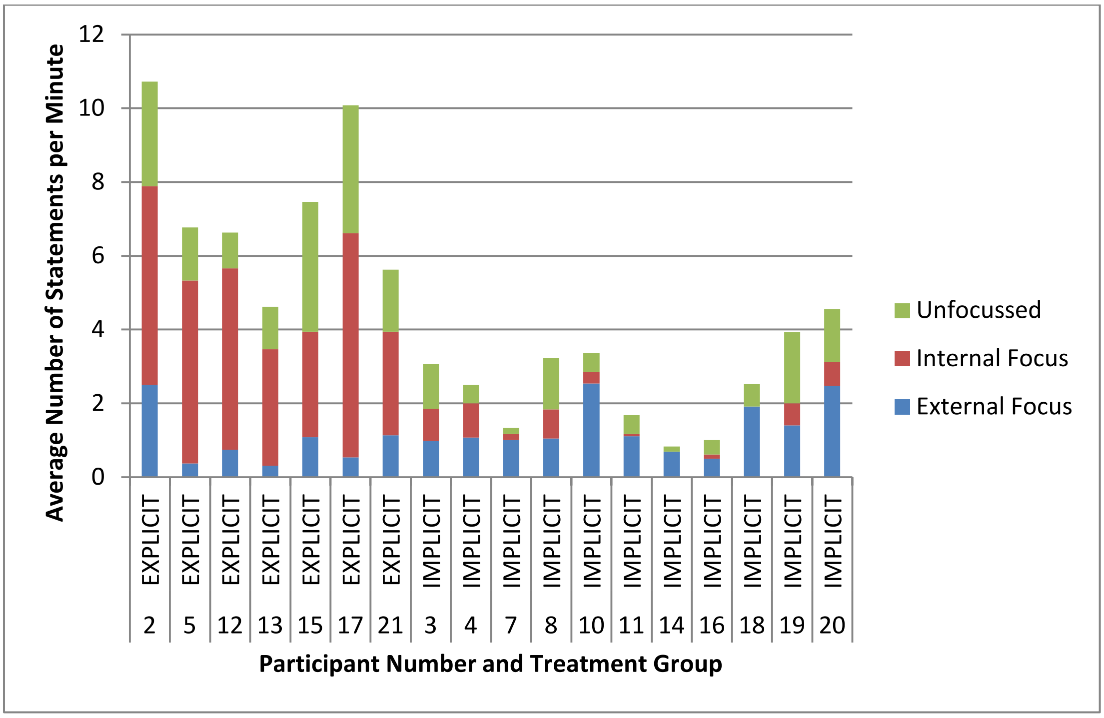


Figure 19 Average number of statements per participant according to focus
Participants in the explicit treatment group (left of graph) received significantly more statements overall and significantly more internally focussed statements, than those in the implicit learning group (right of graph).

5.13.1.4 Unfocussed Statements

The incidence of unfocussed statements was also compared in order to establish any difference between groups. Unfocussed statements were defined as simple prompts or motivational statements that did not elicit any focus of attention, such as *"and again"*, *"keep going", or "good".* It is feasible that in trying to reduce the overall quantity of communication for the implicit group, therapists reduced the use of such unfocussed statements. It was therefore important to consider this data.

Differences between groups were again analysed using the univariate linear regression model, controlling for length of treatment session and overall number of verbal statements. Analysis showed that the intervention group was not a predictor of the total number of unfocussed statements, and we can therefore conclude that there was no significant difference between groups [$F(2, 14) = 0.001$, $p< 0.798$, $r^2 = 0.684$].

	Was there a significant difference between the implicit and explicit treatment groups?
Number of statements per minute	Yes ($p<0.01$)
Number of internal focus statements per minute	Yes ($p< 0.05$)
Number of external focus statements per minute	Yes ($p<0.01$)
Number of unfocussed statements per minute	No ($p<0.798$)

Table 18 Summary of Findings
Summary of the statistical analysis demonstrating significant differences in the verbal communication received between groups.

5.13.2 Validation of the Data Analysis

Given that the analysis matrix underwent robust development and validation in the earlier phase of this research, further detailed validation was not deemed necessary at this stage.

However, in order to confirm that there was a true difference in the interventions provided to participants according to their group of randomisation, a simple method of validation was applied.

An independent assessor, who understood the nature of the study but had not been involved in delivering the interventions (and was therefore blind), was asked to view each of the recorded treatment sessions. She was asked to consider the content of the session, comparing it against the treatment guidelines that had been given to therapists (appendix 17). The independent assessor did not watch each video in its entirety, but was asked to view a self selected minimum of 10 minutes in which task practise was taking place. Once she felt that she had observed enough to be confident, she was then simply asked to state which treatment group she felt the patient was in. The independent assessor correctly identified the treatment group for 17 of the 18 videos (94%). She was incorrect for video 8, which should have been identified as implicit. Interestingly, of all of the videos in the implicit group, video 8 had the highest number of internally focussed statements. When compared to the averages across the implicit learning group as a whole, video 8 also had a higher than average number of statements per minute, a lower than average proportion of silent units. Therefore, whilst video 8 was more implicit than explicit overall, in comparison to the other videos, the bias towards implicit was less.

Table 19 Video 8 compared to overall averages for implicit learning

	Average statements/ min	**% silent units**	**Ratio of internal to external focus statements**
Video 8	3.73 ↑	13 ↑	0.75:1 ↑
All implicit learning videos	**2.24**	**21.96**	**0.41:1**

Breakdown of information for video 8, in which the blind assessor incorrectly identified the treatment session as explicit. ↑ = higher than average for the implicit learning group

Overall, the blind assessor demonstrated a high degree of accuracy in correctly identifying the treatment group based on viewing just a short sub-section of video; thus supporting the overall analysis and providing validity to the findings from the application of the analysis matrix.

5.13.3 Changes in therapists compliance over time

Consideration was given to whether the therapists improved their ability to comply with the treatment guidelines over time. This would provide useful insights to inform the training needs of therapists in any future trial. Consecutive data for each therapist was therefore examined to identify any changes in the delivery of each approach as the trial progressed. However, given the small sample size and therefore the relatively low number of patients treated by each therapist in each treatment group, it was not possible to identify any pattern. This would warrant consideration in any future trial.

5.13.4 Comparison between data from the observational study and the feasibility study

In the development phase of this research, routine physiotherapy practice was observed, and the content analysed using the same process that has been applied during this feasibility trial. The type of treatment session analysed during the development phase varied slightly from this current phase, in that the treatment sessions took place across a variety of settings (both inpatient and outpatient), and on the whole, patients were at a higher level of function than those recruited to this feasibility trial.

However, given that the observations made during the development stage of the research represent current physiotherapy practice, it is useful to consider whether they correlate in any way to those made during this feasibility study, in which therapists were attempting to deliver treatment using either an explicit or an implicit approach.

In the development study, eight physiotherapy treatment sessions were observed and analysed (Chapter 4). Three of these took place in an outpatient setting, with patients who were several months post stroke, and who were more mobile than those included in the current study. Given that therapists' approaches to delivering rehabilitation could be different with this (more chronic) cohort of patients, the data from these three was excluded from this part of the analysis. Data relating to the use of verbal statements/focus of attention for the remaining 5 patients was compared to those who took part in this current feasibility trial. The purpose of this analysis was to establish whether either of the treatment approaches applied during this current study was aligned with the "standard care" observed in the earlier phase.

In the development study, therapists were observed to deliver very high levels of instruction/feedback to patients. A linear regression model was used to compare the total number of statements delivered to patients in the observational study, to those delivered to each treatment group in the feasibility trial. There was no significant difference between the number of statements used in the observational and the explicit learning group [$p = 0.653$], but there was a significant difference between the observational study and the implicit learning group [$p = 0.00$]. If we consider the developmental study to be reflective of "standard care", then those in the explicit learning group were receiving an intervention that could be considered more akin to standard care than those in the implicit group.

Comparisons were also made regarding the focus of attention elicited from the verbal statements. When the explicit learning group were compared to the standard care data, no significant differences were found in numbers of internally or externally focussed statements [$p = 0.297$ and 0.283 respectively]. This would be expected if explicit learning was more closely aligned to standard care. When the implicit group were compared to the standard care data, there was a significant difference in the number of internal focussed statements used [$p = 0.020$] but no difference in the use of external focussed statements [$p = 0.934$].

This is important as it shows that in this feasibility trial, the explicit group did receive communication that could be considered representative of standard care, in terms of both the overall quantity of instructions and also their focus of attention. Importantly, it shows that in the explicit learning group, the use of instructions and feedback was not grossly exaggerated, beyond what could be considered as standard practice. It also demonstrates that the intervention delivered to those in the implicit group not only differed from that delivered to the explicit group, but also differed from standard care. The therapists had clearly managed to reduce the amount of verbal communication, and had done so primarily by reducing the amount of internally focussed statements. However, although therapists delivering the implicit approach had increased the use of external focus statements when compared to the explicit group (see 5.13.1.3), this was not significantly different to standard care.

Given that the explicit group received similar amounts and patterns of communication to the "standard care" observed in initial part of study, if may be justifiable for any future trial to compare implicit learning to a control group who receive standard care. Therefore, any further development of the interventional guidelines should focus primarily on further developing the implicit learning approach. Consideration needs to be given to the use of external focus statements, and whether further work needs to be done to enable therapists to better promote the use of an external focus when trying to promote explicit learning; or whether a reduction in the internal focus statements is sufficient to promote implicit learning.

5.13.5 Distribution of the conversation

The primary analysis focussed on the use of instruction and feedback *during* the practice of therapeutic activities. However, it is also useful to consider the conversation that took place between patient and therapist in-between activities; i.e. when the patient was resting. If therapists were found to communicate explicit information regarding performance during rest periods, then it could impact on the fidelity of the approaches overall.

The verbal dialogue that took place during periods of rest was transcribed verbatim, and transcripts were thematically analysed. A common set of topics during periods of rest were identified, and these are presented below. The periods of rest were all relatively short, lasting between 30 seconds and 3 minutes, and occurred infrequently. Therefore, there was only a small amount of data to be analysed. For this reason, it would be inappropriate to attempt to draw any firm conclusions relating to differences between the implicit and explicit groups. However, the themes and trends are described below.

5.13.5.1 General Social Conversation

The amount of social chat that took place was surprisingly low, with no differences across the groups. Some social conversation took place relating to being in hospital, for example about visiting times, the ward volunteers, or the exercise groups that the patient had attended.

In addition, there were a few occasions in which social conversation took place unrelated to the hospital environment, for example about the weather, holidays, or television programmes.

In both treatment groups, therapists used the rest periods to ask how the patient was feeling. This question was used to establish whether or not the patient felt tired, and whether they felt able to continue with more therapy.

There were no apparent differences between treatment groups with regards to social conversation.

5.13.5.2 Feedback – internally focussed

Feedback about the tasks that had been practised was given on a number of occasions to patients in both groups, although the incidence appeared higher for those in the implicit learning group. When feedback was given about the specific tasks that had been practised, it was always internally focussed feedback (knowledge of performance). It is therefore possible that therapists compromised the fidelity of the implicit approach by providing internally focussed feedback during rest periods. For example, the therapist treating Patient 8 (implicit group) gave feedback about the performance of sit to stand:

> *"It's the last little bit isn't it. You can lean forwards for the first bit, and then as you're getting there, you lean back"*

Internally focussed feedback was commonly given as an indication of overall progress, i.e. by the therapist stating that the patient has performed the task better than the day before. In these circumstances, the feedback was motivational in nature. For example, one therapist gave feedback following a stepping task (Patient 5 - implicit group):

> *"Your actually, getting your foot on the target was better today. Seemed to be a bit more accurate [than yesterday]"*

Whilst another gave feedback about sit to stand ability (Patient 3 – implicit group):

"Yes. Because you stood so much better, your sit to stand was so much better [than yesterday]. Aligned, you were straight. You got your balance so much better than yesterday. But we need to give you harder things to do!"

5.13.5.3 Comments on overall progress

Therapist also talked in more general terms about progress and overall recovery. Such comments are a form of feedback, but are not specific, and do not elicit any focus of attention. Again, it appeared that such comments appeared more frequently for patients in the implicit learning group. For example, *"it's hard work isn't it, but you are making improvements. You can do more than you did previously, it's just slow progress"* (Patient 20 – implicit).

5.13.5.4 Discussion about other impairments

Discussion about other stroke related impairments was common. For example, discussion relating to swallow, speech, dizziness, sleep, continence and pain all took place. The patient typically initiated these themselves. Discussions were brief and related either to the impact of these impairments on the individual, or the impact they were having on the physiotherapy that was taking place. There was no apparent difference between treatment groups in terms of the incidence of such discussions.

5.13.6 Content of the treatment sessions

Therapists used similar exercises and activities for patients in both treatment groups. Variation occurred in accordance with the differing levels of functional ability, but overall, similar tasks were employed. Typically, these included practise of sit to stand, weight transference work in standing, static and dynamic balance work in standing, variations of stepping onto/off a block, side stepping, and, for those that were able, mobilising.

There was no clear distinction between the implicit and explicit treatment groups in terms of how tasks were structured. The difference came primarily as a result in changes in communication (instruction and feedback) rather than task type or structure. This is perhaps not surprising, as the main focus of the training delivered to therapists centred on the quantity and focus of attention of instructions and feedback. However, it is likely that there is scope to further promote implicit processes by designing interventions in different ways. This is discussed further in Chapter 6.

5.13.6.1 Demonstration and visual modelling

The use of demonstration only occurred on a small number of occasions, with no apparent differences between treatment groups.

5.13.6.2 Therapeutic handling

Therapists used handling techniques frequently throughout all of the treatment sessions. As patients were typically at a low functional level, it was evident that the therapist regularly needed to be "hands on" in order to support the patient to move.

It was not possible to analyse the purpose or intention of the therapists handling from the videos alone, nor was this an intention of the study. For those in the explicit learning group, it was noted that when therapists were "hands on", this was generally accompanied by verbal input. Therefore, regardless of the nature of the handling, it was likely to be contaminated by other explicit influences. In the implicit group there was less concurrent verbal communication, which could feasibly allow the therapists handling to have a different purpose.

5.13.6.3 Non verbal instructions and feedback

Therapists occasionally used non verbal means of feedback, such as using a mirror for visual feedback. The frequency was low, with no clear differences between groups.

5.14 Qualitative Analysis - Results

5.14.1 Patient Interviews

Following the retention tests, participants in both groups underwent a short semi-structured interview in which they were asked to discuss: a) what they had been doing in their physiotherapy sessions for the past 3 days, and b) what, if anything, they were thinking about when they practised functional tasks during therapy (any rules, methods or techniques). The interview guide can be found in appendix 24.

Interview data is missing for two participants, who were discharged immediately after completing their final outcome measures, and before the researcher had an opportunity to conduct the interview. Therefore, interviews were conducted with 16 participants.

5.14.1.1 Identification of "Rules"

The term "rule" refers to a piece of explicit, declarative information about how to perform a task (Poolton et al., 2004). For example, participant 3 verbalised a rule relating to foot position, and participant 4 verbalised a rule relating to knee control.

"I have to look at my feet. Make sure they're the correct distance apart [before I stand]"

Participant 3

"[I have to think about] keeping my balance. And keeping this left leg, not rigid, but firm enough to support me. The left knee gives if you don't concentrate"

Participant 4

Interview transcripts were analysed in order to identify any internally focussed rules that patients reported using during the practice of functional activities. On the whole, patients had difficulty recalling the specific details of what they had been doing during their physiotherapy treatment sessions. Table 20 shows the number and nature of rules identified by each participant. The overall identification of specific rules was infrequent, and there was no apparent difference between treatment groups in terms of the number or type of rules reported. The most commonly reported rule related to maintaining stability of the hemiplegic leg during standing activities.

Table 20 Identification and Nature of Rules
The number and nature of rules identified by participants in the post intervention interviews.

Participant Number	Treatment Group	Number of Rules Identified in Interview	Nature of Rule
1	Explicit	Withdrew from study	
2	Explicit	1	Position of hands for sit to stand exercise.
3	Implicit	2	Position of feet prior to sit to stand Ensuring body weight is over hemiplegic leg in standing.

4	Implicit	2	Weight distribution in standing. Keeping the hemiplegic knee braced in standing.
5	Explicit	1	Keeping the hemiplegic knee braced in standing.
6	Explicit	2	Keeping the hemiplegic knee braced in standing. Tightening the buttocks in standing.
7	Implicit	2	Ensuring correct posture in standing. Keeping the hemiplegic knee braced in standing.
8	Implicit	0	
9	Explicit	Withdrew from study	
10	Implicit	1	Lifting the hemiplegic foot during stepping to stop it from dragging.
11	Implicit	1	Lifting the whole leg to clear the floor when stepping.
12	Explicit	1	Trying to get my leg to move.
13	Explicit	0	
14	Implicit	0	
15	Explicit	Withdrew from study	
16	Implicit	1	Trying to control the hemiplegic leg.
17	Explicit	0	
18	Implicit	0	
19	Implicit	Discharged before interview was done	
20	Implicit	0	
21	Explicit	Discharged before interview was done	

5.14.1.2 Patient Perceptions of the Implicit and Explicit Learning Approaches

Although the interviews were relatively short, and the level of patients' insight into the two treatment groups varied significantly, a few patients did make some interesting comments about the physiotherapy they had been receiving. These are not considered to be themes, as they did not occur frequently across the transcripts, but are reported here for interest. Any future study involving larger numbers should explore these issues further.

5.14.1.3 The benefits of an external focus of attention

Participants were asked if they noticed anything different about the therapy they had been receiving as part of the research, when compared to the physiotherapy they had already received prior to enrolling in the study. Whilst most could not identify any differences, Patient 3 perceived some clear benefits of the implicit learning approach. Although this example does contain some internally focussed rules relating to sit to stand, the patient felt that overall, the implicit approach made the activities he was practising easier to perform.

Patient 3 (Implicit Learning Group)

Researcher	***And did you notice anything different about the way that [your physio] was working with you this week?***
Participant 3	*Yeah, no offence to any of the other girls because, erm, they're all singing from the same hymn sheet….but I found her technique a lot easier.*
Researcher	***OK....***
Participant 3	*One of the other ones, I won't name who, because they're all good girls. But some of them are more technical. Whereas [the research physio] can cut down on the technicalities on certain exercises. Like, raising to stand, with [my research physio], it's just a matter of getting your feet in the right position, erm, vertical from the knee, hands on, and rise.*
Researcher	***And you found that makes it better?***
Participant 3	*Yeah – and that's it. And the big table you've got there – I could walk round the table both ways. Erm, but not so much of the technicality, more the practicality. Just get on and do it.*
Researcher	***That's interesting. And you found that made it a good approach - compared to what you've been used to?***
Participant 3	*Yeah, cos compared to, well it doesn't matter who – [this physio] has simplified everything. And cut out half of the*

technicalities. It was such a long winded affair [doing a transfer]. But [this physio] sort of halved the theory on it – which I find easier.......it's easier when you cut down the theory.

Patient 13, who was in the explicit Learning group, reported similar thoughts relating to walking.

Researcher ***And what are you concentrating on when you're doing those activities?***

Participant 13 *I am concentrating, but I realise, there's no good me doing it and watching my foot as I step – cos you don't do that normally. And when I look away, it's not easy, but it works better. Definitely.*

Researcher ***OK – so looking into the distance is better than focussing on your leg?***

Participant 13 *Yeah – you never watch yourself walking. If I'm concentrating on trying to walk it's not as good. I try to just do it. It's coming on.*

5.14.1.4 Patients describing a functional approach

Although there was no difference in how rules were reported between the two treatment groups, patients in the implicit group did tend to talk about the content of their sessions more broadly in functional terms, than those in the explicit learning group. For example, when asked what he had been working on during his treatment sessions, participant 10 (implicit learning group) replied:

Participant 10 *"Well, basically, they've been trying to get me to walk! So, they take me down in the chair. And there's a chair there. And she says, we're going to walk to there. But they hold onto me. I couldn't do it on my own. That's what we were doing this morning. And then, she had me in front of the table; get's me to stand up"*

Similarly, participant 18 gave a functional reply:

Participant 18 *"Mainly standing up, and walking across the table. 10 times! At least! And walking of course – going from each to chair, without a frame. You know – the transfer."*

Researcher ***And have you been focussing on anything in particular?***

Participant 18 *"Yes – getting to walk, is my main aim."*

Researcher ***"So when you're practising, you're thinking about your walking. Are you thinking about anything else whilst you're doing it?"***

Participant 18 *"No – just to get there, just to get on with walking properly."*

In contrast, participant 6, who was in the explicit learning group, described elements relating to how to perform the task (i.e. internal focus).

Researcher ***So...thinking about the standing and stepping activities you've done. When you've been doing those, what sort of things do you think about?***

Participant 6 *Concentrating on what I'm doing!*

Researcher ***In what way – what are you concentrating on?***

Participant 6 On what she [the physiotherapist] said, you know, to get it right. And get my knee straight, and try and stand up straight. And sit up straight.....

Researcher ***And with your standing in particular, what sorts of things was your therapist asking you to think about, or concentrate on?***

Participant 6 *I know she say's about the knee. Get the knee straight. I can't remember, there's been so much.*

5.14.1.5 Concentration and Intensity

A number of participants, from both treatment groups, identified the need for concentration. High levels of attention may impact on attentional capacity, This is, if the (previously automatic) task of walking required high levels of concentration, then the remaining capacity for processing information may be compromised. Examples are given below.

Participant 5 (Explicit Learning Group)

Researcher ***And when you're doing those sorts of exercises in your physiotherapy, what are you focussing on?***

Participant 5 *Concentration. You have to concentrate very hard on the simplest things. Whereas concentrating never [previously] came into it, into the equation, you just did it.*

Researcher ***Yes***

Participant 5 *And now I can't just do it, I have to think hard, and it was quite hard. And then we did, where I had to lift my left leg and put it on the square…cross. And sometimes, without looking down, you are disorientated. And you took larger steps, or wider steps, and didn't hit the target......And I found that very very difficult. It was the concentration between the left and right foot, it was like a treadmill, and yet it didn't happen.*

Patient 11 (Implicit Learning Group)

Researcher **_And what about when you're doing those activities [standing and stepping].... what are you thinking about?_**

Participant 11 *I'm concentrating. It's very easy to lose concentration. Even in the room where we go to [therapy gym]. All we need is for someone to walk past the window, and the concentration has gone.*

In addition, four participants described the therapy they had received as part of this research study as being more *"intensive"* or "*hard work",* when compared to their previous therapy. Three of these were in the explicit learning group. Whilst it is not possible to draw any significant conclusions from this finding given the small number of participants, it is an interesting and important consideration to be explored in any future trial, i.e. do patients undergoing an explicit learning approach perceive their therapy to be more intensive than those receiving an implicit learning approach, and what is the impact of this?

Participant 6 (Explicit Learning Group)

Researcher **_Have you noticed anything different about the way your physio was treating you in the last few days, compared to the physio you were having before? Was it different in any way?_**

Participant 6 *No –I don't think it was a lot different really. It was just intensive.*

Researcher **_OK. Within the session, it's more intensive? Or it's more intensive because you were having more sessions?_**

Participant 6 *Well, I think I had to concentrate more on doing it. So it was more intensive in the session.*

Participant 12 (Explicit Learning Group)

Researcher	***If you can think back, the physio you had last week, when compared to this week – does it seem any different?***
Participant 6	*Not sure. The physio I had in the beginning was relatively easy to achieve, whereas this last few days has been a little more challenging. And more tired.*
Researcher	***And more challenging in what way, would you say?***
Participant 6	*Well, it all felt a little bit harder, and therefore I was trying to concentrate more.*

5.14.2 Awareness of Treatment Group

At the end of the interview, participants were reminded of the explicit and implicit learning treatment groups, and were asked to state which one they felt they had been randomised to. This question was added to the interview guide from participant 3 onwards, so is not available for the first two participants.

Of the 15 participants who were asked this question, 47% (n=7) were able to correctly identify which treatment group they had been part of. Twenty percent of participants (n=3) were not able to state which group they felt they were in, even when pushed to do so. The remaining 33% (n=5) incorrectly identified their treatment group.

5.14.3 Physiotherapist Interviews

Two of the participating therapists were interviewed in order to gain insight into their experience of delivering the implicit and explicit treatment strategies, and to understand their thoughts on the relative benefits of each. The third therapist was not interviewed as she had retired by the time data collection was complete. Although this small sample size is not sufficient to allow for thematic analysis, the points raised by the two therapists were extremely similar. These are reported below.

5.14.3.1 Therapists' experience of delivering the two approaches.

Both therapists stated that they found the delivery of an implicit approach more challenging than an explicit one. Both considered the explicit approach to be in line with their *"natural approach"*, and therefore had little difficulty in delivering this as they did not perceive it to be different from standard care.

> *"I think really that traditionally as physio's, we do a lot of explicit learning anyway, that is kind of our natural approach, so that wasn't too difficult, because it wasn't really deviating away from what I normally do"* Therapist C

The therapists were asked why they felt that physiotherapy practice naturally tended towards an explicit approach. Both felt that this was learnt from seniors and peers, and was embedded in practice without any clear or evidence based rationale. Therapist B felt that it stemmed from her undergraduate training, where she was encouraged to give positive feedback and positive reinforcement to patients, and that although this was never described in relation to explicit learning; it has resulted in a more explicit approach. Therapist C didn't know where the tendency for an explicit approach came from, but felt that it is probably picked up from senior colleagues throughout therapists' early career, and then "*it becomes habit*".

Conversely, both therapists found the delivery of an implicit approach notably more challenging. For therapist B, this was primarily related to the need to reduce her verbal communication, which she found *"really hard*", reporting that there were occasions when long periods of silence felt "*unnatural*" or "*awkward*". Therapist C reported similar challenges, but stated that it was not just with regard to reducing the quantity of information, but also in *"trying to make tasks more function based"*, and designing treatment interventions in a creative way that would promote implicit learning. Both therapists also noted that it was more difficult to find ways to progress exercises for patients in the implicit group, and that this required more "*creativity*" and "*planning*".

5.14.3.2 How patients responded to the two approaches.

Neither therapist reported any particular differences in how patients responded to the two approaches, either in terms of carryover, or other aspects such as motivation. This was probably due, in part, to the short intervention length applied during this study.

Whilst both therapists felt that both implicit and explicit approaches were valid, they indicated that certain patients may respond differently and therefore the choice of approach should be based on the patient's clinical presentation. Therapist B also felt that the patient's own preference with regards to learning styles may be important, saying that some patients preferred to have regular instructions and feedback, whilst others were more comfortable with less communication.

Both therapists identified that the delivery of an implicit approach was more difficult in patients who had a degree of cognitive impairment. They felt that such patients required clear and specific prompts in order to perform activities safely, and that this was more effective when an explicit approach was used.

In terms of level of functional ability, Therapist C found it easier to deliver the implicit learning approach to patients who were more able, as it was then easier to practice whole tasks in a functional and implicit way. For patients who were functioning at a lower level, she felt that it was sometimes necessary to break tasks down into their component parts, and that maintaining an implicit approach was then more challenging. Therapist B however, felt that tasks at any level could be adapted to be more implicit; although she stated this it may require more thought for those at a lower level of function.

5.14.3.3 Clarity of the approaches

Overall, the therapists felt that there was a clear distinction between the explicit and implicit approaches, and felt that there were no specific issues relating to the difference between the two that made either difficult to deliver. They found the training useful, particularly as it gave them a good understanding of the concepts of explicit and implicit learning, which acted as a foundation for the delivery of the approaches. They did not identify any aspects of the treatment guidance that required clarification.

5.14.3.4 Application of learning models over a longer time period

Both therapists felt that maintaining an implicit approach over a longer time period may be challenging, particularly with regards progressing an individual's treatment programme whilst maintaining the implicit approach. Therefore, the development of some specific treatment examples (or a reference guide) for patients at different levels of function was highlighted as a potential way to support the delivery of implicit learning in a larger research trial.

Whilst maintaining the implicit approach for an individual patient was thought to be challenging, Therapist B also recognised that delivering implicit learning more often would be useful to embed the approach.

> *"We were doing it quite infrequently, and you would have to go into a treatment session and think, right, I have to completely change my approach now. But if you were doing it more frequently it would become more natural".* Therapist B

Overall, it was felt that increased exposure to the delivery of implicit learning, alongside a supporting guide to give practical examples, would enable to successful delivery of implicit learning over time. Both therapists felt that the guidance would be easily transferable to other areas of clinical practice, such as upper limb rehabilitation.

5.15 Outcome Data - Results

Comparison between groups in terms of outcome was not a primary objective of this study, and therefore outcome data was not compared with statistical analysis. However, each of the outcome measures has been evaluated, and findings reported using descriptive statistics.

5.15.1 Berg Balance Score

Berg Balance Scores were recorded for all participants at baseline and at follow up. The average BBS at baseline was 12.29 out of a possible 56 (range 2-25; σ = 8.24), with similarities between groups (implicit group, $\bar{x} = 12$, σ = 7.66; explicit group, $\bar{x}$ = 13.6, σ = 9.28).

Eighteen participants demonstrated an improvement in BBS during the course of the study. Two participants (one in each treatment group) showed no change in BBS, both of whom had very low scores at baseline (4/56). One participant in the explicit learning group showed a small reduction in BBS, from 20 to 18/56. On average, those in the explicit learning group improved by 5.2 points, and those in the implicit learning group by 8.5 points. Whilst the difference between groups was not analysed, there appeared to be a trend towards marginally better improvements in BBS for those in the implicit learning group. Figure 20 shows the difference in BBS between baseline and follow up for each individual participant; and Figure 21 shows the change in BBS for each matched pair.

The Berg Balance Score was clearly a responsive and appropriate measure with this patient group, even over the short intervention period.

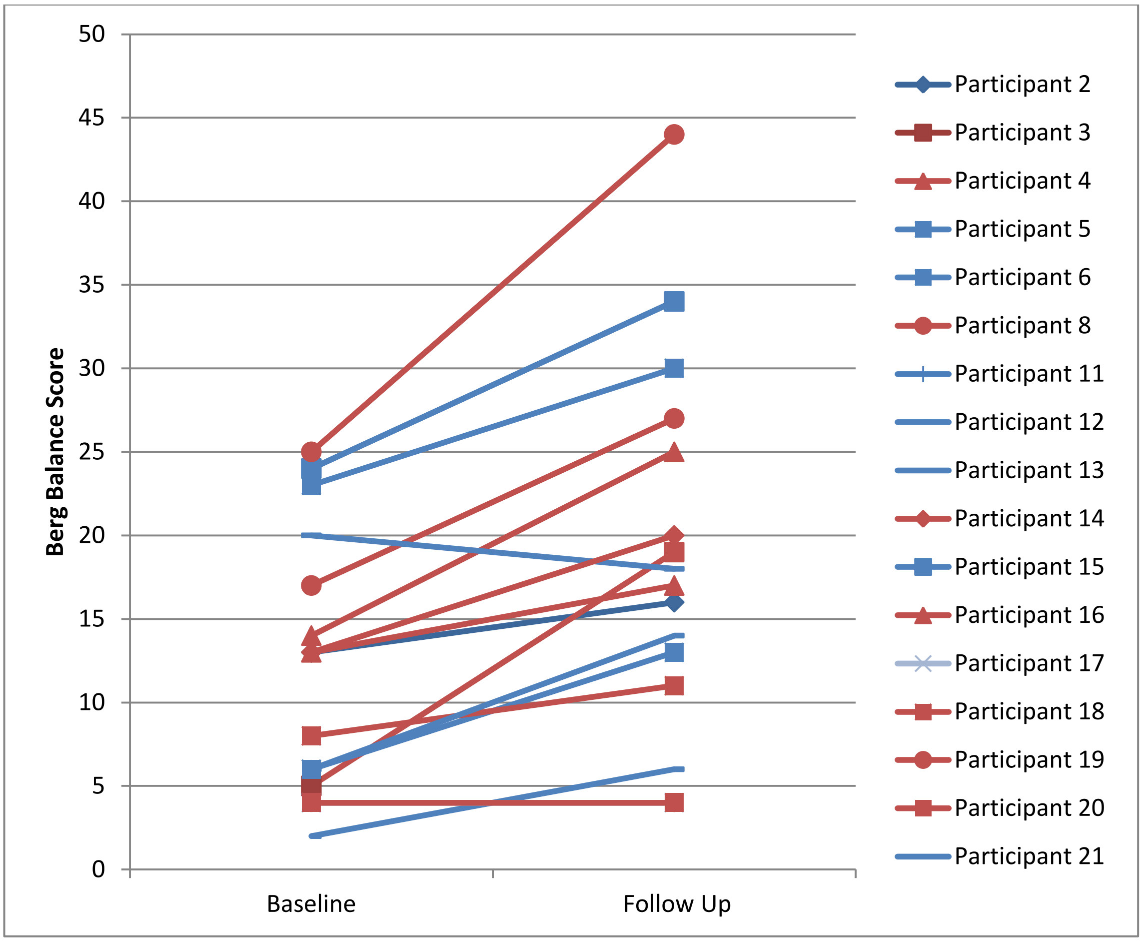


Figure 20 Changes in Berg Balance Score
Differences in BBS between baseline and follow up for each individual participant (for whom this information is available). **Red = IMPLICIT LEARNING GROUP**; **Blue = EXPLICIT LEARNING GROUP**

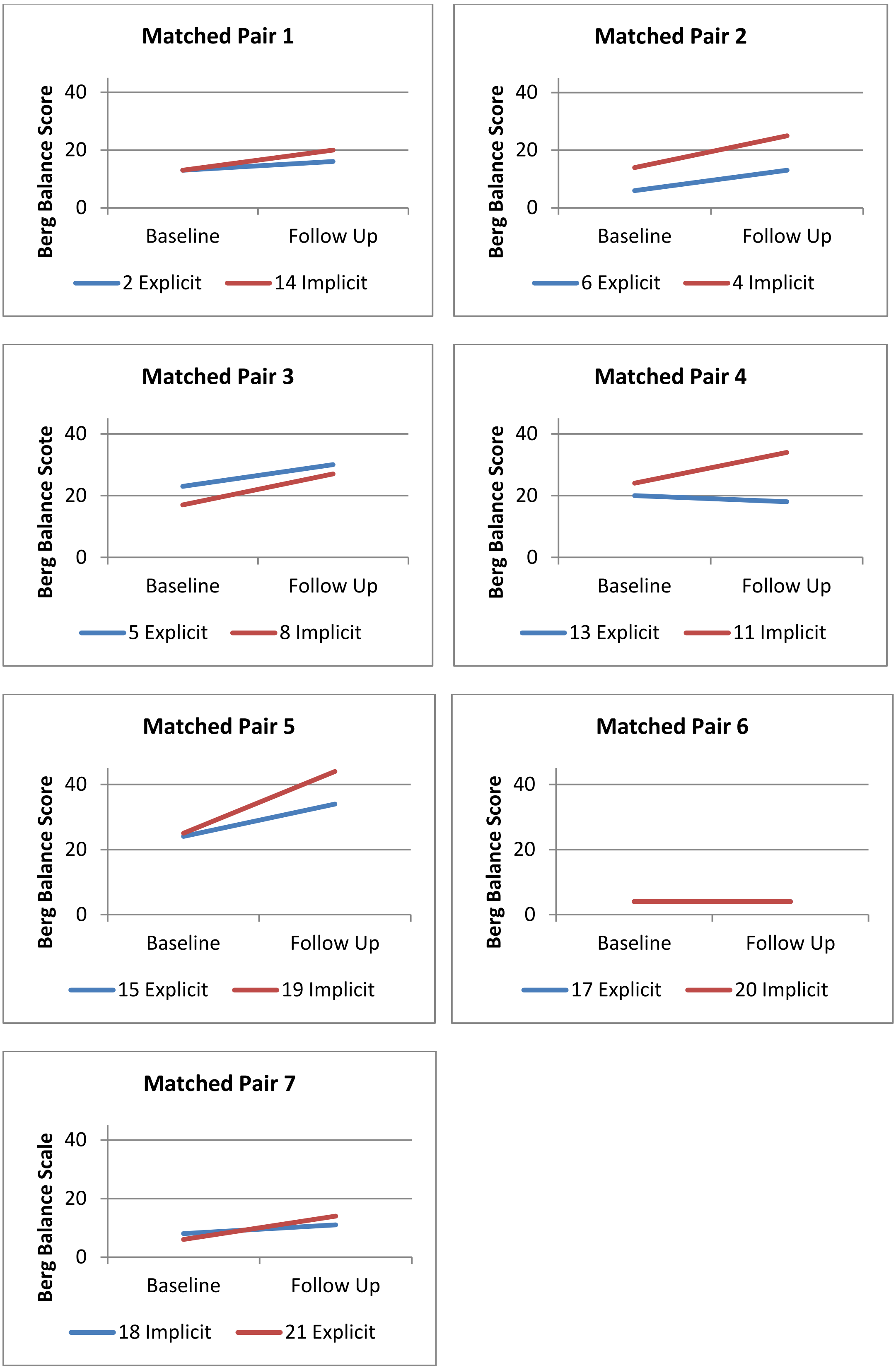


Figure 21 Changes in BBS for each patient pair

Changes in Berg Balance Score between baseline and follow up for each matched patient pair.

5.15.2 Hauser Ambulation Index

Hauser Ambulation Index scores were recorded at baseline and at follow up for each participant. Average HAI score at baseline was 7.7 for the explicit learning group, and 8.1 for the implicit learning group (note that a lower score indicates a better level of function). At follow up, average HAI scores were 6.4 and 6.5 for the explicit and implicit groups respectively. On average, participants in the explicit group improved by 1.2 points, and those in the implicit group by 1.6 points. Improvements in HAI scores were therefore similar between groups. Nine of the 17 participants who had the HAI recorded at both baseline and at follow up did not show any change in their score over the period of the research. It was therefore concluded that the HAI was not sensitive enough to change in this early patient group, particularly over a short intervention period. The HAI may be a useful measure in a future study where intervention is provided over a longer period of time, however, it should be noted that five of the 9 patients who showed no change in HAI scored the lowest possible score of 9, therefore there may also have been a floor effect.

5.15.3 Numerical Rating Scale

Patients were asked to rate their confidence pre and post treatment using a standard question, and an 11 point numerical rating scale.

> *"on a scale of 0 to 10, where 0 equals not at all confident and 10 equals fully confident, how confident do you feel about the way in which you are standing and stepping at the moment?"*

Average NRS score at baseline was 5.5 for the explicit group, and 4.9 for the implicit group. At follow up, average NRS scores were 6.9 and 5.3 for the explicit and implicit groups respectively. On average, participants in the explicit group improved by 1.39 points, and those in the implicit group by only 0.44 points. On the whole, participants had difficulty rating their confidence on the NRS, and it may have been too abstract for patients to use as a measure of confidence. In future research, the use of a more structured patient reported outcome measure (PROM) should be considered. Equally, more meaningful insights into patient confidence may be sought though semi-structured interviews. The limitations of the NRS are discussed later in this chapter.

5.16 Excluded Outcome Measures

Three of the outcome measures proposed in the original plan were excluded from any analysis as they had significant floor effects in this treatment group. These measures are discussed below.

5.16.1 Step Test

The standardised protocol for the Step Test requires individuals to independently step up and down onto a small block as many times as they can in 15 seconds. Physical assistance cannot be given. No participants were able to independently perform the step test at baseline (for either hemiplegic or non-hemiplegic leg), and only 1 was able to achieve this at follow up. This floor effect therefore rendered the Step Test ineffective for this patient group, and data for this measure was not analysed.

5.16.2 2 minute walk

The 2 minute walk requires individuals to mobilise as far as possible around a marked circuit (+/- walking aid) in 2 minutes. Number of steps and distance walked are recorded. Participants could be given standby assistance, but no physical help, and could rest as frequently as required. Again, no participants were able to mobilise without assistance at baseline; and only two participants were able to mobilise independently at follow up (one each for explicit and implicit learning). As a result of this floor effect, data for the 2 minute walk was not analysed.

5.16.3 Wisconsin Gait Scale

The original proposal included the Wisconsin Gait Scale (WGS) in the battery of outcome measures. This is an observational gait analysis tool that examines 14 observable variables related to hemiplegic gait deviations (Rodriquez et al., 1996). It was included in the original proposal to give an indication of changes in gait *quality.* However, since the number of patients who were able to mobilise was so low, it was not feasible to apply the WGS. It was therefore not performed for any patient involved in the trial.

It may be useful to re-visit the use of an observational gait tool in any future trial if the functional level of participants is higher, or the duration of intervention is longer (such that more patients are mobile at follow up).

5.17 Sample Size Calculation

Data from the feasibility trial was used to estimate the required sample size for an appropriately powered Phase II trial. As the Berg Balance Scale was clearly the most responsive outcome measure in this patient group, the sample size calculation was based on BBS data from the feasibility trial. It is estimated that **87 participants** will be required to detect a minimal difference between groups of 6 points on the Berg Balance Scale, with 90% power and significance set at 0.05. This section provides details regarding the sample size calculation, which is based on the Phase II trial being:

- A randomised controlled trial, in which participants are randomised to either an implicit or a control (explicit) group
- Conducted in the sub acute phase post stroke, with participants being recruited at the earliest opportunity (as soon as they are able to stand with assistance), and who remain recruited until the point at which they are discharged from hospital (and who therefore receive all of their gait rehabilitation in line with the group of randomisation)
- Evaluated using the BBS as a primary outcome measure, conducted at baseline (point of recruitment), and with the primary end point being discharge from hospital.

Summary data relating to the follow up BBS scores in the feasibility trial (Fup.BBS) is given in Table 21 below.

Descriptive Statistics

	Mean	Std. Deviation	N
Baseline.BBS	12.29	8.241	21
Fup.BBS	19.76	11.306	17

Table 21 Summary Data - Follow Up Berg Balance Scores

5.17.1 Minimal Detectable Difference

In order to perform the sample size calculation, a figure for the minimal detectable difference in BBS is required. This is described as the smallest difference between means that the study would wish to detect; i.e. a difference between intervention groups that is clinically meaningful. As there is no published literature that can be used for guidance, the minimal detectable difference is based on clinical judgement. As the study will be delivering rehabilitation in the early inpatient phase post stroke, with the primary end point being discharge from hospital, it was felt that an average difference of **6 points** on the BBS would be a clinically worthwhile difference, and the minimal detectable difference was therefore set at this figure.

5.17.2 Pooled Standard Deviation

Pooled standard deviation for Berg Balance Scores for the implicit and explicit learning groups at follow up (based on data from the feasibility trial) was calculated to be 11.35 (appendix 28).

This was calculated using the formula:

$$s^2_p = \frac{(n_1 - 1)s^2_1 + (n_2 - 1)s^2_2}{n_1 + n_2 - k}$$

where s^2_p is the pooled standard deviation, n_i is the sample size of the *i*th sample, s^2_i is the standard deviation of the *i*th sample, and *k* is the number of samples being combined.

5.17.3 Standard Sample Size Calculation

Using this standard deviation, the required sample size to identify a minimally detectable difference of 6 points on the Berg Balance Scale was calculated as 154 (90% power, 0.05 significance) (http://hedwig.mgh.harvard.edu/sample_size/js/js_parallel_quant.html; accessed 12.8.2013). (appendix 28)

5.17.4 Accounting for correlation

As the final study will use ANCOVA for analysis, the sample size calculation also needs to take into account the correlation between baseline and follow up Berg Balance Scores (using BBS end scores as outcome, and the treatment groups and baseline BBS as covariates). This was calculated using the formula:

$$n = \text{sample size}*(1-r^2)$$

where *n* is the required sample size, and *r* is the correlation between baseline and follow up Berg Balance Scores.

The correlation between baseline and follow up scores in the feasibility trial was calculated using Pearson's Correlation as 0.9 (Table 22). This high level of correlation is not surprising given that the intervention in the feasibility trial was only delivered over a period of three days. Therefore, the baseline and follow up measures were taken relatively closely together.

Correlations

		Baseline.BBS	Fup.BBS
Baseline.BBS	Pearson Correlation	1	.900**
	Sig. (2-tailed)		.000
	N	21	17
Fup.BBS	Pearson Correlation	.900**	1
	Sig. (2-tailed)	.000	
	N	17	17

**. Correlation is significant at the 0.01 level (2-tailed).

Table 22 Correlation between baseline and follow up Berg Balance Scores

Using a correlation of 0.9 and the equation given above, the required sample size for a definitive trial would be 29 participants.

However, the correlation between start and end scores in the feasibility study is an *estimate* of the true correlation; hence there is some uncertainty around this. Furthermore, in the definitive trial, the interventions will be provided over a longer time period. It is intended that recruitment would take place as soon as a patient is able to stand, and involvement will continue to the point of discharge. The correlation between baseline and follow up Berg Balance Scores is therefore likely to be lower than the estimate made using data from this feasibility trial. One previous paper has reported the BBS to be moderately responsive in the sub-acute stroke population with an effect size of 0.66 between 2 to 6 weeks post stroke (Wood-Dauphinee et al., 1997). This was judged to be a more appropriate value for estimated correlation in the main study as the population and timeframe is similar to that which will be under investigation. **Using a correlation value of 0.66, the sample size required to detect a minimal difference of 6 points on the BBS, with a significance of 0.05 and 90% power, is 87 participants.** This value was felt to be more realistic in terms of detecting differences in this patient group, and will therefore be the value applied for the future trial.

5.18 LIMITATIONS

5.18.1 Matched Pairs Design

The matched pairs design was chosen in order to minimise the effect of confounding variables. This was considered important when initially designing the trial, as variability within the target population was likely to be large. Therefore, a matched pairs design was chosen to ensure that randomisation resulted in balanced intervention groups. Although no analysis of outcome was intended, this ensured that the feasibility of delivering the two interventions was tested with two similar cohorts of patient. Three criteria were chosen, as these were judged to be most important within the context of this trial. Each criteria was given a degree of flexibility to ensure that matching pairs was feasible; however, these figures were arbitrary, and based on clinical judgement rather than any objective data. For example, participants were matched if they were within 10 years of each other's age, and within 8 points on the Berg Balance Scale. The matched pairs design cannot account for every confounding variable, and is therefore limited in this regard. It is possible that other criteria may be important, such as gender or pre-morbid level of function, although it was felt that such factors would have limited influence on the delivery of implicit and explicit leaning (although they may impact on outcome).

Equally, a matched pairs design does not provide true randomisation, as only one of the pair is randomised. Importantly, in the current study, all eligible patients were recruited and although only 14 were "matched" (7 pairs), data from all participants was included in the analysis. Therefore, the use of a matched pairs design did not create bias in terms of patient selection (i.e. no one was excluded because they did not match another patient's criterion).

However, it is recommended that in the Phase II trial, all participants are randomly allocated to a treatment group at the point of recruitment. As the sample size will be larger, simple randomisation should be sufficient to ensure that groups are equal at baseline in terms of patient characteristics. Regression analysis can then be used to account for confounding variables when analysing for differences in outcome.

5.18.2 Sample Size

The feasibility trial did not intend to determine any differences in outcome between treatment groups, and was not powered to do so. The main purpose was to determine the ability of the therapists to deliver the interventions in line with the explicit and implicit guidance. The analysis of video data took place iteratively, with the intention that the treatment guidelines could be continually revised and the support and training given to therapists could be tailored in order to ensure that fidelity was achieved. In reality, compliance with the guidelines was good from the outset, and it was not necessary for the researcher to intervene in this way. Therefore, the patient sample size was sufficient to test the application of the guidelines and to conclude that the therapists were able to apply them in clinical practice.

However, given that the number of therapists involved in the study was small (n=3), it is not possible to conclude that this ability to comply with the treatment guidelines would be generalisable – i.e. easily translated to a larger group of therapists from the wider population. The three therapists involved in this study were from a single site; by chance, they may have been particularly good at altering their verbal communication in line with the treatment guidance. Other therapists may find this more challenging, particularly if their natural tendency is to be particularly explicit. This could have important implications for a larger, multicentre trial. A concurrent monitoring approach would therefore be necessary to ensure that compliance with the treatment guidance is maintained in any Phase II trial.

5.18.3 Length of Intervention

Participants in this study received only a short period of intervention – lasting three days. This length of intervention was within the confines of a PhD, and would not be the chosen length of intervention in a definitive study. As the primary purpose was to assess the behaviours of the therapists, the study was not intended to demonstrate any differences in outcome. Therefore, three days of intervention was sufficient to determine the therapist's initial ability to comply with each set of treatment guidance. However, understanding of therapists' compliance is limited to this short time frame, and we cannot predict how well therapists would manage to comply with the treatment guidelines if they were applied over a longer period. It is possible that a longer time period would allow therapists more opportunity become familiar with the guidelines, resulting in better or maintained compliance. Conversely, it is possible that a longer period of time would challenge individual therapist's ability to maintain an implicit approach, and that in these circumstances they may revert to their usual practice. Equally, if therapists were expected to deliver both implicit and explicit approaches to patients, according to their group of randomisation, but over a longer time period, it is possible that the difference between the two becomes less distinct. It may also be challenging for a single therapist to have two participants enrolled at the same time, if they were in different treatment groups. These issues should be considered in the design of the Phase II trial, and monitored to ensure that the delivery of implicit learning remains true to the guidance throughout a longer intervention period.

5.18.4 Contamination

Of equal importance is the issue of contamination. As only specific treatment sessions were changed (i.e. those for gait rehabilitation), it is likely that patients in both groups would have got explicit cues from elsewhere, e.g. a session with the occupational therapist or from nursing staff. Whether or not these cues existed, and whether the patient carried these over into their treatment sessions with the physiotherapists would be difficult to assess. It was hoped that the post intervention interviews with patients would provide some insight into this; however these interviews gave little specific detail relating to patients behaviours or thought processes. It is not possible to say whether this means that patients did not received such additional cues, whether they received them but did not act on them, or whether they did act on such cues subconsciously.

Contamination may have also occurred prior to recruitment and randomisation to the feasibility trial. In all cases, participants would have received some input from therapists before being recruited to the trial. For example, physiotherapy assessments may have highlighted certain deficits to patients in an explicit way, and previous treatment sessions were likely to follow explicit approaches as this is now known to be “standard” care. Participants were recruited as early as possible to account for this, but were still an average of 19 days post stroke. Therefore, there would invariably have been some contamination, and this may affect the purity of the implicit approach. It is not possible to say how important this is, but requires consideration when designing any future trial. However, given the difficulty that patient had in recalling specific details relating to their rehabilitation, we can tentatively assume that there was no considerable contamination.

5.18.5 Positive Reinforcement from the Chief Investigator

Therapist’s ability to deliver the treatment interventions as per protocol was found to be high, even though the amount of formal training and support that they received was relatively low. The Chief Investigator was a senior therapist working at the study site throughout the duration of the study. Whilst they did not intervene in any way with the delivery of therapy, the presence of the CI and her position relative to the therapists involved in the trial may have inadvertently contributed to their high levels of compliance, i.e. the therapists may have been particularly motivated to demonstrate their ability to adhere to the treatment guidelines in order to satisfy a senior colleague. Whilst this is not a direct limitation, it needs to be considered and standardised in any future multicentre trial, where the Chief Investigator may have a more distant relationship with each study site.

5.18.6 Use of Video Recording

Video recording was used to examine each therapist's compliance with the treatment guidelines. One treatment session for each patient was recorded. In order to minimise any observer effect, the physiotherapist was given the video equipment and was asked to set this up themselves to record their session. The researcher did not therefore intervene at all during these sessions, and would not have been present, even at the beginning/end.

Despite these attempts to minimise observer effect, it is feasible that therapists changed their behaviour more significantly when they knew they were being recorded, and failed to change their approach during the other two treatment sessions. The only way to account for this would have been to video record all three treatment sessions, but this would have resulted in an unmanageable quantity of video data requiring analysis. Video recording one session was therefore chosen as the most practical and efficient method to monitor physiotherapists compliance. In retrospect, this limitation could have been minimised by recording all three sessions, but retrospectively and randomly selecting one for analysis.

In any future study, in which the intervention may be delivered over a longer period of time, consideration will need to be given to monitoring physiotherapist compliance effectively. This may involve repeated episodes of recording, with sessions selected at random, and with minimum notice given to participants (i.e. consent for the video recording gained immediately prior to the treatment session commencing). In addition, the number of sessions recorded could be grossly over sampled, and then only a smaller sample actually included in the analysis (selected randomly post-intervention).

Video recordings of the treatment sessions were analysed using the matrix developed in Phase 1 of this research. The robust process of developing this matrix gives validity and reliability to the assessment process. However, the recordings were only analysed by one researcher (the Chief Investigator), creating a source of potential bias. Due to the depth of analysis required, and the time consuming nature of this, it was not feasible for every video to be analysed by an independent blinded researcher. However, to provide a level of impartiality to the process, every video was observed by an independent and blind researcher. They were not asked to use the matrix to record individual observed behaviours from the video, but were asked simply to state whether they felt the session they were observing fitted with an implicit or an explicit treatment approach. The independent assessor was correct 94% of the time, indicating fidelity with the treatment guidelines and supporting the findings from the more detailed analysis.

5.19 DISCUSSION

This phase of the research has demonstrated that it is feasible, with a relatively small amount of training, for physiotherapists to alter their communication practices in order to create bias towards either an explicit or implicit approach during early gait rehabilitation post stroke. Content analysis of the treatment sessions delivered during the feasibility trial demonstrated statistically significant differences in both the quantity of verbal statements, and the focus of such statements, dependent on group of randomisation. There was also a notable difference between groups with regards to the amount of silence during task practice. Thus, we can conclude that there was a true difference in the nature of the intervention delivered to each treatment group.

The interventions tested in this phase arose from the observation of therapy treatment, and were therefore grounded within clinical practice, ensuring clinical relevance. Delivery of the explicit and implicit approaches was found to be acceptable to both patients and therapists. No adverse events were reported.

Broad criteria were used for patient inclusion into this feasibility study, therefore testing the delivery of implicit and explicit approaches with individuals that were representative of the acute stroke unit population. Despite these broad criteria, explicit and implicit learning approaches were successfully applied across the sample population; demonstrating the potential for such approaches to be utilised in routine clinical care. Patients were successfully recruited and dropout rates were low.

As this was a feasibility trial, it did not intend to analyse the relative benefits of an explicit versus an implicit approach in terms of functional outcome. However, measurement at baseline and follow up has allowed the protocol as a whole to be tested and the usefulness of the chosen outcome measures to be evaluated. It has also provided data to allow the sample size for an appropriately powered Phase II trial to be calculated.

5.19.1 Assumptions about explicit and implicit learning

One particular challenge in this field of research is the difficulty with actually measuring explicit and implicit learning. In view of this challenge, a number of assumptions are made about the impact that the different practice conditions applied during this study may have on the processes underlying learning.

5.19.1.1 Assumptions about explicit learning

One of the primary characteristics of explicit learning is that it takes place in the presence of factual knowledge about the task being practised. Facilitating learning through the delivery of internally focussed instructions was therefore assumed to promote explicit processes, a view that is supported by a recent Delphi study (Kleynen, 2013). However, we need to consider whether providing proportionally higher frequencies of instruction and feedback in itself promotes explicit learning. One could argue that it is not simply the delivery of explicit information that is important, but what the learner does with this information, i.e. how it is processed. Impairments in memory, attention, information processing and/or language may impact the way in which the learner can use and respond to explicit information; and how transferable the findings from healthy populations are to the stroke population is therefore unknown.

In this feasibility trial, post intervention interviews demonstrated that the patients had limited ability to generate verbal knowledge of their own movement performance, the possible reasons for which are discussed in 6.18.4 below. It is therefore difficult to fully conclude whether or not individuals in the explicit group were entirely attuned to the explicit information they were receiving. However, even if participants were not consistently attempting to act on the explicit information, it is possible that even the background “noise” created by the frequent delivery of instruction impacts on attention, regardless of the individual’s processing ability. Evaluating the impact of quantity of instructions compared to their focus of attention may warrant further exploration in the Phase II trial; it is possible that in patients with cognitive or language deficits, the focus of attention is less important, and overall quantity (and therefore attentional capacity) has a greater impact on performance.

5.19.1.2 Assumptions about implicit learning

In contrast, the primary characteristic of implicit learning is that skill acquisition takes place without the concurrent acquisition of (verbalisable) knowledge about the performance of that skill (Maxwell et al., 2000). In the current study, therapists were asked to promote implicit learning by reducing the amount of verbal instruction and promoting the use of an external focus of attention. Although there was a significant difference *between treatment groups* in terms of both of these factors, the use of an external focus of attention for the implicit group was relatively low, and was not statistically different from that observed in *standard care.* The low frequency of externally focussed statements will, in part, be a result of the therapists' attempts to simply reduce the overall quantity of instructions provided to this treatment group (which is a limitation of changing two aspects of communication – quantity and focus). It was apparent in the feasibility study that therapists had difficulty finding ways to facilitate movement implicitly, or to generate an external focus of attention. This is perhaps not surprising, given that explicit learning is more synonymous with standard practice, and creating implicit learning therefore required therapists to change their behaviour. However, studies in healthy populations have shown that external focus instructions are more effective than no instructions at all, leading to the conclusion that an external focus may actually enhance learning (Wulf et al., 1998, Ford et al., 2005, Koedijker et al., 2011), and is therefore an important consideration.

Given these challenges, it could be argued that therapists in this feasibility trial created bias towards implicit learning by making treatment sessions less explicit – i.e. by taking away the high quantities of verbal instruction and internal focus, but not necessarily by adding anything that would specifically promote implicit learning. One must consider whether, by doing so, the session automatically becomes more implicit – i.e. can implicit learning be promoted simply by reducing explicit information, or does anything else relating to the practice conditions also need to be changed? Given the challenges with objectively measuring explicit and implicit learning, this would be difficult to evaluate. However, we can conclude that patients in the implicit group had greater opportunity to practise activities during therapy without concurrent verbal communication from the therapist; as indicated by the differences in number of "silent units". We can also conclude that patients in the implicit group received fewer overall statements of instruction/feedback, and that the balance between an internal and external focus of attention was tipped in favour of being external. It is therefore likely that unconscious processes for learning were promoted more in the implicit group, when compared to the explicit group, even if the learning did not take place entirely implicitly. In the reality of clinical practice, which is inevitably complex and varied, shifting the bias away from explicit learning is deemed to be sufficient and feasible for comparison in a future trial.

5.19.2 Fidelity of the Implicit and Explicit Approaches

The delivery of interventions as part of this initial feasibility trial was pragmatic. Thus, therapists were given guidance on how to create bias towards implicit or explicit learning, but were not asked to adhere to standardised treatment protocols. This approach ensured that therapy was delivered in line with the individual patient's impairments and functional limitations; respecting the professional judgement of the therapist. The explicit and implicit learning approaches were therefore subject to variation. Whilst a degree of variation was deemed acceptable and therefore tolerated, in order to detect any differences in outcome, it is also important to ensure that there is clear separation between the two interventions. Comparison of the communication delivered to each group (using the validated analysis matrix) demonstrated a statistically significant difference in the overall number of verbal statements, and also in their focus of attention. However, there was a degree of variance within these groups. Therefore, internal validity may have been created at the sacrifice of some external validity. It will be important to continue to monitor fidelity of the interventions in the Phase II trial, particularly as there will be a larger pool of therapists (hence more variability) who will have a more distant relationship with the research team. The therapists will also be required to deliver interventions over a longer time period, and the therapist's compliance with the two approaches may potentially become compromised.

Analysis of the conversation that took place during rest periods highlighted a potential difference in the distribution of the conversation across the two groups. Whilst overall compliance with the implicit treatment guidelines during the practice of tasks was good, there was some indication that therapists were more likely to give internally focussed feedback during periods of rest to those in the implicit group, compared to the explicit group; potentially because they were making a conscious effort not to do so during task practice. The overall amount of conversation taking place at rest was so small, that the importance for learning may be insignificant and any conclusions should be drawn tentatively. However, if this did represent a true difference, then it may have an impact on the fidelity of the treatment approaches being compared. It would therefore require monitoring and potentially further education of the therapists in any future trial.

5.19.3 Patient Perceptions

The participant interviews did not give huge insights into the benefits of an explicit or implicit learning model from the patient's perspective. It was anticipated that when compared to the implicit learning group, those in the explicit learning group would report a higher number of rules if their treatment had indeed been more explicit. This was not the case. As there was no clear difference in the reporting of explicit rules, the interviews did not provide data that could contribute to the validation of the two treatment approaches in this way. There are several potential explanations for this. The patients in this study were in the very early stages of rehabilitation, and therefore did not have a "norm" against which to compare their experience. They would have also been a great deal happening in terms of their overall medical care, as well as their rehabilitation. Early gait rehabilitation forms just one small element of this, and the physiotherapist would be just one of many members of the multidisciplinary team who they would have come into contact with over the week. Therefore, participants would have been receiving multiple sources of information about their care and rehabilitation, potentially making it difficult to recall information that was specifically relevant to this interview. This may have been particularly challenging for those who presented with cognitive and/or language impairments.

Participants typically had difficulty recalling the details of what they had been working on in their therapy sessions; many needed prompting to recognise that they had been practising sit to stand or stepping for example. As the interview was completed the day after the final treatment session, patients may have had difficulty relating the questions to the therapy they had been receiving as part of the trial; an interview immediately after the treatment session may have yielded more detailed findings. In addition, the short intervention length may account for patient's lack of awareness of any specific internally focussed rules. A longer duration may allow for rules to become more embedded and therefore more likely to be recalled.

Therefore, the interviews do not provide sufficient data to demonstrate a difference in patient perception between the two treatment groups. However, they do indicate that patients themselves did not identify any particular difference in how their treatment sessions were delivered, or preference relating to this. One could postulate that those in the implicit group may feel that they were getting less guidance from their therapist, and that this may impact on wider factors such as their motivation, or the patient-therapist relationship. Conversely, constant verbal communication may be detrimental to motivation, by drawing attention to impairments or highlighting aspects of poor performance. Additionally, periods of silence may feel uncomfortable for some, or conversely may actually give a welcome opportunity to concentrate on the task in hand, without the overload from additional verbal input.

The role that instructions and feedback have on motivation therefore warrants consideration; although no negative consequences were reported for either treatment group in the current study. The fact that patients consistently reported little difference from what they considered to be "usual therapy" indicated that changes in treatment practice would be acceptable from a patient point of view.

In light of these potentially important influences on motivation, it is recommended that the Phase II trial includes a qualitative strand that can seek more in-depth views from patients relating to their perception of therapists communication practices.

5.19.4 Physiotherapist Interviews and Training Needs

Given that the explicit approach was found to be reflective of standard care, it is not surprising that therapists identified the delivery of an implicit approach to be more challenging. The insights gained through the patient interviews support the finding that whilst communication was different for each treatment group (in terms of quantity of instructions/feedback and attentional focus), the implicit approach could be enhanced if therapists were more creative in how they structured activities. This further supports the need for some more specific guidance that includes examples of how common activities can be delivered in a more implicit way, and how treatment can be progressed. Equally, designing a trial which will ensure that therapists have frequent opportunity to deliver the implicit approach will help to ensure that this approach is maximised at the earliest opportunity.

Overall, therapists felt that both implicit and explicit approaches were valid and acceptable, and that the choice of approach should be individualised depending on the individual patient's clinical presentation. Interestingly, therapists highlighted patients with cognitive impairment as one particular group for whom the use of implicit approaches was particularly difficult. Both felt that there were occasions where a more explicit approach was required to maintain safety, and ensure that the patient was able to perform tasks effectively. However, one could theorise that the frequent instructions associated with an explicit approach may be particularly challenging for those with cognitive impairment, particularly if there are issues relating to attention or information processing. Sub-analysis of outcome in relation to cognitive impairment, as well as other specific impairments, would be valuable in future research.

5.19.5 Developing the Guidance for Implicit Learning

It is evident from the interviews that therapists involved in this study perceived the delivery of implicit learning to be more challenging. Whilst they successfully managed to alter their communication practices in line with the implicit approach, there may be scope to further refine how implicit learning is promoted. One could argue that in the present study, there were frequent occasions where the implicit learning approach lacked depth; being primarily as a result of a change in quantity of communication, and a reduction in internal focus cues (with a limited increase in the use of external focus cues). It is not known whether this is truly sufficient to create bias towards implicit learning processes at a physiological level, or whether more creative ways of promoting implicit learning in a clinical setting are required to optimise its benefits. More in-depth guidance and training on how common tasks can be delivered in a more implicit way would support the delivery of implicit learning in the next phase of this research (see 6.2).

It was apparent (from both the video analysis and the therapist interviews) that the therapists found it more challenging to promote an external focus and that the variety of the external foci used was therefore limited. For example, occasionally, distant cues were used, primarily to prompt a better standing posture, for example *"look over at the lake".* However, on the whole, external focus cues were limited to functional instructions such as *"I want you to walk over to that chair",* that were not targeted at improving any specific performance characteristics. External focus prompts were therefore limited in their scope. Given that the distance of an external focus relative to the body is potentially important (Porter et al., 2012), this may be one way in which therapists could further promote implicit learning. Therapists highlighted that they would find it useful to have more clinical examples of how external focus cues could be used for common clinical scenarios. Development of such guidance through the use of a consensus group is recommended as part of the next phase of this research.

5.19.6 Appropriateness of the Outcome Measures

A battery of clinical outcome measures was applied in order to evaluate their effectiveness at detecting change within this patient group. A proportion of the participants who were recruited to the study were at a very early stage in terms of "gait rehabilitation". This was for two reasons. Firstly, participants were intentionally recruited at the earliest appropriate opportunity during their rehabilitation in order to limit any influence that previous therapy sessions may have on their explicit knowledge (contamination); and secondly to ensure that they would be likely to remain in hospital for at least 5 days, allowing for complete data collection. In addition, the functional level that was considered for inclusion into the study was low. As a minimum, patients needed to be working on sit to stand, or activities in standing with assistance as required. This was important to capture patients in the early phase of their rehabilitation, and to ensure that sufficient numbers were recruited. It also widened the clinical applicability of the study findings, and reflects the type of patient that receives rehabilitation on inpatient units within the current healthcare climate.

The most useful outcome measure for this patient group was clearly the Berg Balance Scale. All participants were able to complete at least one sub-section of the Berg Balance Scale at baseline, and all but three showed improvements over the course of the study period. It is therefore recommended that the BBS is the primary outcome measure the Phase II trial. Whilst the Hauser Ambulation Index did not appear to show sufficient changes over the course of this study to evaluate statistically, it may be a useful measure in a trial for which the intervention is provided over a longer duration. Both the Step Test and the 2 minute walk had significant floor effects, and were therefore ineffective for this patient group. The Numerical Rating Scale was applied in order to gauge any difference between treatment groups in terms of the patients' perception of their walking ability. It was hypothesised that patients in the explicit learning group may feel less confident about the way in which they move because they possess specific task relevant knowledge about their impairments in relation to standing/stepping. However, on reflection, a NRS may not be sensitive enough to detect such differences, and may not be reliable for use within such an early stroke population because of the impact of factors such as visual, language or cognitive disturbance (Price et al., 1999). Therefore, in retrospect, the NRS is probably not a useful outcome measure; more insights were gained from the participant interviews. In a study of longer duration, other patient reported outcome measures should be considered.

5.19.7 Estimated rates of recruitment and retention

Patients were recruited from a 36 bedded stroke unit that admits in the region of 700 patients per year. For the present study, 21 patients were recruited over a 14 month period. This equates to approximately 1.5 participants per month; or 2.6% of all stroke admissions.

This is a conservative estimate of likely rates of recruitment for a future trial. In reality, the frequency of recruiting patients was limited by the confines of a PhD study. The research was led by the Chief Investigator (LJ) who is a clinician at the study site but had no dedicated time for research during the period of recruitment to the feasibility trial. There were also only two therapists able to provide treatment at any given point throughout the study, which presented challenges if they were on annual leave or were not scheduled to work a full week. Furthermore, the tight intervention protocol required the patient to be recruited on a Monday and available from Monday to Friday for assessment, treatment and re-assessment. This was not always possible if the patient was unlikely to remain in hospital for a full week (Monday to Friday), or if the therapist was not available for the designated treatment days (set at Tuesday, Wednesday and Thursday). Equally, patients could not be recruited in weeks where there was a bank holiday. Therefore, the relatively slow rate of recruitment resulted from the inflexibility of the research design, rather than a lack of potentially eligible patients.

The overall dropout rate was 19% (n=4). Two patients were withdrawn from the study due to being unwell – one with a urinary tract infection and one with raised blood pressure. These complications were not related to involvement in this study, and are inevitable in an acute setting. Two further patients were withdrawn because they were discharged from the stroke unit part way through the intervention period. One was discharged home on the third day of intervention, and the other was transferred to a community hospital on the day of final assessments. This is not unusual given the high turnover of an acute stroke unit. No patients chose to withdraw from the study.

One could argue that this dropout rate is also the result of the Monday to Friday study design. Both patients who were withdrawn due to being unwell may have been able to miss one day of intervention but continue on the subsequent day if the design allowed for this – i.e. if the interventions were being applied over a longer time period. Equally, those that were discharged or transferred could have been recruited earlier if the design didn't necessitate initial assessments on a Monday, and may have had a sufficient period of intervention and follow up measures before their discharge.

Therefore, in order to support greater recruitment and improved retention, it is recommended that the Phase II trial takes a more pragmatic approach, in that patients receive their therapy using either an implicit or explicit approach for the duration of their inpatient stay, however long that may be. The study design should allow for patients to be enrolled into the study on any day of the week, as early as possible post admission, in order to maximise recruitment.

Only three therapists were recruited to the present study to ensure that they had sufficient opportunity to practise delivering the interventions within the small sample size. In a larger study, there would need to be a greater pool of therapists available to provide the interventions throughout the week, which would also maximise recruitment. With this greater resource, and more flexibility in terms of study design, it is anticipated that 3-4 patients per month could comfortably be recruited from a unit of this size, and that the dropout rate would be low.

5.19.8 Development of a Phase II trial

Data from the feasibility trial has been used to estimate the required sample size for an appropriately powered experimental study. However, it is acknowledged that any assumptions about the required sample size should be made with caution when the evaluation is scaled up to a Phase II or III trial. The effects of explicit and implicit learning may be smaller, or more variable, when the interventions are rolled out across a wider range of settings, and for longer time periods. Therefore, it is recommended that the next phase of this research is a Phase II pilot study, which evaluates the efficacy of implicit learning for early gait rehabilitation in the inpatient phase post stroke, and therefore allows for a more accurate sample size calculation prior to a definitive Phase III trial.

Based on 87 participants being required to the Phase II trial, with three study sites and a conservative estimate of 3 patients being recruited per site per month, then recruitment would need to take place over a 10 month period.

6. CONCLUSIONS AND FUTURE RECOMMENDATIONS

This final chapter collates the findings from the research programme as a whole. Each phase is briefly summarised and proposals for future research are made.

6.1 SUMMARY OF FINDINGS

6.1.1 Research Questions

This programme of research aimed to answer the following research questions:

1. What is the current evidence regarding the use of explicit and implicit models of learning in both healthy and neurologically impaired individuals?
2. What strategies do physiotherapists currently use for the rehabilitation of gait; and how do these fit with the explicit and implicit paradigms?
3. Can the content of standard therapy be delineated in order to describe what constitutes an explicit versus and implicit learning environment for early gait rehabilitation?
4. Can therapists effectively deliver interventions to create bias towards explicit or implicit learning, and how this can be monitored or measured within a research setting?

6.1.2 The Literature Review

Evidence for the relative benefits of explicit and implicit learning in both healthy and neurologically impaired individuals was considered. Empirical evidence for the use of internal and external focus of attention during learning was also systematically reviewed.

Research conducted with healthy individuals supports the idea that implicit learning is more beneficial for motor skill learning (e.g. Ferdinand et al., 2008, Sanchez et al., 2010, Gheysen et al., 2009, Willingham et al., 2000). Whilst research supporting the benefits of implicit learning for *performance* of motor skills is equivocal, the benefits for *learning* are clear; skills learnt implicitly are more likely to be retained, and are more robust under secondary task load. However, many of the studies in this field adopt controlled laboratory tasks, which do not reflect the complexities of motor learning within a functional or clinical scenario. Transferability of the findings into clinical practice is therefore unknown.

Evidence from healthy populations has also consistently shown differences in learning relative to the learners' focus of attention. An external focus of attention has repeatedly been shown to be of benefit to motor learning, when compared to an internal focus. Theories propose that focussing on specific movements (internal focus) may actually constrain or interfere with automatic control processes that would normally regulate movement, whereas if attention is focussed towards the movement effect (external focus) the motor system is able to more naturally self-organize (Wulf et al., 2001), resulting in more effective performance, and learning (Vance et al., 2004). An internal focus of attention is therefore aligned to explicit learning; whilst an external focus of attention is aligned to implicit learning.

There is very limited evidence relating to a) implicit and explicit leaning in stroke rehabilitation; and b) focus of attention during stroke rehabilitation. Therefore, the first stage of this research sought to better understand these concepts from the perspective of neurological physiotherapy practice.

6.1.3 The Observational Study

In this phase of the research, standard physiotherapy practice for gait rehabilitation was observed and analysed, particularly with regard to the physiotherapist's use of instructions and feedback. Eight physiotherapy sessions were observed and video recorded, each involving a different patient-therapist pair. Analysis showed that therapists communicate vast amounts of information to their patients during their treatment sessions, and that such information is given concurrently with task practice, and is typically internally focussed. These observations fit within an explicit learning paradigm; where learning is taking place in the presence of factual knowledge about the task being performed.

The observations made during this phase appear to be at odds with the available evidence in this area (albeit primarily from healthy populations); highlighting some potentially important considerations for physiotherapy practice and supporting the need for further evaluation.

In addition to gaining insights into clinical practice, there were two outputs from this phase:

i) a matrix for the analysis of implicit and explicit learning behaviours in practice was developed and tested.

ii) guidelines for implicit and explicit learning within the context of early gait rehabilitation were developed.

In the vast majority of real world situations, implicit and explicit learning will be occurring in parallel. Although current practice trends tend to favour explicit learning, it would be very difficult to find a situation where only one type is engaged. The extent to which each is taking place will however differ dependent on the situation. **It is not known whether changing the bias towards implicit learning, which may be done by modifying the behaviour of therapists, has any impact on the retention of sensorimotor skills.**

6.1.4 The Feasibility Trial

The feasibility trial tested the ability of physiotherapists to deliver treatment according to the explicit and implicit guidelines developed through the observational study. Using a matched pairs design, participants underwent three days of training using either the explicit or implicit approach (according to group of randomisation). Sessions were video recorded and later analysed (using the previously developed matrix) to establish therapist compliance with the guidelines. Therapists were able to successfully deliver the interventions according to the appropriate guidance. Patient and therapist perceptions were sought through the use of semi-structured interview. Patients did not report any preference for either style of therapy. This small feasibility trial was underpowered, therefore data were not analysed for differences in outcome between groups. However, the results allowed for the sample size to be estimated for the Phase II trial, and for recommendations to be made about suitable outcome measures.

6.2 LIMITATIONS

The limitations of each separate phase of this research have been discussed within the relevant chapter (sections 4.12 and 5.18). This section summarises the key methodological limitations of the research programme as a whole.

The initial chapters of this thesis describe motor learning as a complex phenomenon that may be influenced by many different and interacting factors, which may be difficult to control in a clinical setting. Recognising this complexity, the Medical Research Council Framework was used to structure the research programme. Whilst this provides a clear framework for the evaluation of a complex intervention, its application in the current research was limited by the scope of a PhD. It consisted of a pragmatic programme of developmental work which focussed specifically on the potential relationship between the use of verbal instructions/feedback and implicit/explicit motor learning. However, verbal communication is not the only factor likely to influence learning, and different practice conditions may interact to influence outcome - the findings are therefore limited in this regard. Furthermore, as a development study, the scope of this research does not allow for recommendations to be made that will influence clinical practice. Although this is not a direct limitation, since this pilot work did not intend to test hypotheses that would directly inform practice, applying the current findings within a rehabilitation setting is limited.

The decision to focus on the verbal behaviour of therapists, in particular their use of instructions and feedback, was based on the need to clearly define the interventions that would be compared, ensuring that they could realistically be delivered by different therapists, and applied to different clinical scenarios. Focussing on one specific area of clinical practice was therefore deemed necessary for this initial pilot work. Verbal communication was chosen based on several factors. Firstly, that there is a sound basis of evidence within healthy populations (yet a paucity of evidence within stroke rehabilitation) to indicate that verbal instructions and feedback have an important influence on performance and learning of motor tasks. In addition, the observational study highlighted that the use of instructions/feedback by therapists was particularly common within clinical practice; therefore it is important to explore its efficacy. Finally, verbal interactions can be clearly defined, "tested" and also measured (in terms of quantity and type) within a clinical research setting, making this an ideal place to begin research in this field. However, it must be acknowledged that other factors, for example therapists handling, may contribute equally to the implicit/explicit paradigm, and we cannot conclude instructions and feedback to be most important.

In defining the interventions that were compared in the pilot study, some assumptions are made about the nature of instructions/feedback and their potential relationship to implicit/explicit learning. In particular, it is proposed that instructions that promote an external focus of attention are likely to bias implicit learning processes, and those with an internal focus of attention bias explicit learning processes. Although there is currently no empirical research to confirm this (i.e. no studies that investigate the central processes underlying learning under the two different conditions), there is a theoretical basis to support this assumption (section 3.11) and also an expert consensus statement agreeing that the two are linked (Kleynen et al., 2013a). Based on this theory, it was deemed justifiable to use focus of attention as one of the main elements of verbal communication differentiating implicit from explicit learning during the pilot study. Future research that uses functional neuroimaging techniques to investigate the underlying central processes taking place under each learning condition would be valuable to confirm the link between focus of attention and implicit/explicit learning processes.

Recognising these limitations, it is acknowledged that our understanding of implicit and explicit learning and their application to clinical practice must come from a wide range of studies that consider varied practice conditions. Future research first needs to confirm which elements of rehabilitation delivery impact on the underlying mechanisms of learning taking pace (i.e. explicit or implicit) and then to test whether implicit learning is superior to explicit learning in terms of functional outcome. This current research provides a foundation for this future work, recommendations for which are made in the following section.

6.3 FUTURE RESEARCH

There is currently no published research that has specifically considered how stroke rehabilitation can be delivered to promote implicit learning, and no clinically based research evaluating the benefits of an implicit approach. Therefore, future research is required to assess the potential efficacy of implicit and explicit learning in a larger, randomised controlled trial.

6.3.1 Further clinical evaluation

Based on the findings from the observational study, and knowledge from existing literature, standard physiotherapy practice can be considered as largely explicit in nature. Therefore, it is suggested that future research should focus on developing our understanding of implicit learning, and the impact this has on clinical outcome. It is proposed that the next stage of this research moves into the evaluation phase of the MRC Framework, where the evidence gathered so far is tested further in a Phase II randomised controlled trial. In line with the flexible nature of the MRC Framework, it is recommended that the next stage remains iterative, allowing for further evaluation and refinement of the actual intervention (i.e. implicit learning).

After further evaluation, it may be appropriate for future research to simply compare implicit learning to conventional therapy (which is assumed to be explicit in nature). However, at this stage a three-arm study is proposed, comparing standard care (control), an explicit model, and an implicit model. The recommendations for the Phase II trial are that it should:

- Assess the feasibility of delivering implicit learning over a longer time period (throughout the inpatient stay), with patients recruited as soon as possible post admission, and the primary end point being discharge from hospital.
- Include a longer follow up phase.
- Be a multicentre trial, involving a larger number of physiotherapists (aim for 2-3 sites with 2-3 physiotherapists at each)
- Be appropriately powered to evaluate differences in primary outcome (Berg Balance Scale) between treatment groups (n = 87); informing further sample size calculations for a Phase III trial.
- Include secondary measures relating to functional independence and a patient reported outcome measure (PROM)
- Include an economic evaluation, including analysis of any differences in process related measures, particularly hospital length of stay and care requirements on discharge.
- Include further detailed qualitative work exploring the perceptions of both patients and therapists.

Where possible, future research should include sub-analysis of the different aspects of the complex intervention, scoping the ability to delineate which factors may have the greatest impact on outcome (e.g. amount of silence, focus of attention, quantity of instructions, other forms of feedback etc). It would also be valuable, within a larger sample size, to begin to understand which patients, if any, may benefit from a more implicit approach – for example, how do deficits in cognition, perception, language, mood, sensation and strength inform the optimal type of learning strategy for an individual. These two areas of sub-analysis may not be feasible within the Phase II trial, but are a consideration for the subsequent Phase III trial.

The Dutch Movement Specific Re-Investment Scale (DMSRS) may be a useful tool to aid this sub-analysis. The DMSRS is a newly developed psychometric tool that can be used to identify patients who may have a particular propensity for skill breakdown under pressure (Kleynen et al., 2013c). Early work suggests that it may be a reliable method within stroke for identifying such patients, and that this could then be used to guide decision making about rehabilitation approaches. The use of the DMSRS may be useful within the Phase II trial to begin to categorise patient characteristics that may contribute to the relative benefits of an implicit approach.

6.3.1.1 Development of the intervention

Prior to conducting a Phase III trial, further work is required to develop the intervention. This current programme of research has addressed, in part, the first two a stages of the MRC Framework for the Evaluation of Complex Interventions, as outlined in section 2.2. Further work is required to fully define how implicit learning can be delivered within neurological physiotherapy, taking into account all of the factors outlined in the modelling exercise and evaluating the impact that these have individually, and collectively, on motor learning. However, given that verbal communication from therapists was observed to be high during clinical practice, and that this contradicts evidence from healthy populations, further research focussing specifically on these common practices is justified.

It is recommended that future work continues to refine the treatment guidance, particularly for the implicit approach. It may be useful to develop guidance that is more specific, particularly for any future trail that may include a larger number of therapists over several sites. A series of focus groups or workshops, involving experienced physiotherapists, could be used to achieve this. The output should be a consensus on how common therapy interventions can be modified to be delivered in a way that will promote implicit learning. For practical application, this could be translated into the development of a "manual" of implicitly delivered exercises for common impairments and functional limitations.

6.3.1.2 Development of the analysis methods

Although it has been shown to be a reliable tool for identifying various behaviours relating to implicit and explicit learning, the analysis matrix developed through this research is time consuming to apply. Any future research will continue to require a means of monitoring and evaluating the interventions provided. Therefore, it is suggested that future research should be conducted to translate the current matrix, which is in paper format, into one that can be applied using video analysis software. There are existing software packages that are used for similar purposes, and so adaptation and validation of such methods would support further research.

6.3.2 Parallel areas for research development

In addition to this direct progression of the current research, there are parallel areas of research that would complement the overall evidence base in this field.

In order to ensure clinical applicability, this current research has focussed on evaluating learning within a clinical scenario. In future research, it would be particularly useful to consider implicit and explicit learning in the context of other areas of stroke rehabilitation – for example upper limb rehabilitation, in order to begin to understand the generalisability of these findings to neurological physiotherapy practice as a whole.

However, in order to progress our understanding of how learning takes place in individuals with stroke, it would also be valuable to consider some more defined areas of research relating to learning behaviour in patients with stroke. Replication of studies that have been performed with healthy individuals could provide some particularly useful insights. For example, research could investigate:

- The impact of explicit learning for a defined motor task with directly measurable outcomes – for example, accuracy of kicking a ball at a target under explicit or implicit conditions. Such experiments could be set up in a similar way to those carried out in healthy populations and are more easily controlled and measured. They may provide useful insights into learning behaviour, and may give further support for the use of implicit approaches.
- Whether the observation that muscle activation (measured using EMG) is more efficient when healthy individuals practice a task under external focus conditions (when compared to internal focus conditions) is transferable to those with stroke.
- Whether insights into learning behaviour can be gained using functional neuroimaging during the practice of tasks under implicit and explicit conditions (in patients with stroke).

6.4 CONCLUSION

Research within healthy populations supports the use of implicit strategies for motor skill learning. However, to date, very little research relating to implicit learning has been conducted in the field of stroke rehabilitation. Whilst numerous factors are likely to have an impact on the processes of motor learning, it is argued through this thesis that one of the most important may be the way in which instructions and feedback are used – their quantity, timing, and attentional focus.

Communication is an inherent part of physiotherapy practice, yet very little is known about how therapists communication during stroke rehabilitation. Furthermore, no previous studies have considered communication practices specifically in relation to their impact on motor learning or recovery following stroke. Given the extent of the research within healthy populations, this is perhaps surprising.

Evidence gained through this and previous research identifies neurological physiotherapy practice as being primarily explicit in nature. During the initial stage of this study, patients were observed to receive frequent, internally focussed instructions and feedback statements throughout their rehabilitation. This current work argues that such communication practices are historical, and are based on assumptions about what may be effective, rather than scientific evidence. Indeed, if the findings from studies within healthy populations were to be replicated in stroke, it would have important consequences for the delivery of therapy. The initial stages of this research (the literature review and the observational study) therefore provide a strong rationale for further empirical work in this area.

The second part of this research tested the ability of therapists to deliver rehabilitation with a bias towards either explicit or implicit learning. To our knowledge, it is the first study to investigate the application of explicit and implicit approaches within a clinical rehabilitation setting (i.e. outside of a laboratory setting). It therefore provides knowledge and understanding that is directly relevant and applicable to clinical practice. During this study, therapists were successfully able to change their communication practices, although the scope of the implicit interventions was limited and warrants further development. Importantly, both styles of learning were found to be acceptable to both patients and therapists. Insights have been gained to enable to development of a clinically relevant and viable Phase II trial.

Although there is little evidence within stroke rehabilitation to support the use of implicit learning techniques, there is equally no evidence to support a more explicit approach. The few studies that do exist generally replicate the findings from studies in sport, and therefore give preliminary support for the use of implicit learning post stroke. Greater effort needs to be taken to dovetail the strong body of motor learning research from the fields of sports science and psychology, with that from the field of rehabilitation. Much can be learned from these fields of evidence, and future research should build on the foundation of knowledge they provide to gain greater understanding of implicit and explicit learning within stroke rehabilitation.

Appendix 1 – Observational Study, Therapist Information

Letter of Invitation

Participant Information Sheet

Consent Forms

Note:

When the proposal for this research was initially developed, the intention was to investigate the impact that explicit learning strategies had on the severity of upper limb associated reactions during gait. The concept came from the researchers' clinical observation that associated reactions increase in the presence of increased cognitive effort, as well as in the presence of increased physical effort. Therefore, it was hypothesised that the use of high amounts of internally focussed instructions would present a cognitive demand to patients, and that this may have a detrimental effect on the severity of associated reactions.

The literature review highlighted a lack of evidence regarding implicit and explicit learning more broadly, and the observational study revealed interesting insights into clinical practice. At this very early stage, it was clear that the research programme would be more relevant if it considered the impact of these different types of learning more broadly within stroke rehabilitation, and the research therefore took a different path. Hence, the participant information sheets contained in the following appendices refer to associated reactions when describing the purpose of the study, despite the fact that this is no longer in line with the objectives of the research programme, and has not been discussed elsewhere in this thesis.

Louise Johnson DClinP
University of Southampton
Highfield Campus
Building 45
Southampton
SO17 1BJ

Tel: 07799 65 77 64
Email: lj1b06@soton.ac.uk
November 2009

Dear Physiotherapist

Invitation to take part in a research study

Observation of Physiotherapy Treatment Sessions - exploring how therapists work towards improving walking in patients with stroke

I would like to invite you to take part in a research study that will investigate the effects that different approaches to physiotherapy and motor relearning have on upper limb associated reactions in people with stroke. Before you decide whether or not to take part, you need to understand why this research is being done and what your involvement may consist of. I have therefore enclosed a Participant Information Sheet. This explains what the study is about, why you are being asked to participate, what your participation would consist of, and how to find out more information.

Please take time to read the following information carefully. Talk to others about the study if you wish, and please feel free to contact me to ask questions if there is anything that you are unsure about – my details are at the top of this letter.

At the end of the information sheet is an “Expression of Interest Reply Slip” and a pre-paid envelope. Please complete and return this slip if you would like to volunteer, or if you would like more information. I will then contact you to discuss your potential involvement further. Completion of this slip does not in any way commit you to taking part.

Thank you for taking the time to read this information.

I look forward to hearing from you.

With best wishes

Louise Johnson   MCSP

UNIVERSITY OF Southampton
School of Health Sciences

Participant Information Sheet (A)

Title: **Exploring what happens in physiotherapy for patients after stroke.**

Researcher: **Louise Johnson MCSP**

Ethics Submission Number: 09/H0504/80

What is the purpose of this study?

As part of my doctoral research, I am carrying out a study to investigate how the different learning strategies used during rehabilitation affect associated reactions in patients with stroke, particularly during gait. In order to help me to develop the methodology for the main study, I am carrying out several preliminary pieces of work, including this particular study.

During this first part of the research, I am intending to observe a number of physiotherapy treatment sessions. The aim of this is to provide an insight into the different ways in which physiotherapists work towards re-educating gait with stroke patients. I will gain factual data about clinical practice by observing and videoing treatment sessions with a selection of physiotherapists and patients, which will then be themed and analysed.

Why have I been chosen?

You have been chosen because you are a physiotherapist who specialises in treating people with neurological disorders including stroke. I hope to observe therapists with varying levels of experience in order to get a picture of current clinical practice.

Do I have to take part?

No - it is entirely up to you to decide. This information sheet describes what will happen during this part of the study. There is an "expression of interest" form at the end of this sheet – please return this form in the pre-paid envelope if you wish to receive further information. This does not commit you to taking part. I will then contact you to answer any questions you may have, and to discuss your potential involvement further. If you decide to participate, you will be asked to sign a consent form, which you will be given a copy of to keep. You are free to withdraw at any time, without giving a reason and without prejudice.

What will happen to me if I take part?

I will be observing and video recording a number of standard physiotherapy treatment sessions involving different therapists and different patients. If you agree to take part, you will be asked to identify and approach patients from your caseload who have suffered a stroke, and who are currently receiving rehabilitation including gait rehabilitation. I will meet separately with patients to provide information, answer questions and discuss potential involvement.

Observation will take place of up to two treatment sessions between yourself and a patient(s) who is known to you. I will observe and video record the treatment session, and I may also take some notes. It is intended that this will give an insight into practice, and you will not therefore be given any further specific guidance, other than that the session must be one in which the purpose of therapy is towards improving gait. The length and content of this session will be determined by you. I will try to remain as discreet as possible, and will not intervene or influence the treatment session in any way.

What are the potential risks or inconveniences of taking part?

I will endeavour to keep any risk or inconveniences to an absolute minimum. Should you agree to take part, I will liaise with you to arrange a time that is convenient to both yourself and your patient(s). Observation will take place in your usual place of work, and during a routine therapy session.

What are the benefits of taking part?

There are no direct benefits to you of taking part. This observational study is part of a larger piece of research. The results of this part of the study will help to inform the main research methodology, and it is hoped that this will provide an improved understanding of the nature and management of associated reactions.

Will my participation be kept confidential?

Yes. I will not tell anybody whether or not you have taken part. All information collected throughout the research will be kept confidential, and personal data will be held in accordance with the Data Protection Act (1998). The video recordings will be viewed and analysed by me and a second researcher from the University of Southampton. Researchers viewing the videos will have a duty of confidentiality to you as a research participant. Any observations taken from the treatment session or the video recording will be reported anonymously. However, in the unlikely event that any unprofessional conduct is observed, or in the event of a patient complaint, I will not be able to maintain confidentiality and will report the event through a service manager. If necessary, in this situation the recordings may be used as evidence.

It may be useful to use video footage during presentations relating to this research, which may involve a wide audience of professionals and public, for example during conference presentations. In these circumstances, it is possible that videos may be viewed by your peers and colleagues. You will be given the opportunity to view the video(s), and will be asked to provide separate consent for if you agree to have your videos used for wider audiences. This is not obligatory, and should you decline, will not affect your involvement in the study in any other way.

What will happen to the video recordings?

Once the study is complete, video recordings will be retained in a secure place at the University of Southampton for ten years, after which they will be disposed of securely.

What happens if something goes wrong or if I want to complain?

If you have a concern or a complaint about this study you should contact Susan Rogers, Head of Research and Enterprise Services, at the School of Health Sciences (Address: University of Southampton, Building 67, Highfield, Southampton, SO17 1BJ; Tel: 023 8059 7942; Email: S.J.Rogers@soton.ac.uk). If you remain unhappy and wish to complain formally, Susan Rogers can provide you with details of the University of Southampton Complaints Procedure.

What will happen to the results of the research study?

It is intended that the study findings will be submitted part of a Doctorate in Clinical Practice thesis to the University of Southampton. Results will also be published in relevant peer reviewed journals and may be presented at conferences. A summary of study findings will be available during 2011. If you wish to receive a copy of this, please contact me (Louise Johnson, 07799 65 77 64, lj1b06@soton.ac.uk). You will not be personally identified in any report or publication.

Who has reviewed this study?

All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee to protect your safety, rights, well-being and dignity. This study has been reviewed and given favourable opinion by Southampton and South West Hampshire Research Ethics Committee B.

What do I do next?

If you have any further questions about this research, please feel free to contact me.

I would be grateful if you could complete the reply slip overleaf indicating whether or not you are interested in taking part in this stage of the research. Please return the slip in the stamped addressed envelope enclosed. If you state that you are interested in taking part, I will then contact you to discuss your potential involvement further, and to make necessary arrangements.

What will happen in the rest of the research?

This part of the study will be followed be a series of focus groups. The focus groups will involve a number of physiotherapists, and will aim to discuss issues relating to current practice and the management of associated reactions. Whether or not you decide to participate in this observational study, it is likely that you will be contacted again in the future inviting you to take part in one of the focus groups.

Thank you for taking the time to read this.

UNIVERSITY OF Southampton
School of Health Sciences

EXPRESSION OF INTEREST: Exploring what happens in physiotherapy for patients after stroke.

If you would like more information about this research, or would like to take part, please provide your contact details on this reply slip. I will then contact you to discuss your involvement further, and to make necessary arrangements. This does not commit you to taking part.

Name: ____

Address:____

____

______________________________ **Post Code** ______________________________

Daytime telephone number: ____

E-mail address: ____

Job Title and Area of Work: ____

Number of years experience working in neurology (please circle)

< 5 **5 – 10** **11 – 20** **20 +**

Please return this reply sheet in the pre-paid envelope, by [date] at the latest:

Louise Johnson
Community Neuro Team
Day Hospital
Christchurch Hospital
Fairmile Road
Christchurch
Dorset
BH23 2JX
Tel: 07799 65 77 64 Email: lj1b06@soton.ac.uk

UNIVERSITY OF Southampton
School of Health Sciences

Centre Number:

Ethics Submission Number: 09/H0504/80

Participant Identification Number:

CONSENT FORM

Title: Exploring what happens in physiotherapy for patients after stroke.

Researcher: Louise Johnson

Please initial box

I confirm that I have read and understood the information sheet dated July 2009 (version 5) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason, and without prejudice. ☐

I understand that my participation in this study will involve the direct observation and video recording of me (for research purposes) during my clinical practice. ☐

I agree to take part in the above study. ☐

______________________	__________________	__________________
Name of participant	Date	Signature

______________________	__________________	__________________
Name of person taking consent	Date	Signature

Centre Number:

Ethics Submission Number: 09/H0504/80

Participant Identification Number:

CONSENT FORM – USE OF VIDEO RECORDINGS

Title: Exploring what happens in physiotherapy for patients after stroke.

Researcher: **Louise Johnson**

Please initial box

I have been offered the opportunity to view the video recordings made of me during this research.	
I agree to video recordings of me being used for the purpose of educating others about this research, for example at training sessions or conferences. I understand that this will result in these videos being viewed by other professionals with an interest in this area.	

________________________ ____________________ ____________________

Name of participant Date Signature

______________________ ___________________ ___________________

Name of person taking consent Date Signature

Appendix 2 – Observational Study, Patient Information

Letter of Invitation

Participant Information Sheet

Consent Forms

University of Southampton
School of Health Sciences

Louise Johnson
University of Southampton
Highfield Campus
Building 45
Southampton
SO17 1BJ

Tel: 07799 65 77 64
Email: lj1b06@soton.ac.uk

REC Ref Number: 09/H0504/80

November 2009

Dear Sir or Madam

Exploring what happens in physiotherapy for patients after stroke.

I am a physiotherapist, and am currently carrying out a research study to look at how physiotherapists work with patients after stroke to improve walking. For the first part of this study I will be coming along to some physiotherapy treatment sessions to observe what happens, and I would like to invite you to take part in this.

I have enclosed an information sheet which explains more about what this research is about and what involvement would consist of. I would be grateful if you could have a look through this information. At the end there is an opt-in reply slip. If you think that you might like to take part, or if you would like more information, please fill in this slip and hand it back to one of your therapists. I will then arrange to come and meet with you on the ward where we can chat about your potential involvement further and I will answer any questions that you may have.

Thank you for your time.

With best wishes

Louise Johnson

UNIVERSITY OF Southampton
School of Health Sciences

Participant Information Sheet (B)

Title: Exploring what happens in physiotherapy for patients after stroke.

Researcher: **Louise Johnson MCSP**

Ethics Submission Number: **09/H0504/80**

I would like to invite you to take part in a research study. Before you decide whether or not to take part, you need to understand why this research is being done and what your involvement may consist of. Please take time to read the following information carefully. Talk to others about the study if you wish, and please feel free to ask questions if there is anything that you are unsure about. *Thank you for reading this.*

What is the purpose of this study?

I am a physiotherapist, currently carrying out a piece of Doctorate research to investigate ways of reducing the abnormal and unintended arm posture commonly adopted following stroke, which can affect walking.

This is the first stage of the study. During this stage I will be looking at what physiotherapists do during treatment sessions to help patients improve their ability to walk.

Why have I been chosen?

You have been chosen because your physiotherapist has identified you as someone who has had a stroke, and who is currently working towards improving their walking ability.

Do I have to take part?

No - it is entirely up to you to decide. If you do decide to participate, you will be asked to sign a consent form, which you will be given a copy of to keep. You are free to change your mind and withdraw at any time, without giving any reason and without it affecting your treatment in any way whatsoever.

What will happen to me if I take part?

If you agree to take part, I will arrange a time to come to one of your physiotherapy sessions. You will attend this physiotherapy session as usual, but a video camera will be set up to record the session and I will sit in the background and take notes about your treatment. The focus of this observation is on the physiotherapy treatment.

What are the potential risks or inconveniences of taking part?

There are no risks or inconveniences of taking part. Your care and treatment will not be affected in any way.

What are the benefits of taking part?

There are no direct benefits to you of taking part.

Will my participation be kept confidential?

Yes. All information collected throughout the research will be kept confidential, and personal data will be held in accordance with the Data Protection Act (1998).

The video recordings will be viewed and analysed by me and also by a second researcher from the University of Southampton. Researchers viewing the videos will have a duty of confidentiality to you as a research participant. Any observations taken from the treatment session or the video recording will be reported entirely anonymously.

It may be useful to use video footage during presentations relating to this research, which may involve a wide audience of professionals and public, for example during conference presentations. You will be given the opportunity to view the video recordings, and if you agree to do so, you will be asked to provide separate consent for your videos to be used for wider audiences. This is not obligatory, and should you decline, will not affect your involvement in the study in any other way.

What will happen to the video recordings?

Once the study is complete, video recordings will be retained in a secure place at the University of Southampton for ten years, after which they will be disposed of securely.

What happens if something goes wrong or if I want to complain?

If you have a concern or a complaint about this study you should contact Susan Rogers, Head of Research and Enterprise Services, at the School of Health Sciences (Address: University of Southampton, Building 67, Highfield, Southampton, SO17 1BJ; Tel: 023 8059 7942; Email: S.J.Rogers@soton.ac.uk). If you remain unhappy and wish to complain formally, Susan Rogers can provide you with details of the University of Southampton Complaints Procedure.

What will happen to the results of the research study?

It is intended that the study findings will be submitted as part of a Doctorate in Clinical Practice thesis to the University of Southampton. Results will also be published in relevant peer reviewed journals and may be presented at conferences. A summary of study findings will be available during 2011. If you wish to receive a copy of this, please contact me (Louise Johnson, 07799 65 77 64, lj1b06@soton.ac.uk). You will not be personally identified in any report or publication.

Who has reviewed this study?

All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee to protect your safety, rights, well-being and dignity. This study has been reviewed and given favourable opinion by South and South West Hampshire Research Ethics Committee B.

What do I do next?

If you are interested in taking part and wish to discuss this with me, please complete the attached reply slip and return it to one of your physiotherapists. I will then arrange to come and meet with you.

Thank you for taking the time to read this.

UNIVERSITY OF Southampton
School of Health Sciences

REPLY SLIP

Exploring what happens in physiotherapy for patients after stroke.

Please complete this reply slip if you are interested in taking part in the above study. Hand it back to one of your therapists, who will pass it onto me. I will then arrange to come and meet with you on the ward to discuss the study further. This does not commit you to taking part.

I ____ (name) am interested in finding out more about the above research study. I would be happy for the researcher to come and meet with me on the ward.

Physiotherapists Name: ____________________________ Ward: ___________

Signed: ____ Date: ____________

Thank you

Louise Johnson

(Researcher)

UNIVERSITY OF Southampton
School of Health Sciences

Ethics Submission Number: 09/H0504/80

Participant Identification Number:

CONSENT FORM

Title: Exploring what happens in physiotherapy for patients after stroke.

Researcher: Louise Johnson

Please initial box

I confirm that I have read and understood the information sheet dated July 2009 (version 5) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason, and without my medical care or rehabilitation being affected in any way.	
I understand that my participation in this study will involve the direct observation and video recording of me during a therapy session.	
I agree to take part in the above study.	

____________________	________________	________________
Name of participant	Date	Signature
____________________	________________	________________
Name of person taking consent	Date	Signature
____________________	________________	________________
Name of Witness (if applicable)*	Date	Signature

In circumstances where a patient is not able to clearly sign due to PHYSICAL impairment, they will be asked to sign this consent form to the best of their ability and this will be witnessed by a family member or health care professional who is NOT involved in the research.

UNIVERSITY OF Southampton
School of Health Sciences

Ethics Submission Number: 09/H0504/80

Participant Identification Number:

Centre:

CONSENT FORM – USE OF VIDEO RECORDINGS

Title: Exploring what happens in physiotherapy for patients after stroke.

Researcher: Louise Johnson

Please initial box

I have been offered the opportunity to view the video recordings made of me during this research.	
I agree to these video recordings being used for the purpose of educating others about this research, for example at training sessions or conferences. I understand that this will result in these videos being viewed by other professionals with an interest in this area.	

______________________	__________________	__________________
Name of participant	Date	Signature
____________________	_________________	_________________
Name of person taking consent	Date	Signature
______________________	__________________	___________________
Name of Witness (if applicable)*	Date	Signature

* In circumstances where a patient is not able to clearly sign due to PHYSICAL impairment, they will be asked to sign this consent form to the best of their ability and this will be witnessed by a family member or health care professional who is NOT involved in the research.

Appendix 3 – Modified Rivermead Mobility Index

Modified Rivermead Mobility Index

Task	Instructions	Date
1. Turning over	Please turn over from your back to your ______ side	
2. Lying to sitting	Please sit up on the side of the bed	
3. Sitting Balance	Please sit on the edge of your bed (the assessor times patient for 10 secs)	
4. Sitting to standing	Please stand up from your chair (patient takes less than 15 secs)	
5. Standing	Please remain standing (the assessor times patient for 10 secs)	
6. Transfers	Please go from your bed to the chair and back again	
7. Walking Indoors	Please walk for 10 metres in your usual way	
8. Stairs	Please climb up and down this flight of stairs in your usual way	
	TOTAL	**/ 40**

0 = unable to perform	2 = assistance of one person	4 = requires an aid or appliance
1 = assistance of two people	3 = requires supervision or verbal instruction	5 = independent

Appendix 4 – Observational Study, Ethics Approval

NHS

National Research Ethics Service
SOUTHAMPTON & SOUTH WEST HAMPSHIRE
RESEARCH ETHICS COMMITTEE (B)
1ST Floor, Regents Park Surgery
Park Street, Shirley
Southampton
Hampshire
SO16 4RJ

Tel: 023 8036 2466
023 8036 3462
Fax: 023 8036 4110

Email: scsha.SWHRECB@nhs.net

RK/STA/hph

07 August 2009

Mrs Louise Johnson
Trainee Consultant Practitioner in Neurological Rehabilitation
NHS Education South Central
Innovation, Development and Wider
Workforce, NESC, Southern House,
Otterborne, Winchester
SO21 2RU

Dear Mrs Johnson

Study Title:	**Do implicit and explicit learning strategies applied during gait re-education influence concurrent expression of associated reactions in individuals with hemiplegia?**
REC reference number:	**09/H0504/80**
Protocol number:	**7 - Phase 1**

Thank you for your letter of 24 July 2009, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Alternate Vice-Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk. *Where the only involvement of the NHS organisation is as a Participant Identification*

Appendix 5 – Observational Study, Sponsorship, R&D and Insurance

UNIVERSITY OF Southampton

Mrs Louise Johnson
School of Health Sciences
University of Southampton
University Road
Highfield
Southampton
SO17 1BJ

13 January 2009

Dear Mrs Johnson

RGO Ref: 6243

Project Title Do Implicit and Explicit Learning Strategies Applied during Gait Re-Education Influence Concurrent Epression of Associated Reactions in Individuals with Hemiplegia

I am writing to confirm that the University of Southampton is prepared to act as sponsor for this study under the terms of the Department of Health Research Governance Framework for Health and Social Care (2nd edition 2005).

The University of Southampton fulfils the role of Research Sponsor in ensuring management, monitoring and reporting arrangements for research. I understand that you will be acting as the Principal Investigator responsible for the daily management for this study, and that you will be providing regular reports on the progress of the study to the Research Governance Office on this basis.

I would like to take this opportunity to remind you of your responsibilities under the terms of the Research Governance Framework, and the EU Clinical Trials Directive (Medicines for Human Use Act) if conducting a clinical trial. We encourage you to become fully conversant with the terms of the Research Governance Framework by referring to the Department of Health document which can be accessed at:

http://www.dh.gov.uk/assetRoot/04/12/24/27/041224

In this regard if your project involves NHS patients or resources please send us a copy of your NHS REC and Trust approval letters when available.

Please do not hesitate to contact me should you require any additional information or support. May I also take this opportunity to wish you every success with your research.

Yours sincerely

Dr Martina Prude
Head of Research Governance
Tel: 023 8059 5058
email: rgoinfo@soton.ac.uk

Corporate Services, University of Southampton, Highfield Campus, Southampton SO17 1BJ United Kingdom
Tel: +44 (0) 23 8059 4684 Fax: +44 (0) 23 8059 5781 www.southampton.ac.uk

UNIVERSITY OF Southampton

Mrs Louise Johnson
School of Health Sciences
University of Southampton
University Road
Highfield
Southampton
SO17 1BJ

RGO REF - 6243

12 January 2009

Dear Mrs Johnson

Professional Indemnity and Clinical Trials Insurance

Project Title Do Implicit and Explicit Learning Strategies Applied during Gait Re-Education Influence Concurrent Epression of Associated Reactions in Individuals with Hemiplegia

Participant Type:	No Of Participants:	Participant Age Group:	Notes:
Patients	44	Adults	
Healthy volunteers	26	Adults	

Thank you for forwarding the completed questionnaire and attached papers.

Having taken note of the information provided, I can confirm that this project will be covered under the terms and conditions of the above policy, subject to written informed consent being obtained from the participating volunteers.

Insurance will only be activated when we have received a copy of the Ethics Committee approval and you must not begin your project prior to this. Please forward a copy of the Ethics Committee approval letter as soon as it is to hand to complete the insurance placement.

If there are any changes to the above details, please advise us as failure to do so may invalidate the insurance.

Yours sincerely

Mrs Ruth McFadyen
Insurance Services Manager

The Royal Bournemouth and Christchurch Hospitals
NHS Foundation Trust

The Royal Bournemouth Hospital
Castle Lane East
Bournemouth
BH7 7DW

01202 303626
www.rbch.nhs.uk

Miss Claire Moloney
Senior Clinical Lead for Stroke
Education Centre
The Royal Bournemouth Hospital
Castle Lane East
BOURNEMOUTH
BH7 7DW

8th October 2009

Dear Miss Moloney,

Reference:	**Do implicit and explicit learning strategies applied during gait reeducation influence concurrent expression of associated reactions in individuals with hemiplegia?**
REC reference:	**09/H0504/80**
CLRN ID:	**N/A**

I am pleased to inform you that this project has now received approvals from all parties and that you now have formal permission to start.

Please let me know when you officially start and I would be grateful for a progress report annually.

Good luck with the study,

Dr R. M. Chapman
Head of Research

Appendix 6 – Definitions

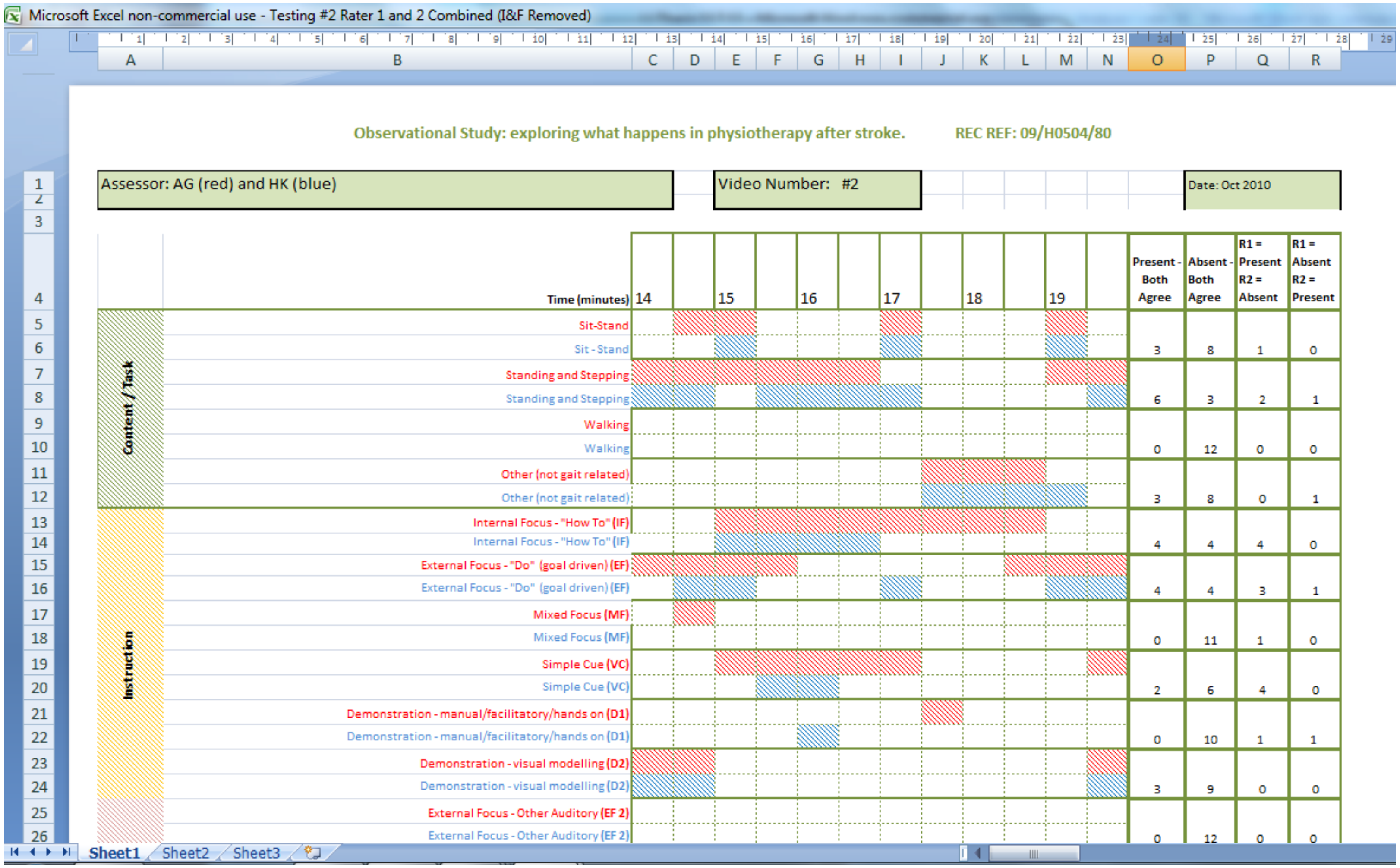
	Code	Category	Examples
Activity	Sit to Stand	Sit to stand when performed as an exercise/therapeutically. If the patient simply stands of their own accord, for example in order to move to another part of the gym, then this does not constitute an exercise and shouldn't be marked as such.	Repetitive sit to stand. Asymmetrical sit to stand. Sit to stand performed with specific instructions from the therapist (e.g. regarding foot position, alignment or weight bearing).
	Standing and Stepping	Any exercise performed in standing that is equal to or less than one gait cycle (initial contact on one foot to initial contact on the **same** foot). May include exercises for lower limb strengthening, alignment, weight bearing etc.	Stepping back and forth, e.g. by a plinth/table. Stepping onto a block with either leg. Squatting. Working on weight transference.
	Walking	Any activity in which the patient continuously performs **more than** one full gait cycle (moving forwards only)	Practicing walking by a plinth/table. Walking with equipment/an aid. Walking with assistance from the therapist. Walking.
	Other	Any activity that does not fit into the categories above. **No further analysis required for these activities.**	Any activity in supine, prone, side lying, kneeling, sitting etc.
		General Plan – Internal Focus Therapist tells the patient what the plan for the session/next part of the session it – with a focus towards the specific movements or movement patterns that will be worked on.	"We're going to spend some time practising lifting your foot as you step" "We're going to work on getting your heel to the floor first and bringing your weight over"
		General Plan – External Focus Therapist tells the patient what the plan for the session/next part of the session it – with a focus	"We're going to spend some time practising walking" "We're going to focus on stepping the left leg"

		towards the overall activity.	
Instruction	I-IF	**Internal Focus - "How To"** Instruction that directs attention towards the movement itself (i.e. relates to the biomechanical/kinematic features)	"Move your **hips** to the left and straighten your **knee** before stepping." "Bend your **knee** and swing through." "Squeeze your **bottom** and straighten your **hips**."
	I-EF	**External Focus - "Do"** Instruction that directs attention towards the desired effects of the movement on the environment (i.e. goal driven)	"Step up onto the **marker** on the **block**." "Look up at the **clock** on the **wall**."
	I-MF	**Mixed Focus** Where a **single instruction** includes both information of internal and external foci – WITHIN THE SAME SENTENCE (if in doubt, mark separately as I-IF and I-EF)	"Lift your toes up and step onto the block"
	I – SC	**Simple Cue** Short, concise phrases that serve to prompt or encourage an action	"And again" "Step up....and down" "Keep going" "Wait"
	I-D1	**Demonstration - manual/facilitatory/hands on**	Therapists hands on the patient guiding them or giving proprioceptive/sensory input **as part of the instruction** (as opposed to as feedback) e.g., touching the patients gluteals whilst telling them to "squeeze your bottom" or manually moving their hips over to the side in order to demonstrate weight transfer.
	I-D2	**Demonstration - visual modelling** The use of demonstration as a means of conveying information about how to perform the skill (Magill 2010, pg 309)	The therapist demonstrates the activity or the movement pattern, possibly also demonstrating the incorrect way – e.g. demonstrating stepping with a hip hitch, and then showing how it should be done correctly.
	Exp	**Explanation of the problem/reasons for the exercise (explicit) (Exp)**	Therapist gives an explanation for the exercise/activity that is being practised, "e.g. this will help with the muscle at the back of your leg that is tight"; "your muscles at the front of your thigh are weak, which is why this is difficult"

	T	**Think about (T)**	Therapist encourages patient to think about how they are moving, without giving specific instructions e.g. "I want you to think about all the things we have discussed as you walk" "you're going to stand up, and I want you to think about how you are doing it"
Feedback	F-IF	**Internal Focus/Knowledge of Performance – Verbal** Relates to how the patient has performed the movement/the **movement pattern** used to achieve the goal (kinematics) – will contain some reference to the relevant body part (either direct or indirect) It might: **a) focus on movement error** - i.e. the therapist tells the patient what they have done wrong **b) focus on how to correct movement error** - i.e. the therapist tells the patient how to improve their next attempt **c) focus on correct aspects of performance** - i.e. the therapist tells the patient what they have done well	a) "You **didn't** bend your knee enough"; "you **didn't** have your weight over enough"; "you **haven't** got your weight far enough over" b) "Next time you need to bend you knee more"; "try to shift your weight over to the left more" c) "Good – you straightened your knee a lot more then"; "you were nice and light on your foot that time"
	F-EF1	**External Focus/Knowledge of Results Verbal** Provided after the completion of a movement about the outcome with regard to the **goal** (i.e. relates to function) It might: a) **relate to errors in overall goal achievement** b) **relates to successful overall goal achievement**	a) "You didn't manage to get your foot fully on the step"; "that turning was really difficult" b) "You managed that step up really well"; "you managed to turn a lot better that time"
	F-EF2	**External Focus - Other Auditory**	Use of auditory feedback mechanisms such as buzzers.

	F-EF3	**External Focus - Visual (e.g. mirror, target)**	Use of augmented feedback such as mirrors, taped lines on the floor, markers to aim for.
	F - MF	**Mixed Focus** Where a **single episode of feedback** includes both information of internal and external foci – WITHIN THE SAME SENTENCE (if in doubt, mark separately as IF and EF)	"You need to bend your **knee** more to get your foot onto the **step**"
	F-Q	**Quantified Feedback**	"You were 3 seconds faster that time"; "You managed 3 more step ups than last week"
	F-MG	**Tactile/Manual Guidance/Facilitation** Therapist providing feedback through handling.	Tapping/squeezing relevant muscle groups; joint approximation Therapist actively assisting or guiding the correct movement e.g. lifting foot to give dorsi flexion during stepping
	F-MS	**Simple Motivational Statement** (e.g. well done, good) One or two word positive statement – without specifically referring to the any aspect of the performance	"Well Done" "Good"
	F-PS1	**Patient Statement to Therapist – either automatic or prompted**	Patient: "that felt better"; "I managed it that time" (+ve) Patient: "that was awful" (-ve) Therapist asks the patient for their own feedback "how did that feel?"; "what did you think of that?"
General	GF	**General feedback with regard to overall progress, rehab goals, return home etc**	General discussion about rehabilitation, which may include overall feedback about how someone is doing e.g. "you've improved a lot since last week"

Appendix 7 – Example of Inter-Rater Reliability Testing



Microsoft Excel non-commercial use - Testing #2 Rater 1 and 2 Combined (I&F Removed)

Observational Study: exploring what happens in physiotherapy after stroke. REC REF: 09/H0504/80

Assessor: AG (red) and HK (blue)

Video Number: #2

Date: Oct 2010

	Time (minutes)	14		15		16		17		18		19		Present - Both Agree	Absent - Both Agree	R1 = Present R2 = Absent	R1 = Absent R2 = Present
Content / Task	Sit-Stand																
	Sit - Stand													3	8	1	0
	Standing and Stepping																
	Standing and Stepping													6	3	2	1
	Walking																
	Walking													0	12	0	0
	Other (not gait related)																
	Other (not gait related)													3	8	0	1
Instruction	Internal Focus - "How To" (IF)																
	Internal Focus - "How To" (IF)													4	4	4	0
	External Focus - "Do" (goal driven) (EF)																
	External Focus - "Do" (goal driven) (EF)													4	4	3	1
	Mixed Focus (MF)																
	Mixed Focus (MF)													0	11	1	0
	Simple Cue (VC)																
	Simple Cue (VC)													2	6	4	0
	Demonstration - manual/facilitatory/hands on (D1)																
	Demonstration - manual/facilitatory/hands on (D1)													0	10	1	1
	Demonstration - visual modelling (D2)																
	Demonstration - visual modelling (D2)													3	9	0	0
	External Focus - Other Auditory (EF 2)																
	External Focus - Other Auditory (EF 2)													0	12	0	0

Sheet1 Sheet2 Sheet3

Microsoft Excel non-commercial use - Testing #2 Rater 1 and 2 Combined (I&F Removed)

Row	A	B	O	P	Q	R
28		External Focus - Visual (e.g. mirror, target) (EF3)	0	12	0	0
29		Mixed Focus (MF)				
30		Mixed Focus (MF)	0	12	0	0

Page 1

Video Analysis Chart

Observational Study: exploring what happens in physiotherapy after stroke. **REC REF: 09/H0504/80**

Row	A	B	O	P	Q	R
31		Quantified Feedback (Q)				
32		Quantified Feedback (Q)	0	12	0	0
33		Simple Motivational Statement (e.g. well done, good) (MS)				
34		Simple Motivational Statement (e.g. well done, good) (MS)	2	8	1	1
35		Patient Statement to Therapist - automatic or prompted (PS1)				
36		Patient Statement to Therapist - automatic or prompted (PS1)	4	3	2	3
37	General	General feedback with regard to overall progress, rehab goals, return home... (Gen)				
38		General feedback with regard to overall progress, rehab goals, return home... (Gen)	0	10	1	1
39		Time (minutes)	31	144	20	9
40			204			

Sheet1 Sheet2 Sheet3

Microsoft Excel non-commercial use - Kappa - Video 2 (I&F Removed)

Video 2

kappa = $\frac{Pr(a) - Pr(e)}{1-Pr(e)}$

		Rater 1		
Rater 2		Present	Not Present	**Total**
Present		32	19	51
Not present		9	144	153
	Total	41	163	204

k = 1 = complete agreement between raters

k = < (or equal to) 0 = no agreement

Where Pr(a) = relative observed agreement between raters
and Pr(e) = hypothetical probability of chance agreement

Columns = rater 1
Rows = rater 2

Pr(a) = **0.862745**

Rater 1 said "present" 20.09804 % of the time
Rater 2 said "present" 25 % of the time

Therefore, the probability that they would both say "present" randomly is 0.0502
And the probability that they would both say "not present" randomly is 0.5993
Thus, the overall probability of random agreement, Pr(e) is **0.6495**

Kappa = $\frac{Pr(a) - Pr(e)}{1-Pr(e)}$ **0.608392**

κ	**Interpretation**
< 0	Poor agreement
0.0 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 1.00	Almost perfect agreement

Sheet1 Sheet2 Sheet3

Appendix 8 – Final Analysis Matrix

Microsoft Excel non-commercial use - Video Analysis Chart V3 - for external raters

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Assessor:				Video Number:											Date:			
2																			
3		**Time (minutes)**																	
4	**Content / Task**	Sit-Stand																	
5		Exercises in Standing																	
6		Walking (any stepping exercise > 1 gait cycle)																	
7		Other (not gait related)																	
8	**Instruction**	Internal Focus - "How To" **(IF)**																	
9		External Focus "Do" (goal driven) **(EF)**																	
10		Mixed Focus **(MF)**																	
11		Verbal Cue **(VC)**																	
12		Demonstration - manual/facilitatory/hands on **(D1)**																	
13		Demonstration - visual modelling **(D2)**																	
14	**Feedback**	Internal Focus/KP - Verbal **(IF)**																	
15		External Focus/KR - Verbal **(EF)**																	
16		External Focus - Other Auditory **(EF 2)**																	
17		External Focus - Visual (e.g. mirror, target) **(EF 3)**																	
18		Mixed Focus **(MF)**																	
19		Quantified Feedback **(Q)**																	
20		Tactile/Manual Guidance/Facilitation **(MG)**																	
21		Simple Motivational Statement (e.g. well done, good) **(MS)**																	
22		Patient Statement to Therapist (automatic or prompted) **(PS1)**																	
23	**General**	Genreral chat with regard to progress, rehab goals, return home etc																	
24		**Time (minutes)**																	
25																			
26																			

Appendix 9 – Examples of Explicit and Implicit Learning

Example 1: Weight Bearing Activity in Standing

Rationale – patients with stroke commonly have difficulty transferring their weight onto their hemiparetic leg. This can be for numerous reasons, including muscle weakness, sensory loss and perceptual problems. Ability to weight transfer is essential to walking, and activities to address this are therefore common in early gait re-education.

Activity – patient standing and practicing shifting their weight over to their hemiparetic side and then back to midline.

Explicit Learning – practice the activity with instruction and feedback from the therapist. Give feedback and correct the movement as the patient practices.

" I want you to take your weight over onto your right leg. Think about straightening your knee and squeezing your bottom. Make that leg strong and then move your hips over to the right……..”

Implicit Learning – practice repetitively reaching over to the right to pick up a cup placed on a table, which will elicit automatic weight shift to the right. Allow the patient to practice and self modify.

“Reach for that cup over there and pass it to me [in the middle]”

Example 2: Stepping with Hemiparetic Leg

Rationale – patients with hemiparesis may have difficulty sequencing the muscle activity required to step their leg forwards. This may be due to a number of factors including muscle weakness, increased muscle tone and sensory loss. Patients often compensate, for example by hitching at the hip, or by swinging the leg out (circumducting). Improving the pattern of stepping with the hemiparetic leg is common during gait re-education.

Activity – practicing stepping the hemiparetic leg forwards and backwards whilst standing (with a therapy table on one side for support/safety if necessary).

Explicit Learning - practice stepping with instruction and feedback from the therapist.

“ We're going to practice stepping with your right leg now – forwards and back. So, I want you to take your weight to the left, and then step the right foot forwards. Think about dropping your pelvis and then bending at your hip and knee, bring the leg forwards, and then heel to the floor”

Implicit Learning – practice the activity without detailed instruction. A small 2” block could be placed in front of the patient for them to place their foot on as this will encourage hip and knee flexion. Allow the patient to practice and self modify.

“Step onto this block and then down……and keep going with practicing that”

Example 3: Walking

Rationale – enabling the opportunity to practice the activity of walking is essential in order to put the component parts into practice.

Activity – practicing walking with support/aids as necessary.

Explicit Learning – practice walking with ongoing instruction and feedback from the therapist.

"Let's practice some walking. Really try to pick your foot up as you swing the leg through. Think about getting your heel to the floor. Stay up tall......."

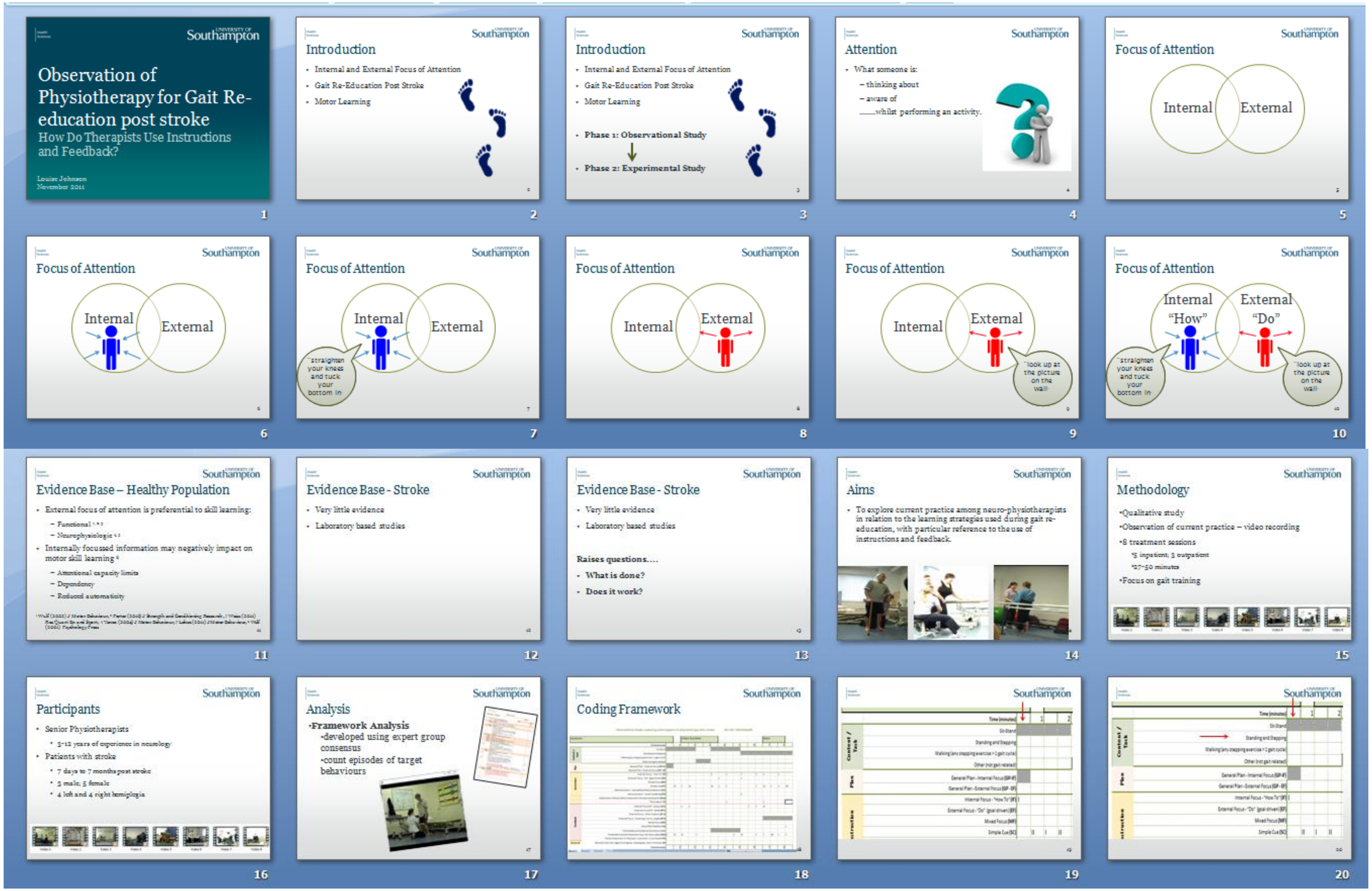
Implicit Learning – practice walking with supervision from the therapist

"OK, let's walk back to the ward!"

Appendix 10 – Observational Study Conference Presentations

UK Stroke Forum, Glasgow 2011 – Presentation Slides

Post Graduate Conference, University of Southampton 2011 - Poster


Southampton
Observation of Physiotherapy for Gait Re-education post stroke
How Do Therapists Use Instructions and Feedback?
Louise Johnson
November 2011
1
Introduction
Internal and External Focus of Attention
Gait Re-Education Post Stroke
Motor Learning
2
Introduction
Internal and External Focus of Attention
Gait Re-Education Post Stroke
Motor Learning
Phase 1: Observational Study
Phase 2: Experimental Study
3
Attention
What someone is:
– thinking about
– aware of
whilst performing an activity.
4
Focus of Attention
Internal
External
5
Focus of Attention
Internal
External
6
Focus of Attention
Internal
External
"straighten your knees and tuck your bottom in"
7
Focus of Attention
Internal
External
8
Focus of Attention
Internal
External
"look up at the picture on the wall"
9
Focus of Attention
Internal "How"
External "Do"
"straighten your knees and tuck your bottom in"
"look up at the picture on the wall"
10
Evidence Base – Healthy Population
External focus of attention is preferential to skill learning:
– Functional
– Neurophysiologic
Internally focussed information may negatively impact on motor skill learning
– Attentional capacity limits
– Dependency
– Reduced automaticity
11
Evidence Base - Stroke
Very little evidence
Laboratory based studies
12
Evidence Base - Stroke
Very little evidence
Laboratory based studies
Raises questions....
What is done?
Does it work?
13
Aims
To explore current practice among neuro-physiotherapists in relation to the learning strategies used during gait re-education, with particular reference to the use of instructions and feedback.
14
Methodology
Qualitative study
Observation of current practice – video recording
8 treatment sessions
5 inpatient; 3 outpatient
27-50 minutes
Focus on gait training
15
Participants
Senior Physiotherapists
5-12 years of experience in neurology
Patients with stroke
7 days to 7 months post stroke
3 male; 5 female
4 left and 4 right hemiplegia
16
Analysis
Framework Analysis
developed using expert group consensus
count episodes of target behaviours
17
Coding Framework
18
19
20


Southampton
Analysis
•Thematic Content Analysis
•iterative process
•transcripts and video's
•describe and interpret themes and patterns of behaviour
Results
Therapists talk a lot!!
On average 19.5 feedback statements per treatment session, compared to an average of 69.5 instructions.
Approximately one instruction or piece of feedback was given every 14 seconds
Example:
T: OK – and again. Before you erm, lift your toes up...just a second...let your knee just drop forwards a little bit. Not that one – yeah, then toes up.
P: Not both of them?
T: No – that's it. Good – OK. And then toes up. And down – OK. So it's – knee drops, toes....so what you're doing is, you're sort of isolating the movement to you knee and your ankle. And again – toes up. You shouldn't have too much upper body stuff going on. And again, drop your knee. Toes up. Good.
Example
T: So all these things are working towards that goal.
P: That's it, yeah.
T: OK, right – so we're going to do standing work, sit to stand work.
P: OK
T: OK. You need to stand up, then you need to be moving your feet – stepping. OK – so that's the programme we planned. Are you happy with that?
P: Yeah – that's fine, yeah.
T: That's what you want to do?
Results – Attentional Focus of Statements
•67% internally focussed
•22% externally focussed
•11% mixed focus
Mixed Focus Statement
External Focus Statement
Internal Focus Statement
Video Number
Results – Attentional Focus of Instructional Statements
Mixed Focus
External Focus
Internal Focus
Video Number
Results – Attentional Focus of Feedback Statements
Results – Attentional Focus of Feedback Statements
Additional Themes
Conversational Padding
– Prompts – "and again", "keep going"
– General Motivation – "well done", "good"
Think About
– "....if you want to stand up again – but think about how you're standing up."
Overt Observation
– "...I'm just going to have a look at how you are moving"
Conversational Padding
Discussion
Encouraging patients to think about how to move may.....
increase cognitive and attentional demand
not give patients the opportunity to demonstrate what they can achieve themselves
constrain or interfere with automatic control processes [7,8]
increase self-consciousness/pressure to perform well
conscious control = reduced automaticity
Next Steps
Develop two "libraries" of intervention to be compared in an experimental study
– Internal versus external focus of attention
– Feasibility randomised controlled trial
– Early gait re-education post stroke
Acknowledgements:
Professor Jane Burridge – University of Southampton
Dr Sara Demain – University of Southampton
Hayden Kirk – Expert Clinical Advisor
Anna Gould - Expert Clinical Advisor
Thank you!
Questions?
Louise Johnson
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Observation of Physiotherapy for Early Gait Re-Education Post Stroke – How Do Therapists Use Instructions and Feedback?

Johnson, L School of Health Sciences, University of Southampton, UK (lj1b06@soton.ac.uk)

Introduction

The use of instruction and feedback forms an integral part of the sensorimotor learning process. Such statements can direct attention of the learner either internally or externally.

INTERNAL FOCUS OF ATTENTION – directs the performers attention towards the actual components of movement *e.g. "straighten your knees and tuck your bottom in"*

EXTERNAL FOCUS OF ATTENTION – directs the performers attention towards the desired effects of the movement, *e.g. "look up at the clock on the wall"*

Research carried out within healthy populations has consistently shown that externally focussed information is preferential for skill learning and skill retention. Theories propose that when learners are prompted to adopt an internal focus, they try to consciously control their movements – which constrains the motor system and inadvertently disrupts automatic control processes; whereas if attention is focussed towards the movement effect (external focus) the motor system is able to more naturally self-organize[1]. Providing declarative, explicit knowledge through internally focussed instructions/feedback therefore has the potential to cause skill breakdown.

Despite the use of verbal instruction and feedback being unequivocally embedded within clinical practice, little is known about how therapists use internal and external focus statements, or about the impact that focus of attention has on learning post stroke.

The aim of this study was to explore current practice among neuro-physiotherapists in relation to the learning strategies used during gait re-education, with particular reference to the use of instructions and feedback.

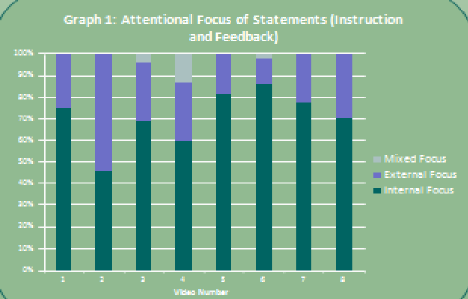
1. [illegible]

Design: Observational analysis of physiotherapy treatment sessions with data collected via video recording (n=8).

Setting: inpatient and outpatient stroke rehabilitation facilities in two NHS Trusts.

Participants: 8 stroke patients, aged 36 to 85 years, and ranging from 7 to 216 days post stroke; 8 senior neuro physiotherapists with 3-12 years experience working in neurological rehabilitation.

Data Analysis: Verbal dialogue from the recordings was transcribed verbatim. Transcripts and videos were then analysed concurrently using fundamental qualitative description. A **framework analysis** approach was applied to relevant sections of video in order to count episodes of target behaviours. Using expert group consensus, codes were generated from the data itself, were constantly modified, and then systematically applied. Alongside this, an iterative process was used to apply **thematic content analysis** to both the transcripts and the video's themselves, in order to report, describe and interpret themes and patterns of behaviour.



Findings

On average, verbal instruction or feedback statements were delivered **every 14 seconds.**

Instructional statements were particularly frequent.

Feedback statements were less common.

Internally focussed statements were common (73% of all statements).

Externally focussed statements substantially less common (25% of all statements).

Simple motivational statements (e.g. "good") and verbal prompts (e.g. "and again") were also used regularly.

Patients were frequently encouraged to "think about" their performance.

Conclusion

Physiotherapy practice tends toward an explicit learning environment where the patient is encouraged to be consciously aware of their performance. This may reduce automaticity of movement and hinder learning and retention. Greater consideration of the attentional focus and timing of instructions/feedback may optimise motor learning post stroke.

Next steps.....

The next phase of this research will compare implicit and explicit learning strategies for early gait re-education post stroke. The interventions that will be applied have been derived from the observations made during this study.

UNIVERSITY OF Southampton
School of Health Sciences

Appendix 11 – Observational Study Publication

Internal and External Focus of Attention During Gait Re-Education: An Observational Study of Physical Therapist Practice in Stroke Rehabilitation

Louise Johnson, Jane H. Burridge, Sara H. Demain

Background. Focus of attention is known to play an important role in motor skill learning, yet little is known about how attention is directed within the context of stroke rehabilitation.

Objective. The aims of this study were: (1) to identify physical therapists' use of internal and external focus of attention during gait rehabilitation for individuals with hemiplegia following stroke and (2) to use the findings to design an experimental study examining the impact of focus of attention on learning poststroke.

Design. The study design involved direct nonparticipation observation of physical therapy treatment sessions.

Methods. Eight physical therapy treatment sessions, in which gait rehabilitation was taking place, were video recorded. Patients were aged between 36 and 85 years, and ranged from 7 to 216 days poststroke; physical therapists had between 3 and 12 years of experience in stroke rehabilitation. Data analysis took 2 forms: (1) clear definitions of internal and external focus of attention were agreed on via a consensus group and used to develop an analysis matrix through which incidences of instruction and feedback were identified, categorized, and counted; and (2) verbal dialogue was transcribed verbatim and transcripts were thematically analyzed to provide a detailed description of how instructions and feedback were used, illustrated by examples.

Results. The use of instructions and feedback (internal and external focus) was high; an average of one verbal instruction or feedback statement was delivered every 14 seconds. Sixty-seven percent of the statements were internally focused, 22% were externally focused, and 11% were of mixed focus. Unfocused statements (eg, "good") also were used regularly. Patients were frequently encouraged to "think about" their performance.

Limitations. Observational data collection methods may result in changes in the behavior of those observed, which is a potential source of bias. The small sample size also was a limitation of the study.

Conclusion. Physical therapists frequently encouraged patients to be aware of their movements and their performance (internal focus). This approach may reduce automaticity and hinder learning and retention.

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Submitted: July 23, 2012

Appendix 12 – TEA Standard Protocol

Test of Everyday Attention

Subtest 2 – Elevator Counting

Imagine that you are in an elevator in your hotel. The visual floor indicator light that should show you what floor you are on is not working. You need to know which floor you are at, so you can get off and go to your room. The elevator is only going up. You are helped by the fact that as the elevator passes each floor, a tone sounds. So, by counting the tomes you can work out which floor the elevator is at. Tell me how many floors you count, or in other words which floor you have reached when the tones stop, and when the voice on the tape says "how many?". You will notice that the tome the elevator takes to move up from floor to floor may vary.

Play the first example, counting with the subject, and if they are right, say:

That's right; you would be on the third floor.

If they are wrong, rewind and play it again, continuing until they are right.

Let's have another practice.

Now I would like you to do the same thing, with another series of elevator tones.

String	Answer	Correct?
1		
2		
3		
4		
5		
6		
7		
	Total Correct	

Score 7 = normal; score 6 = doubtful; score 5 or less = definitely abnormal

Subtest 3 – Elevator Counting with Distraction

This time you will hear the same elevator tone, but now there are also higher pitched tomes as well as the lower tones you are listening for. Try to ignore the high pitched tones and count the other tones to tell which floor you are on, as in the last exercise. Let's try two practice trials to make sure you can tell the elevator tone indicator from the higher tone, remembering that you are trying to ignore the high tone and try not to count it. The first tone you will hear i each string is always the low tone.

Play the first example, counting with the subject, and if they are right, say:

That's right, you would be on the third floor.

If they are wrong, rewind and play again until they get it right.

Let's have another practice.

Now, I would like you to do the same thing, with another series of elevator tones.

String	Answer	Correct?
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
	Total Correct (Raw Score)	
	Scaled Score	

Hearing Impairment? Yes / No

____

Normal / Abnormal

Version A					Version B				
	18-34	35-49	50-64	65-80		18-34	35-49	50-64	65-80
0	4	4	4	4	0	-	1	-	-
1	4	5	4	5	1	-	2	-	1
2	5	5	4	5	2	1	2	1	2
3	5	6	5	6	3	2	3	2	3
4	6	6	5	6	4	3	4	3	3
5	6	7	6	7	5	3	5	4	4
6	7	7	7	7	6	4	6	5	5
7	8	8	7	8	7	6	7	6	6
8	9	9	8	9	8	7	8	7	8
9	10	11	10	11	9	9	10	9	10
10	13	13	12	13	10	12	13	12	12

Red = ABNORMAL

Appendix 13 – Berg Balance Scale

Appendix 14 – Hauser Mobility Index

Appendix 15 – Wisconsin Gait Scale

Appendix 16 – Numerical Rating Scale

Berg Balance Scale

GENERAL INSTRUCTIONS

Demonstrate each task and/or give instructions as written. When scoring, record the lowest response category that applies for each item.

In most items, the subject is asked to maintain a given position for specific time. Progressively more points are deducted if the time or distance requirements are not met, if the subject's performance warrants supervision, or if the subject touches an external support or receives assistance from the examiner. Subjects should understand that they must maintain their balance while attempting the tasks. The choices of which leg to stand on or how far to reach are left to the subject. Poor judgment will adversely influence the performance and the scoring.

Equipment required for testing are a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5 and 10 inches (5, 12.5 and 25 cm). Chairs used during testing should be of reasonable height. Either a step or a stool (of average step height) may be used for item #12.

1. *SITTING TO STANDING*

INSTRUCTIONS: Please stand up. Try not to use your hands for support.

( ) 4 able to stand without using hands and stabilize independently

( ) 3 able to stand independently using hands

( ) 2 able to stand using hands after several tries

( ) 1 needs minimal aid to stand or to stabilize

( ) 0 needs moderate or maximal assist to stand

2. STANDING UNSUPPORTED

INSTRUCTIONS: Please stand for two minutes without holding.

( ) 4 able to stand safely 2 minutes

( ) 3 able to stand 2 minutes with supervision

( ) 2 able to stand 30 seconds unsupported

( ) 1 needs several tries to stand 30 seconds unsupported

( ) 0 unable to stand 30 seconds unassisted

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

3. SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL

INSTRUCTIONS: Please sit with arms folded for 2 minutes.

( ) 4 able to sit safely and securely 2 minutes

( ) 3 able to sit 2 minutes under supervision

( ) 2 able to sit 30 seconds

( ) 1 able to sit 10 seconds

( ) 0 unable to sit without support 10 seconds

4. STANDING TO SITTING

INSTRUCTIONS: Please sit down.

( ) 4 sits safely with minimal use of hands

( ) 3 controls descent by using hands

( ) 2 uses back of legs against chair to control descent

( ) 1 sits independently but has uncontrolled descent

( ) 0 needs assistance to sit

5. TRANSFERS

INSTRUCTIONS: Arrange chairs for a pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without arm rests. You may use two chairs (one with and one without arm rests) or a bed and a chair.

( ) 4 able to transfer safely with minor use of hands

( ) 3 able to transfer safely definite need of hands

( ) 2 able to transfer with verbal cueing and/or supervision

( ) 1 needs one person to assist

( ) 0 needs two people to assist or supervise to be safe

6. STANDING UNSUPPORTED WITH EYES CLOSED

INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.

( ) 4 able to stand 10 seconds safely

( ) 3 able to stand 10 seconds with supervision

( ) 2 able to stand 3 seconds

( ) 1 unable to keep eyes closed 3 seconds but stays steady

( ) 0 needs help to keep from falling

7. STANDING UNSUPPORTED WITH FEET TOGETHER

INSTRUCTIONS: Place your feet together and stand without holding.

( ) 4 able to place feet together independently and stand 1 minute safely

( ) 3 able to place feet together independently and stand for 1 minute with supervision

( ) 2 able to place feet together independently and to hold for 30 seconds

( ) 1 needs help to attain position but able to stand 15 seconds feet together

( ) 0 needs help to attain position and unable to hold for 15 seconds

8. REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING

INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the finger reaches while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)

( ) 4 can reach forward confidently >25 cm (10 inches)

( ) 3 can reach forward >12.5 cm safely (5 inches)

( ) 2 can reach forward >5 cm safely (2 inches)

( ) 1 reaches forward but needs supervision

( ) 0 loses balance while trying/ requires external support

9. PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION

INSTRUCTIONS: Pick up the shoe/slipper which is placed in front of your feet.

( ) 4 able to pick up slipper safely and easily

( ) 3 able to pick up slipper but needs supervision

( ) 2 unable to pick up but reaches 2-5cm (1-2 inches) from slipper and keeps balance independently

( ) 1 unable to pick up and needs supervision while trying

( ) 0 unable to try/needs assist to keep from losing balance or falling

10. TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING

INSTRUCTIONS: Turn to look directly behind you over toward left shoulder. Repeat to the right.

(Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.)

( ) 4 looks behind from both sides and weight shifts well

( ) 3 looks behind one side only other side shows less weight shift

( ) 2 turns sideways only but maintains balance

( ) 1 needs supervision when turning

( ) 0 needs assist to keep from losing balance or falling

11. TURN 360 DEGREES

INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.

( ) 4 able to turn 360 degrees safely in 4 seconds or less

( ) 3 able to turn 360 degrees safely one side only in 4 seconds or less

( ) 2 able to turn 360 degrees safely but slowly

( ) 1 needs close supervision or verbal cueing

( ) 0 needs assistance while turning

12. PLACING ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED

INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.

( ) 4 able to stand independently and safely and complete 8 steps in 20 seconds

( ) 3 able to stand independently and complete 8 steps >20 seconds

( ) 2 able to complete 4 steps without aid with supervision

( ) 1 able to complete >2 steps needs minimal assist

( ) 0 needs assistance to keep from falling/unable to try

13. STANDING UNSUPPORTED ONE FOOT IN FRONT

INSTRUCTIONS: (DEMONSTRATE TO SUBJECT)

Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject's normal stride width)

( ) 4 able to place foot tandem independently and hold 30 seconds

( ) 3 able to place foot ahead of other independently and hold 30 seconds

( ) 2 able to take small step independently and hold 30 seconds

( ) 1 needs help to step but can hold 15 seconds

( ) 0 loses balance while stepping or standing

14. STANDING ON ONE LEG

INSTRUCTIONS: Stand on one leg as long as you can without holding.

( ) 4 able to lift leg independently and hold >10 seconds

( ) 3 able to lift leg independently and hold 5-10 seconds

( ) 2 able to lift leg independently and hold = or >3 seconds

( ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently

( ) 0 unable to try or needs assist to prevent fall

TOTAL (maximum 56) _____

Interpretation:

0–20, wheelchair bound

21–40, walking with assistance

41–56, independent

Hauser Ambulation Index

❑ 0 = Asymptomatic; fully active.

❑ 1 = Walks normally, but reports fatigue that interferes with athletic or other demanding activities.

❑ 2 = Abnormal gait or episodic imbalance; gait disorder is noticed by family and friends; able to walk 25 feet (8 meters) in 10 seconds or less.

❑ 3 = Walks independently; able to walk 25 feet in 20 seconds or less.

❑ 4 = Requires unilateral support (cane or single crutch) to walk; walks 25 feet in 20 seconds or less.

❑ 5 = Requires bilateral support (canes, crutches, or walker) and walks 25 feet in 25 seconds or less; *or* requires unilateral support but needs more than 20 seconds to walk 25 feet.

❑ 6 = Requires bilateral support and more than 20 seconds to walk 25 feet; may use wheelchair* on occasion.

❑ 7 = Walking limited to several steps with bilateral support; unable to walk 25 feet; may use wheelchair* for most activities.

❑ 8 = Restricted to wheelchair; able to transfer self independently.

❑ 9 = Restricted to wheelchair; unable to transfer self independently.

*The use of a wheelchair may be determined by lifestyle and motivation. It is expected that patients in Grade 7 will use a wheelchair more frequently then those in Grades 5 or 6. Assignment of a grade in the range of 5 to 7, however, is determined by the patient.s ability to walk a given distance, and not by the extent to which the patient uses a wheelchair.

Source: Hauser SL, Dawson DM, Lehrich JR, Beal MF, Kevy SV, Propper RD, Mills JA,Weiner HL. Intensive immunosuppression in progressive multiple sclerosis. A randomized,threearm study of high-dose intravenous cyclophosphamide, plasma exchange, andACTH.N Engl J Med. 1983 Jan 27;308(4):173-80.

Wisconsin Gait Score

Observe subject walking toward and away from observer, and from the side.

STANCE PHASE AFFECTED LEG

1. Use of a hand held gait aid
   - 1 = No gait aid
   - 2 = Minimal gait aid use — Gait aid used optionally with minimal weight transferred on to it, narrow base of support.
   - 3 = Minimal gait aid, wide base — Gait aid used minimally, may rock the legs of a quad cane as weight transferred forward. Distance between unaffected foot to cane is greater than distance between affected and unaffected foot (wide support base).
   - 4 = Marked use — Weight through the aid, narrow base of support.
   - 5 = Marked use, wide base — Transfers weight through the aid, wide support base.
2. Stance time on impaired side
   - 1 = Equal — An equal amount of time is spent on the affected leg compared to the unaffected leg during single leg stance.
   - 2 = Unequal — The subject remains on the affected leg for a shorter period of time compared to the unaffected leg during single leg stance.
   - 3 = Very brief — The subject spends the least amount of time on the affected time necessary to accomplish advancing the unaffected leg.
3. Step length of unaffected side
   - 1 = Step through — The heel of the unaffected foot clearly advances beyond the toe of the affected foot.
   - 2 = Foot does not clear — The heel of the unaffected foot does not advance beyond the toe of the affected foot.
   - 3 = Step to — The unaffected foot is placed behind or up to, but not beyond the affected foot.
4. Weight shift to the affected side, with or without a gait aid.
   - 1 = Full shift — The subject's head and trunk shift laterally over the affected foot during single stance.
   - 2 = Decreased shift — The subject's head and trunk crosses midline, but not over the affected foot.
   - 3 = Very limited shift — The subject's head and trunk does not cross midline, minimal weight shift in the direction of the affected side.
5. Stance width (measure distance between feet prior to toe off of affected foot)
   - 1 = Normal — Up to one shoe width between feet.
   - 2 = Moderate — Up to two shoe widths between feet.
   - 3 = Wide — Greater than two shoe widths between feet.

TOE OFF AFFECTED LEG

6. Guardedness (pause prior to advancing affected leg)
   - 1 = None — Good forward momentum with no hesitancy noted.
   - 2 = Slight — Slight pause prior to toe off.
   - 3 = Marked hesitation — Subject pauses prior to toe off.
7. Hip extension of affected side (observe gluteal crease from behind subject)
   - 1 = Equal extension — Hips equally extend during push-off. Maintains erect posture during toe off.
   - 2 = Slight flexion — Hip extends at least to neutral, but less than unaffected side
   - 3 = Marked flexion — Forward trunk and hip flexion at toe-off.

SWING PHASE AFFECTED LEG

8. External rotation during initial swing
   - 1 = Same as unimpaired leg
   - 2 = Increased rotation — Externally rotates the leg <45°, but more than the uninvolved side.
   - 3 = Marked — Externally rotates the leg >45°.
9. Circumduction at mid swing (observe path of affected heel)
   - 1 = None — Affected foot adducts no more than unaffected foot during swing.
   - 2 = Moderate — Affected foot adducts up to one she width during swing.
   - 3 = Marked — Affected foot circumducts more than one shoe width during swing.
10. Hip hiking at mid swing
    - 1 = None — Pelvis slightly dips during swing.
    - 2 = Elevation — Pelvis is elevated during swing phase.
    - 3 = Vaults — Little true hip flexion, subject contracts lateral trunk muscles and elevates hip during swing.
11. Knee flexion from toe off to mid swing
    - 1 = Normal — Affected knee flexes equally to unaffected side.
    - 2 = Some — Affected knee flexes, but less than unaffected of knee flexion.
    - 3 = Minimal — Minimal flexion noted in affected knee (flexion barely seen).
    - 4 = None — Knee remains in extension through out swing.
12. Toe clearance
    - 1 = Normal — Toe clears the floor throughout swing.
    - 2 = Slight drag — Toe drags slightly at beginning of swing phase.
    - 3 = Marked — Toe drags during the majority of the swing.
13. Pelvic rotation at terminal swing
    - 1 = Forward — The pelvis is rotated forward to prepare for heel strike.
    - 2 = Neutral — Posture is erect with pelvis in neutral rotation.
    - 3 = Retracted — Pelvis has marked lag behind the unaffected pelvis.

HEEL STRIKE AFFECTED LEG

14. Initial foot contact
    - 1 = Heel strike — Heel makes initial contact with the floor.
    - 2 = Foot flat — Foot lands with weight distributed over entire foot.
    - 3 = No contact of heel — Foot lands on lateral border of the foot or toes.

* Items 1 and 4 are weighted by 3/5 and 3/4, respectively, before adding individual items for a total score.

Total score = SUM(points for 2 to 10; 12 to 14) + (3/5*(points for 1)) + (3/4* (points for 11)).

Interpretation:

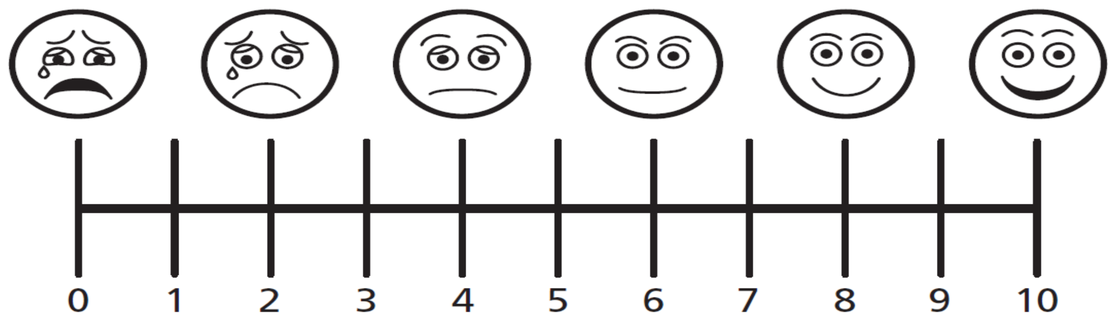
Minimum score = 13.35

Maximum score = 42

The higher the score, the more affected the gait.

Numerical Rating Scale

"On a scale of 0 to 10, where 0 equals not at all confident and 10 equals fully confident......how confident do you feel about the way in which you are walking?"



Appendix 17 – Implicit and Explicit Learning Treatment Guidance

Characteristics of explicit and implicit Learning – Guidance for Therapists.

Activities based around:

A) Sit to stand

B) Standing (static or < 1 gait cycle)

i. Stance

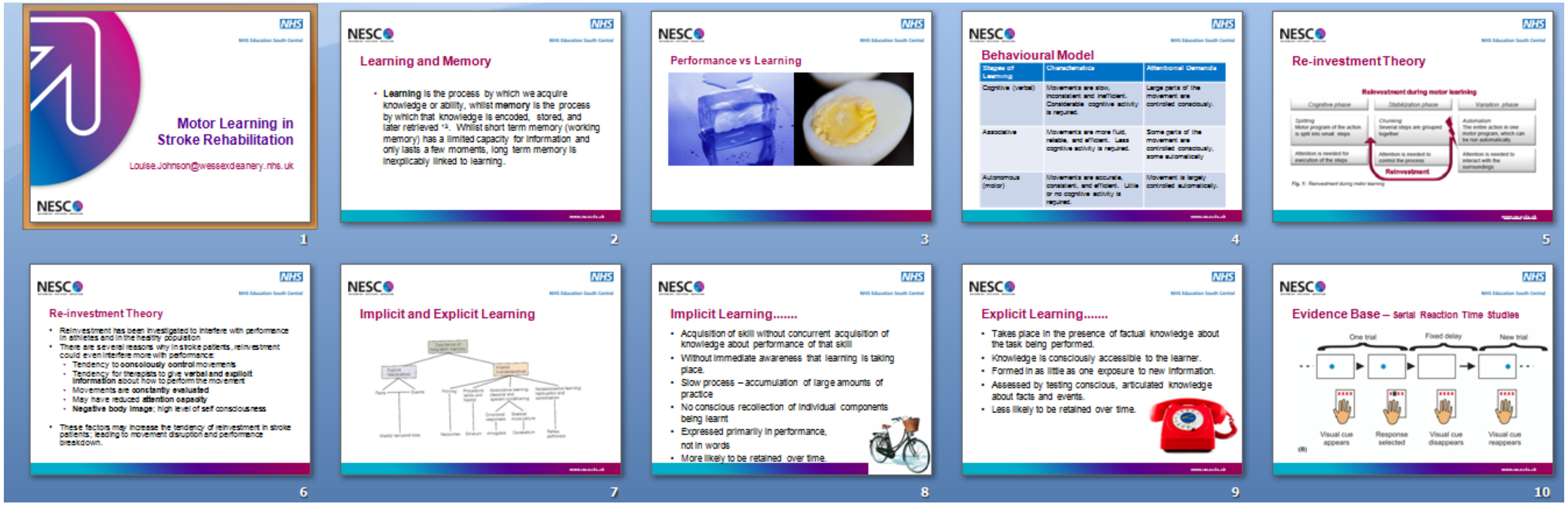
ii. Swing

iii. Walking (> 1 gait cycle)

	IMPLICIT LEARNING GROUP	**EXPLICIT LEARNING GROUP**
Duration of session	Aim for 30-45 minutes	Aim for 30-45 minutes
Task	Ensure the activity is functional; practice “whole” activities/ tasks. Use the environment or other non-verbal cues to elicit the desired movement. Promote automacity; allow self modification.	Break activities down and practice component parts. Ensure the patient is thinking about how they are moving; readily correct poor performance.
Instructions	Externally focussed and simple – goal orientated. Given at the beginning of the activity. May be accompanied by demonstration	Internally focussed and detailed – encourage patient to think about how to move. Given at the beginning and throughout the activity. May be accompanied by demonstration.
Feedback	Keep to a minimum. Avoid giving during the task. Keep externally focussed.	Give frequently – at least once for every 5 repetitions of any task. Can be given before, during and after the activity. Keep internally focussed.
Therapeutic Handling	Continue as normal but minimise concurrent verbal communication.	Continue as normal and accompany with verbal instruction/feedback.
Demonstration	Can use demonstration; but keep associated verbal instruction/feedback to a minimum [e.g. “like this…..”]	Can use demonstration; combine with related instruction and feedback to draw attention towards what the patient is seeing [e.g. “look at how I am doing it…..see how I am bending my knee”]
Visual Feedback	Can use visual feedback (e.g. mirrors); but keep associated verbal instruction/feedback to a minimum [e.g. I’m going to put a mirror here for you to look in……]	Can use visual feedback (e.g. mirrors); combine with related instruction and feedback to draw attention towards what the patient is seeing [e.g. “look at yourself in the mirror…..look at the

		position of your hips…"
Repetition	Provided that the activity is being performed safely, allow high numbers of repetitions. If the patient is not performing the activity well, allow them to practice. This will be dependent on ability/fatigue, but try to allow at least 3 sets of 5-10 repetitions (more if able). Give instructions and feedback only as outlined above. If they continue to struggle then **modify the task** if in order to make it more achievable.	Provided that the activity is being performed safely, allow high numbers of repetitions. If the patient is not performing the activity well, correct them immediately following the first few repetitions. Continue to give instruction and feedback (as outlined above) frequently. If they continue to struggle, **move on to a new task**.

Appendix 18 – Training Materials for Therapists


Motor Learning in Stroke Rehabilitation
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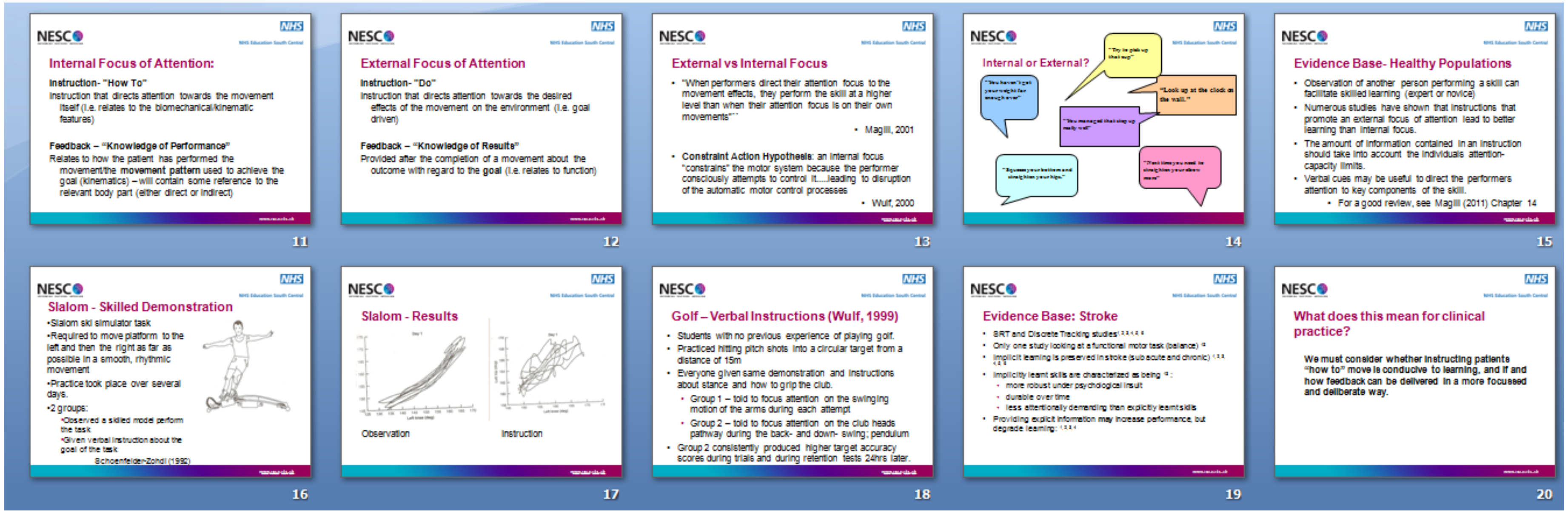
NESCO
NHS
1
Learning and Memory
Learning is the process by which we acquire knowledge or ability, whilst memory is the process by which that knowledge is encoded, stored, and later retrieved. Whilst short term memory (working memory) has a limited capacity for information and only lasts a few moments, long term memory is inexplicably linked to learning.
2
Performance vs Learning
3
Behavioural Model
Stages of Learning
Characteristics
Attentional Demands
Cognitive (verbal)
Movements are slow, inconsistent and inefficient. Considerable cognitive activity is required.
Large parts of the movement are controlled consciously.
Associative
Movements are more fluid, reliable, and efficient. Less cognitive activity is required.
Some parts of the movement are controlled consciously, some automatically
Autonomous (motor)
Movements are accurate, consistent, and efficient. Little or no cognitive activity is required.
Movement is largely controlled automatically.
4
Re-investment Theory
Reinvestment during motor learning
Cognitive phase
Stabilization phase
Variation phase
Reinvestment
5
Re-investment Theory
Reinvestment has been investigated to interfere with performance in athletes and in the healthy population
There are several reasons why in stroke patients, reinvestment could even interfere more with performance:
Tendency to consciously control movements
Tendency for therapists to give verbal and explicit information about how to perform the movement
Movements are constantly evaluated
May have reduced attention capacity
Negative body image; high level of self consciousness
These factors may increase the tendency of reinvestment in stroke patients; leading to movement disruption and performance breakdown.
6
Implicit and Explicit Learning
7
Implicit Learning.......
Acquisition of skill without concurrent acquisition of knowledge about performance of that skill
Without immediate awareness that learning is taking place.
Slow process – accumulation of large amounts of practice
No conscious recollection of individual components being learnt
Expressed primarily in performance, not in words
More likely to be retained over time.
8
Explicit Learning.......
Takes place in the presence of factual knowledge about the task being performed.
Knowledge is consciously accessible to the learner.
Formed in as little as one exposure to new information.
Assessed by testing conscious, articulated knowledge about facts and events.
Less likely to be retained over time.
9
Evidence Base – Serial Reaction Time Studies
One trial
Fixed delay
New trial
Visual cue appears
Response selected
Visual cue disappears
Visual cue reappears
10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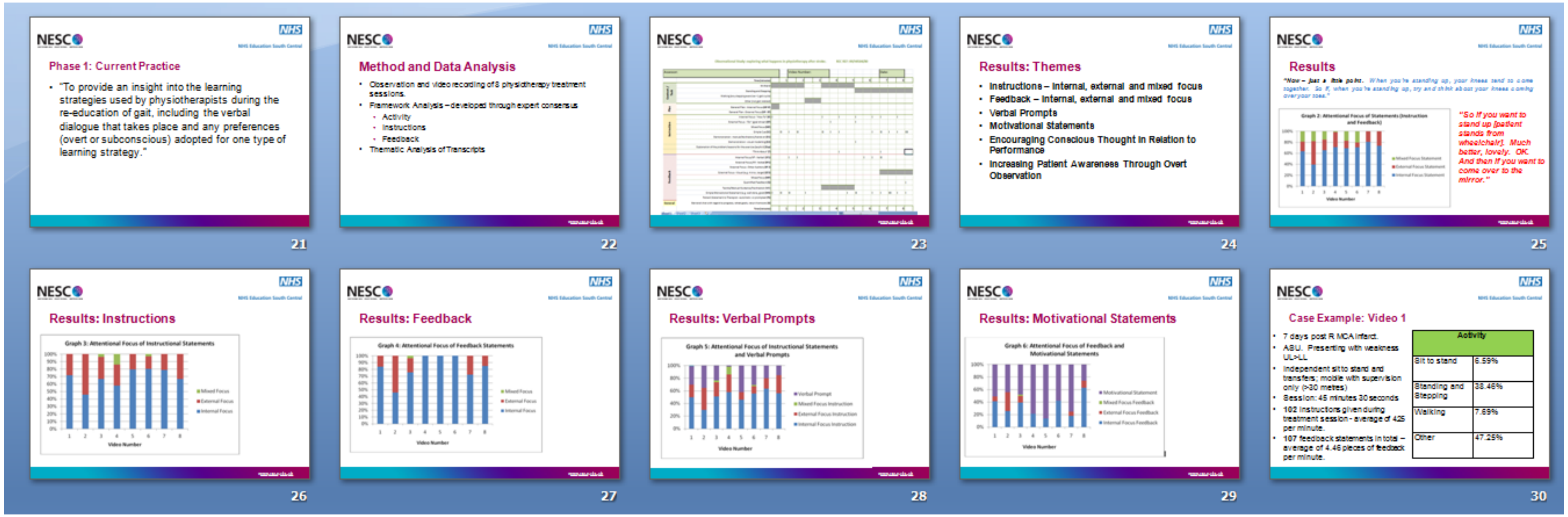
Internal Focus of Attention:
Instruction- "How To"
Instruction that directs attention towards the movement itself (i.e. relates to the biomechanical/kinematic features)
Feedback – "Knowledge of Performance"
Relates to how the patient has performed the movement/the movement pattern used to achieve the goal (kinematics) – will contain some reference to the relevant body part (either direct or indirect)
11
External Focus of Attention
Instruction- "Do"
Instruction that directs attention towards the desired effects of the movement on the environment (i.e. goal driven)
Feedback – "Knowledge of Results"
Provided after the completion of a movement about the outcome with regard to the goal (i.e. relates to function)
12
External vs Internal Focus
• "When performers direct their attention focus to the movement effects, they perform the skill at a higher level than when their attention focus is on their own movements"
• Magill, 2001
• Constraint Action Hypothesis: an internal focus "constrains" the motor system because the performer consciously attempts to control it....leading to disruption of the automatic motor control processes
• Wulf, 2000
13
Internal or External?
"Look up at the clock on the wall."
14
Evidence Base- Healthy Populations
• Observation of another person performing a skill can facilitate skilled learning (expert or novice)
• Numerous studies have shown that instructions that promote an external focus of attention lead to better learning than internal focus.
• The amount of information contained in an instruction should take into account the individuals attention-capacity limits.
• Verbal cues may be useful to direct the performers attention to key components of the skill.
• For a good review, see Magill (2011) Chapter 14
15
Slalom - Skilled Demonstration
•Slalom ski simulator task
•Required to move platform to the left and then the right as far as possible in a smooth, rhythmic movement
•Practice took place over several days.
•2 groups:
•Observed a skilled model perform the task
•Given verbal instruction about the goal of the task
Schoenfelder-Zohdi (1992)
16
Slalom - Results
Observation
Instruction
17
Golf – Verbal Instructions (Wulf, 1999)
• Students with no previous experience of playing golf.
• Practiced hitting pitch shots into a circular target from a distance of 15m
• Everyone given same demonstration and instructions about stance and how to grip the club.
• Group 1 – told to focus attention on the swinging motion of the arms during each attempt
• Group 2 – told to focus attention on the club heads pathway during the back- and down- swing; pendulum
• Group 2 consistently produced higher target accuracy scores during trials and during retention tests 24hrs later.
18
Evidence Base: Stroke
• SRT and Discrete Tracking studies
• Only one study looking at a functional motor task (balance)
• Implicit learning is preserved in stroke (sub acute and chronic)
• Implicitly learnt skills are characterized as being:
• more robust under psychological insult
• durable over time
• less attentionally demanding than explicitly learnt skills
• Providing explicit information may increase performance, but degrade learning:
19
What does this mean for clinical practice?
We must consider whether instructing patients "how to" move is conducive to learning, and if and how feedback can be delivered in a more focussed and deliberate way.
20


NESC
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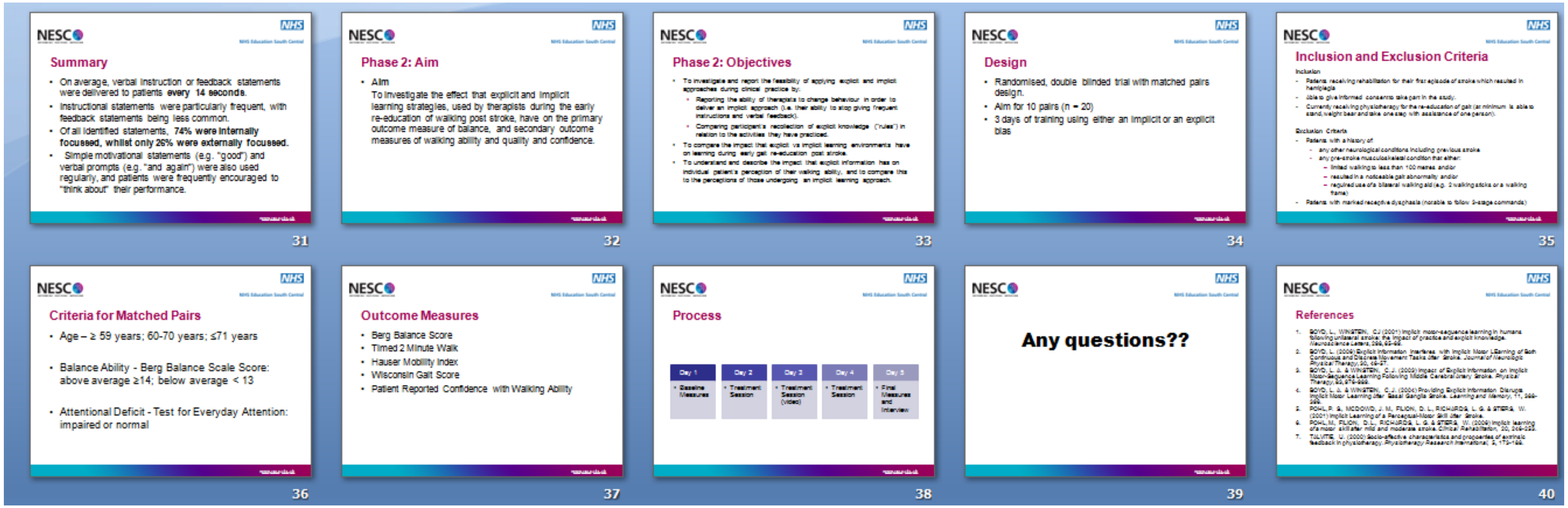
Phase 1: Current Practice
• "To provide an insight into the learning strategies used by physiotherapists during the re-education of gait, including the verbal dialogue that takes place and any preferences (overt or subconscious) adopted for one type of learning strategy."
21
Method and Data Analysis
• Observation and video recording of 8 physiotherapy treatment sessions.
• Framework Analysis – developed through expert consensus
• Activity
• Instructions
• Feedback
• Thematic Analysis of Transcripts
22
23
Results: Themes
• Instructions – Internal, external and mixed focus
• Feedback – Internal, external and mixed focus
• Verbal Prompts
• Motivational Statements
• Encouraging Conscious Thought in Relation to Performance
• Increasing Patient Awareness Through Overt Observation
24
Results
Graph 2: Attentional Focus of Statements (Instruction and Feedback)
Video Number
"So if you want to stand up [patient stands from wheelchair]. Much better, lovely. OK. And then if you want to come over to the mirror."
25
Results: Instructions
Graph 3: Attentional Focus of Instructional Statements
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8
Video Number
Mixed Focus
External Focus
Internal Focus
26
Results: Feedback
Graph 4: Attentional Focus of Feedback Statements
1 2 3 4 5 6 7 8
Video Number
Mixed Focus
External Focus
Internal Focus
27
Results: Verbal Prompts
Graph 5: Attentional Focus of Instructional Statements and Verbal Prompts
100%
80%
60%
40%
20%
0%
1 2 3 4 5 6 7 8
Video Number
Verbal Prompt
Mixed Focus Instruction
External Focus Instruction
Internal Focus Instruction
28
Results: Motivational Statements
Graph 6: Attentional Focus of Feedback and Motivational Statements
100%
80%
60%
40%
20%
0%
1 2 3 4 5 6 7 8
Video Number
Motivational Statement
Mixed Focus Feedback
External Focus Feedback
Internal Focus Feedback
29
Case Example: Video 1
• 7 days post R MCA infarct.
• ASU. Presenting with weakness UL>LL
• Independent sit to stand and transfers; mobile with supervision only (>30 metres)
• Session: 45 minutes 30 seconds
• 102 instructions given during treatment session - average of 4.25 per minute.
• 107 feedback statements in total – average of 4.46 pieces of feedback per minute.
Activity
Sit to stand 6.59%
Standing and Stepping 38.46%
Walking 7.69%
Other 47.25%
30


NESCO
NHS
NHS Education South Central
Summary
• On average, verbal instruction or feedback statements were delivered to patients every 14 seconds.
• Instructional statements were particularly frequent, with feedback statements being less common.
• Of all identified statements, 74% were internally focussed, whilst only 26% were externally focussed.
• Simple motivational statements (e.g. "good") and verbal prompts (e.g. "and again") were also used regularly, and patients were frequently encouraged to "think about" their performance.
31
Phase 2: Aim
• Aim
To investigate the effect that explicit and implicit learning strategies, used by therapists during the early re-education of walking post stroke, have on the primary outcome measure of balance, and secondary outcome measures of walking ability and quality and confidence.
32
Phase 2: Objectives
• To investigate and report the feasibility of applying explicit and implicit approaches during clinical practice by:
• Reporting the ability of therapists to change behaviour in order to deliver an implicit approach (i.e. their ability to stop giving frequent instructions and verbal feedback).
• Comparing participant's recollection of explicit knowledge ("rules") in relation to the activities they have practiced.
• To compare the impact that explicit vs implicit learning environments have on learning during early gait re-education post stroke.
• To understand and describe the impact that explicit information has on individual patient's perception of their walking ability, and to compare this to the perceptions of those undergoing an implicit learning approach.
33
Design
• Randomised, double blinded trial with matched pairs design.
• Aim for 10 pairs (n = 20)
• 3 days of training using either an implicit or an explicit bias
34
Inclusion and Exclusion Criteria
Inclusion
- Patients receiving rehabilitation for their first episode of stroke which resulted in hemiplegia
- Able to give informed consent to take part in the study.
- Currently receiving physiotherapy for the re-education of gait (at minimum is able to stand, weight bear and take one step with assistance of one person).
Exclusion Criteria
- Patients with a history of:
- any other neurological conditions including previous stroke
- any pre-stroke musculoskeletal condition that either:
– limited walking to less than 100 metres and/or
– resulted in a noticeable gait abnormality and/or
– required use of a bilateral walking aid (e.g. 2 walking sticks or a walking frame)
- Patients with marked receptive dysphasia (not able to follow 3-stage commands)
35
Criteria for Matched Pairs
• Age – ≥ 59 years; 60-70 years; ≤71 years
• Balance Ability - Berg Balance Scale Score: above average ≥14; below average < 13
• Attentional Deficit - Test for Everyday Attention: impaired or normal
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Outcome Measures
• Berg Balance Score
• Timed 2 Minute Walk
• Hauser Mobility Index
• Wisconsin Gait Score
• Patient Reported Confidence with Walking Ability
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Process
Day 1
• Baseline Measures
Day 2
• Treatment Session
Day 3
• Treatment Session (video)
Day 4
• Treatment Session
Day 5
• Final Measures and Interview
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Any questions??
39
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Appendix 19 – Feasibility Study, Therapist Information

Letter of Invitation

Participant Information Sheet

Consent Forms

UNIVERSITY OF Southampton
School of Health Sciences

Louise Johnson
University of Southampton
Highfield Campus
Building 45
Southampton
SO17 1BJ

Tel: 07799 65 77 64
Email: lj1b06@soton.ac.uk

REC Ref Number: 11/YH/0111

January 2011

Dear Sir or Madam

How do different styles of information provision affect learning during early gait rehabilitation post stroke?

I am a physiotherapist, and am currently carrying out a research study examining different approaches to early gait rehabilitation post stroke. As part of this study, I will be looking at the effect that different ways of talking to patients has on their learning. I would like to invite you to take part in this.

I have enclosed an information sheet which explains more about what this research is about and what involvement would consist of. I would be grateful if you could have a look through this information. If you think that you might like to take part, or if you would like more information, please complete and return the reply slip. I will then arrange to come and meet with you and I will answer any questions that you may have.

Thank you for your time.

With best wishes

Louise Johnson

UNIVERSITY OF Southampton
School of Health Sciences

Participant Information Sheet

Title: How do different styles of information provision affect learning during early gait rehabilitation post stroke?

Researcher: **Louise Johnson MCSP**

Ethics Submission Number: **11/YH/0111**

I would like to invite you to take part in a research study. Before you decide whether or not to take part, you need to understand why this research is being done and what your involvement may consist of. Please take time to read the following information carefully. Talk to others about the study if you wish, and please feel free to ask questions if there is anything that you are unsure about. *Thank you for reading this.*

What is the purpose of this study?

I am a physiotherapist, currently carrying out a piece of Doctoral research about early gait rehabilitation post-stroke. I will be investigating how the different ways in which physiotherapists give instructions and feedback may affect this learning.

In normal physiotherapy practice, most therapists use a combination of both *implicit learning* and *explicit learning* when training patients. I want to find out if one is better than the other in terms of the effect it has when people with stroke are re-learning to step or walk. Patients will be recruited during their inpatient stay, and will be randomised to receive three days of training using one of these approaches. If you agree to take part, you will be delivering this training.

Why have I been chosen?

You have been chosen because you are a senior physiotherapist who regularly works with patients who have had a stroke.

Do I have to take part?

No - it is entirely up to you to decide. I will describe the study and go through this information sheet, which I will then give to you. You will have the opportunity to ask questions, and will be given some time to think about whether or not you would like to participate. If you do decide to participate, you will be asked to sign a consent form which you will be given a copy of to keep. You are free to withdraw from the study at any time, without giving a reason and without prejudice.

What will happen to me if I take part?

Before we recruit patients to the main study it is important to make sure that all therapists are trained in providing explicit and implicit learning. Those therapists that agree to take part in this study will attend a workshop lasting approximately 2 hours. This will be led by me, will include both theory and practical elements, and will provide an opportunity to discuss and practice the learning strategies which will be compared. It does not matter if you don't yet know anything about implicit and explicit learning – it will all be covered in the workshop. The types of tasks and activities/exercises that you would use under each of the approaches are similar, but they are delivered in different ways – mainly by changing the instructions and feedback that you give.

The therapy that you would provide to patients enrolled in this study would be largely pragmatic – you will be able to use your clinical judgement to design treatment sessions that are appropriate for each patient. However, depending on whether the patient is randomised to the implicit or the explicit learning group, you will be asked to change how they instruct the patient, and how you give feedback. Since this is a feasibility trial, one of the objectives is to see how easy it is for physiotherapists to learn and implement new communication styles – therefore it wouldn't matter if you found this hard to do. You will be able to contact the researcher at any time for support with implementing these learning styles; however the researcher will not participate in the treatment sessions themselves.

In order to monitor the content of the therapy sessions, you will be asked to keep a log of the activities performed during each session. You will be given a form on which to do this, and a copy can be put into the patient's therapy notes. In addition, with your consent, I will be observing and video recording a number of sessions, which will be selected at random. These videos are not designed to evaluate the quality of treatment you give. They will be used to determine how much physiotherapists were able to adapt to the explicit and implicit learning styles. If one of your sessions is randomly selected you will be informed prior to the session commencing and your consent will be gained.

How long will I be involved for?

Recruitment of patient participants for this study will take place over a period of approximately 6 months, between April and October 2011. Unless you decide to withdraw, you will remain involved throughout this time. However, you will only be actively providing the study treatment protocols when there is a patient from your clinical area enrolled in the study.

What happens if I change my mind?

You are free to completely withdraw from this study at any time, without giving reason, and without prejudice. Unless you ask us not to, we will still use the data collected up to that point.

What are the potential risks or inconveniences of taking part?

I will endeavour to keep any risk or inconveniences to an absolute minimum. Each time a patient from your clinical area is recruited to the study, I will meet with your team to agree a timetable for that patient's involvement. I will be completing all research assessments pre and post treatment; you will be delivering physiotherapy treatment, according to the relevant learning style. The physiotherapy that you provide will replace any therapy that the patient will have otherwise received for general mobility, and sessions are expected to last for around 45 minutes. This should not, therefore, represent any additional burden in terms of therapy provision. I anticipate that each clinical area will have more than one physiotherapist enrolled in the study, so you should not have to provide training for every patient enrolled. Sessions will take place in your usual physiotherapy setting and with patients that you are familiar with.

What are the benefits of taking part?

There are no direct benefits to you of taking part. However, it is hoped that you will find the study interesting, and that you may gain new knowledge through participating.

What will happen to the video recordings?

Once the study is complete, video recordings will be retained in a secure place at the University of Southampton for fifteen years, after which they will be disposed of securely.

Will my participation be kept confidential?

Yes. I will not tell anybody whether or not you have taken part in this study. All information collected throughout the research will be kept confidential, and personal data will be held in accordance with the Data Protection Act (1998).

The video recordings will be viewed and analysed by me and a second researcher from the University of Southampton. Researchers viewing the videos will have a duty of confidentiality to you as a research participant. Any observations taken from the treatment session or the video recording will be reported anonymously.

It is often useful to use video footage from research during presentations. These may involve a wide audience of professionals and public, for example during conference presentations. You will be asked to consider providing separate consent for this, however should you decline, this will not affect your involvement with the study in any other way.

What happens if something goes wrong or if I want to complain?

If you have a concern or a complaint about this study you should contact Susan Rogers, Head of Research and Enterprise Services, at the School of Health Sciences (Address: University of Southampton, Building 67, Highfield, Southampton, SO17 1BJ; Tel: 023 8059 7942; Email: S.J.Rogers@soton.ac.uk). If you remain unhappy and wish to complain formally, Susan Rogers can provide you with details of the University of Southampton Complaints Procedure.

What will happen to the results of the research study?

It is intended that the study findings will be submitted part of a Doctorate in Clinical Practice thesis to the University of Southampton. Results will also be published in relevant peer reviewed journals and may be presented at conferences. A summary of study findings will be available during 2012. If you wish to receive a copy of this, please contact me (Louise Johnson, 07799 65 77 64, lj1b06@soton.ac.uk). You will not be personally identified in any report or publication.

Who has reviewed this study?

In order to protect your safety, rights, well-being and dignity, all research in the NHS is looked at by an independent group of people, called a Research Ethics Committee This study has been reviewed and given favourable opinion by _________Research Ethics Committee.

What do I do next?

If you have any further questions about this research or would like to take part, please complete the attached reply slip and return it to me in the envelope provided. I will then contact you to arrange a time to meet and discuss your potential involvement further.

If you do decide to take part, I will ask you to sign a consent form, of which I will give you a copy.

UNIVERSITY OF Southampton
School of Health Sciences

REPLY SLIP

How do different styles of information provision affect learning during early gait rehabilitation post stroke?

Please complete this reply slip if you are interested in taking part in this research and return it to me in the envelope provided. I will then arrange to come and meet with you to discuss the study further. This does not commit you to taking part.

I ____ (name) am interested in finding out more about the above research study. I would be happy for the researcher to contact me to arrange a time to meet.

Physiotherapists Name: _____________________________ Ward: ___________

Signed: ____ Date: ____________

Thank you

Louise Johnson

(Researcher)

UNIVERSITY OF Southampton
School of Health Sciences

Participant Identification Number:

CONSENT FORM

Title: How do different styles of information provision affect learning during early gait rehabilitation post stroke?

Researcher: Louise Johnson

Please initial box

I confirm that I have read and understood the information sheet dated January 2011 (version 1) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason, and without prejudice	
I understand that for the purpose of analysis, my participation in this study will be video recorded.	
I agree to take part in the above study.	

I agree / do not agree (delete as appropriate) to video recordings of me being used for the purpose of dissemination, for example at training sessions or conferences.

______________________ ______________________ ______________________

Name of participant Signature Date

______________________ ______________________ ______________________

Name of person taking consent Signature Date

Appendix 20 – Feasibility Study, Patient Information

Letter of Invitation

Participant Information Sheet

Consent Forms

UNIVERSITY OF Southampton
School of Health Sciences

Louise Johnson
University of Southampton
Highfield Campus
Building 45
Southampton
SO17 1BJ

Tel: 07799 65 77 64
Email: lj1b06@soton.ac.uk

REC Ref Number: 11/YH/0111

January 2011

Dear Sir or Madam

How do different styles of information provision affect learning during the early re-training of walking after stroke?

I am a physiotherapist, and am currently carrying out research about how physiotherapists work with people after stroke to improve stepping or walking. As part of this study, I will be looking at the effect that different ways of teaching exercises has on their learning. I would like to invite you to take part in this.

I have enclosed an information sheet which explains more about what this research is about and what involvement would consist of. I would be grateful if you could have a look through this information. If you think that you might like to take part, or if you would like more information, please speak to your physiotherapist. I will then arrange to come and meet with you on the ward and I will answer any questions that you may have.

Thank you for your time.

With best wishes

Louise Johnson

UNIVERSITY OF Southampton
School of Health Sciences

Participant Information Sheet

Title: How do different styles of information provision affect learning during the early re-training of walking after stroke?

Researcher:	Louise Johnson MCSP
Ethics Submission Number:	11/YH/2011

I would like to invite you to take part in a research study. Before you decide whether or not to take part, you need to understand why this research is being done and what taking part might involve. Please take time to read the following information carefully. Talk to others about the study if you wish, and please feel free to ask questions if there is anything that you are unsure about. *Thank you for reading this.*

What is the purpose of this study?

I am a physiotherapist, carrying out a piece of Doctoral research about re-learning to step and/or walk after stroke. I will be investigating how the different ways in which physiotherapists talk to patients may affect this learning.

Why have I been chosen?

You have been chosen because your physiotherapist has identified you as someone who has had a stroke, and who is currently working towards improving their standing, stepping or walking ability.

Do I have to take part?

No - it is entirely up to you to decide. I will describe the study and go through this information sheet, which I will then give to you. You will have the opportunity to ask questions, and will be given at least 24 hours to think about whether or not you would like to participate. If you do decide to participate, you will be asked to sign a consent form; you will be given a copy to keep. You are free to withdraw from the study at any time, without giving a reason, and without your medical care or rehabilitation being affected in any way whatsoever.

What will happen to me if I take part?

I will be comparing two particular approaches to teaching people physiotherapy exercises – one is called *implicit learning* and one is called *explicit learning*. In normal physiotherapy practice, most therapists use a combination of both approaches, but I want to find out if one is better than the other in terms of the effect it has on re-learning to step or walk. The types of tasks and activities/exercises that you would do under each of the approaches are similar, but they are delivered by the therapist in different ways. If you agree to take part, you will receive three physiotherapy treatment sessions based on one of these approaches. Which one you receive will be chosen at random.

If you do choose to take part, you will be asked to sign a consent form. I will then need to ensure that you meet the inclusion criteria.

I will collect some basic information from your medical notes, for example what type of stroke you have suffered and when, as well as details of your past medical history and medications. Any information taken from your medical records will be anonymised and will be stored and treated confidentially.

I will also check how well you are currently able to move by asking you to complete a few simple tasks. I will be asking you to stand up from a chair, and to take a few steps. I will stand close whilst you do this to make sure you are safe and you can use a walking stick or frame if you need to.

If you do meet the inclusion criteria and you wish to continue, I will organise a convenient time to meet with you to start the initial assessments.

If you don't meet the inclusion criteria, or if you decide not to continue, then you will be thanked for your time but I will not contact you again and your rehabilitation will continue as normal.

How long will I be involved for?

This study will take place over a period of approximately 5 days from start to finish. You will complete some assessments on day one (normally Monday), will then receive three days of treatment, and will complete the same assessments again on day 5 (normally Friday).

What assessments will I have to do?

All assessments are simple, relatively quick to perform and are non-invasive.

The first assessment looks at how well you manage to maintain attention. You will be asked to listen to and count sequences of tones on an audiotape. It is a simple assessment that takes about 10 minutes to complete. It will be carried out in a quiet room.

The second assessment looks at how far you are currently managing to walk over a time of 2 minutes. You will be asked to walk at a comfortable pace, using a walking stick or frame if necessary and you will be given close supervision, but no assistance. You can stop to rest for as long as needed and as often as needed. It does not matter how far you manage to walk – we expect that some people will only manage one or two steps. With your agreement, we will video record you walking and will later be looking at the video recording to assess the pattern of your walking.

The third assessment will look at your balance. You will be asked to try a series of everyday tasks, such as standing up and stepping. Each task is scored by the researcher. You may not be able to do some of the tasks; this is expected and is not a problem. Again, you can rest between tasks, and you will be given supervision throughout. This assessment will also be video recorded. This is so that a second person can check the score.

For the final assessment, you will be asked what you think about your walking. You will be asked to rate this on a scale from 0 to 10. It is important that you say what you really think – there is no right or wrong answer.

At the end of the study, you will also be asked to take part in a short interview with the researcher. This is so that we can ask you some questions about the therapy you have been receiving. It is expected that this will only last around 10 minutes. The interview will be carried out in a private room and will be audio taped. The interviews will later be analysed; any reporting of what you say will be anonymous and confidential.

What happens during the treatment?

After you have completed the assessments, we will agree a day for you to start the treatment sessions – normally the next day. You will receive three physiotherapy treatment sessions on consecutive days. Each session will last for around 45 minutes, will take place in your usual physiotherapy gym, and will be delivered by one of the therapists from your ward.

During each session, you will be asked to practice a series of exercises, which may involve standing, stepping and walking. As with any physiotherapy session, you will be able to stop to rest if necessary. The types of exercises that you do will be familiar, but the therapist may instruct.

With your consent, the researcher may observe and video record some of your treatment sessions. If they do, they will not influence or participate in any other way. This is to monitor the content of the session. You will be made aware of this prior to the session starting.

Will the rest of my therapy stop whilst I am in the study?

No. This study is only looking at physiotherapy that aims to improve your general mobility. The therapy provided as part of the study will therefore *replace* any therapy you would have otherwise received for mobility. All other planned therapy and care, including physiotherapy and occupational therapy, will continue as normal for the duration of the study. You can also continue to follow any exercise plans that have been given to you.

What happens at the end of the study?

Once the final assessments have been completed, your involvement in the study will end. You will then return to receiving standard rehabilitation.

What happens if I change my mind?

You are free to completely withdraw from this study at any time, without giving reason, and without affecting your care in any way whatsoever. Unless you ask us not to, we may still use the data collected up to that point.

What will happen to the video recordings?

Once the study is complete, video recordings will be retained in a secure place at the University of Southampton for fifteen years, after which they will be disposed of securely.

What are the potential risks or inconveniences of taking part?

We will endeavour to keep any risk or inconveniences to an absolute minimum. I will liaise with you and your physiotherapist to agree a date for you to have the assessments and to start the research treatment sessions. I will negotiate times with you to ensure that it doesn't interfere with the rest of your rehabilitation in any way. You may, however, find that the extra assessment and treatment sessions that you do as part of this study leave you feeling tired.

I appreciate that walking carries some risks, especially if your balance is poor. You will be very closely supervised during all of the walking assessments and throughout the treatment sessions, just as you would do in your usual physiotherapy sessions.

What are the benefits of taking part?

There are no direct benefits to you of taking part. It is anticipated that the amount of therapy provided during this study will be equal to or greater than that which you would have otherwise received.

It is hoped that the results of this research study will help health care professionals understand more about how people with stroke re-learn to walk.

Will my participation be kept confidential?

Yes. Other than members of staff involved in your care, I will not tell anybody whether or not you have taken part in this study. All information collected throughout the research will be kept confidential, and personal data will be held in accordance with the Data Protection Act (1998).

The video recordings will be viewed and analysed by me and a second researcher from the University of Southampton. Researchers viewing the videos will have a duty of confidentiality to you as a research participant. Any observations taken from the treatment session or the video recording will be reported anonymously.

It may be useful to use video footage during presentations which may involve a wide audience of professionals and public, for example during conference presentations. You will be asked to provide separate consent for if you agree to have your videos used for wider audiences. This is not obligatory, and should you decline, will not affect your involvement in any other way.

What happens if something goes wrong or if I want to complain?

If you have a concern or a complaint about this study you should contact Susan Rogers, Head of Research and Enterprise Services, at the School of Health Sciences (Address: University of Southampton, Building 67, Highfield, Southampton, SO17 1BJ; Tel: 023 8059 7942; Email: S.J.Rogers@soton.ac.uk). If you remain unhappy and wish to complain formally, Susan Rogers can provide you with details of the University of Southampton Complaints Procedure.

What will happen to the results of the research study?

It is intended that the study findings will be submitted part of a Doctorate in Clinical Practice thesis to the University of Southampton. Results will also be published in relevant peer reviewed journals and may be presented at conferences. A summary of study findings will be available during 2012. If you wish to receive a copy of this, please contact me (Louise Johnson,07799 65 77 64, lj1b06@soton.ac.uk). You will not be personally identified in any report or publication.

Who has reviewed this study?

To protect your safety, rights, well-being and dignity, all research in the NHS is looked at by an independent group of people, called a Research Ethics Committee. This study has been reviewed and given favourable opinion by _________Research Ethics Committee.

What do I do next?

If you have any further questions about this research or would like to take part, please complete the attached reply slip and hand it back to one of your physiotherapists. I will then come and meet with you on the ward to answer any questions you may have.

If you do decide to take part, I will ask you to sign a consent form, of which I will give you a copy. I will then arrange a time with you to start the first assessment.

UNIVERSITY OF Southampton
School of Health Sciences

REPLY SLIP

How do different styles of information provision affect learning during the early re-training of walking after stroke?

Please complete this reply slip if you are interested in taking part in this research. Hand it back to one of your therapists, who will pass it onto me. I will then arrange to come and meet with you on the ward to discuss the study further. This does not commit you to taking part.

I ____ (name) am interested in finding out more about the above research study. I would be happy for the researcher to come and meet with me on the ward.

Physiotherapists Name: ____________________________ Ward: ___________

Signed: ____ Date: ____________

Thank you

Louise Johnson

(Researcher)

UNIVERSITY OF Southampton
School of Health Sciences

Participant Identification Number:

Researcher: Louise Johnson

CONSENT FORM

Title: How do different styles of information provision affect learning during the early re-training of walking after stroke?

	Please initial box
I confirm that I have read and understood the information sheet dated January 2011 (version 1) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason, and without my medical care or rehabilitation being affected in any way.	
I understand that the physiotherapy treatment that I receive for the duration of this study will *replace* any therapy that I would have otherwise received *specifically for improving walking,* but that all other therapy provision will continue as normal throughout.	
I understand that for the purpose of analysis, my participation in this study will be video recorded.	
I agree to take part in the above study.	

I agree / do not agree (delete as appropriate) to video recordings of me being used for the purpose of educating others, for example at training sessions or conferences.

______________________	__________________	__________________
Name of participant	Signature	Date
______________________	__________________	__________________
Name of person taking consent	Signature	Date
______________________	__________________	__________________
Witness (if applicable)	Signature	Date

Appendix 21 – Feasibility Study, Ethics Approval Letter

NHS

National Research Ethics Service

NRES Committee Yorkshire & The Humber - Humber Bridge
Yorkshire and the Humber Research Ethics Office
First Floor
Millside
Mill Pond Lane
Leeds
LS6 4RA

Telephone: 0113 3050127
Facsimile:

27 May 2011

Mrs Louise Johnson
Trainee Consultant Practitioner in Neurological Rehabilitation
Wessex Deanery
Innovation, Development and Wider
Workforce, NESC, Southern House,
Otterborne, Winchester
SO21 2RU

Dear Mrs Johnson

Study title:	**How do different styles of information provision affect learning during early gait training post stroke? A Feasibility Study.**
REC reference:	**11/YH/0111**
Protocol number:	**RGO Ref 7938**

Thank you for your letter of 11 May 2011, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair and Vice-Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

NHS sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Non-NHS sites

The Committee has not yet been notified of the outcome of any site-specific assessment (SSA) for the non-NHS research site(s) taking part in this study. The favourable opinion does not therefore apply to any non-NHS site at present. We will write to you again as soon as one Research Ethics Committee has notified the outcome of a SSA. In the meantime no study procedures should be initiated at non-NHS sites.

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Covering Letter		28 March 2011
Evidence of insurance or indemnity		28 January 2011
Interview Schedules/Topic Guides	1	01 May 2011
Investigator CV		
Letter from Sponsor		28 January 2011
Letter of invitation to participant	1	01 January 2011
Letter of invitation to participant	1	01 January 2011
Letter of invitation to participant	1	01 January 2011
Other: CV - Jane Burridge		
Other: CV - Sara Demain		01 February 2011
Participant Consent Form: Consent Form - Patients Workshop	1	01 January 2011
Participant Consent Form: Consent Forms for Therapists	2	01 May 2011
Participant Consent Form: Consent Forms for Patients	2	01 May 2011
Participant Information Sheet: PIS for Patients	1	01 January 2011
Participant Information Sheet: PIS for Workshop - Patients	1	01 January 2011
Participant Information Sheet: PIS for Therapists	3	01 May 2011
Protocol	3	01 May 2011
REC application		

Response to Request for Further Information		11 May 2011

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

Notifying substantial amendments
Adding new sites and investigators
Progress and safety reports
Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

11/YH/0111	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project

Yours sincerely

pp **Dr David Horton**
Chair

Email: nicola.mallender-ward@nhs.net

Enclosures: "After ethical review – guidance for researchers"

Copy to: *Dr Martina Prude, University of Southampton*
Ms Clair Wright, Southampton City PCT

NHS
Health Research Authority
National Research Ethics Service

NRES Committee Yorkshire & The Humber - Humber Bridge
HRA NRES Centre North West
Barlow House
3rd Floor
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M1 3DZ

Tel: 0161 625 7816
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30 August 2013

Mrs Louise Johnson
Trainee Consultant Practitioner in Neurological Rehabilitation
Wessex Deanery
Innovation, Development and Wider
Workforce, NESC, Southern House,
Otterbome, Winchester
SO21 2RU

Dear Mrs Johnson

Study title:	**How do different styles of information provision affect learning during early gait training post stroke? A Feasibility Study.**
REC reference:	**11/YH/0111**
Protocol number:	**RGO Ref 7838**
Amendment number:	**2**
Amendment date:	**18 July 2013**
IRAS project ID:	**72881**

<u>Overview of amendment</u>

The amendment proposes to interview therapists to gain insight into their experience of using implicit and explicit learning in clinical practice.

The above amendment was reviewed by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

Approved documents

The documents reviewed and approved at the meeting were:

Document	Version	Date
Interview Schedules/Topic Guides		
Participant Information Sheet	1	20 July 2013
Protocol	5	18 July 2013
Notice of Substantial Amendment (non-CTIMPs)	2	18 July 2013

A Research Ethics Committee established by the Health Research Authority

Participant Consent Form: Therapist Consent Form	1	
Reply slip	1	20 July 2013

Membership of the Committee

The members of the Committee who took part in the review are listed on the attached sheet.

R&D approval

All investigators and research collaborators in the NHS should notify the R&D office for the relevant NHS care organisation of this amendment and check whether it affects R&D approval of the research.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

We are pleased to welcome researchers and R & D staff at our NRES committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

11/YH/0111:	**Please quote this number on all correspondence**

Yours sincerely

Dr Lynn Cawkwell
Chair

E-mail: nrescommittee.yorkandhumber-humberbridge@nhs.net

Enclosures: List of names and professions of members who took part in the review

Copy to: Ms Clair Wright, Southampton City PCT - Shared RM&G
Dr Martina Prude

Appendix 22 – Feasibility Study, Sponsorship and Insurance

UNIVERSITY OF Southampton

Mrs Louise Johnson
School of Health Sciences
University of Southampton
University Road
Highfield
Southampton
SO17 1BJ

28 March 2011

Dear Mrs Johnson

RGO Ref: 7938

Project Title How do Different Styles of Information Provision Affect Learning during Early Gait Re-Education Post Stroke? A Feasibility Study

I am writing to confirm that the University of Southampton is prepared to act as Research Sponsor for this study under the terms of the Department of Health Research Governance Framework for Health and Social Care (2nd edition 2005).

http://www.dh.gov.uk/en/Aboutus/Researchanddevelopment/Researchgovernance/DH_400211

I would like to take this opportunity to remind you of your responsibilities under the terms of the Research Governance Framework Medicines for Human Use Act 2004 if conducting a clinical trial.

We encourage you to become fully conversant with the terms of the Research Governance Framework by referring to the Department of Health document which can be accessed at:

http://www.legislation.gov.uk/uksi/2004/1031/contents/made

http://www.legislation.gov.uk/uksi/2006/1928/contents/mad

The University of Southampton fulfils the role of Research Sponsor in ensuring management, monitoring and reporting arrangements for research. I understand that you will be acting as the Principal Investigator responsible for the daily management for this study, and that you will be providing regular reports on the progress of the study to the Research Governance Office on this basis.

Please also familiarise yourself with the Terms and Conditions of Sponsorship on our website:

http://www.soton.ac.uk/corporateservices/rgo/media/TCSpons%20(CTIMP)%20V2%2022011.do

http://www.soton.ac.uk/corporateservices/rgo/media/TCSpons%20(Non%20CTIMP)%20V2%20022011.doc

In this regard if your project involves NHS patients or resources please also be reminded that you may need a Research Passport to apply for an honorary research contract of employment. Information can be found on our website:

http://www.soton.ac.uk/corporateservices/rgo/respassport/about.htm

(...continued overleaf)

Corporate Services, University of Southampton, Highfield Campus, Southampton SO17 1BJ United Kingdom
Tel: +44 (0) 23 8059 4684 Fax: +44 (0) 23 8059 5781 www.southampton.ac.uk

UNIVERSITY OF Southampton

Please send us a copy of your NHS REC and Trust approval letters when available.

Please do not hesitate to contact me should you require any additional information or support. May I also take this opportunity to wish you every success with your research.

Yours sincerely

Dr Martina Prude
Head of Research Governance
Tel: 023 8059 5058
email: rgoinfo@soton.ac.uk

Corporate Services, University of Southampton, Highfield Campus, Southampton SO17 1BJ United Kingdom
Tel: +44 (0) 23 8059 4684 Fax: +44 (0) 23 8059 5781 www.southampton.ac.uk

UNIVERSITY OF Southampton

Mrs Louise Johnson
School of Health Sciences
University of Southampton
University Road
Highfield
Southampton
SO17 1BJ

RGO REF – 7938

28 March 2011

Dear Mrs Johnson

Professional Indemnity and Clinical Trials Insurance

Project Title How do Different Styles of Information Provision Affect Learning during Early Gait Re-Education Post Stroke? A Feasibility Study

Participant Type:	No Of Participants:	Participant Age Group:	Notes:
Patients	20	Adults	
Healthy volunteers	4	Adults	

Thank you for forwarding the completed questionnaire and attached papers.

Having taken note of the information provided, I can confirm that this project will be covered under the terms and conditions of the above policy, subject to written informed consent being obtained from the participating volunteers.

Insurance will only be activated when we have received a copy of the Ethics Committee approval and you must not begin your project prior to this. Please forward a copy of the Ethics Committee approval letter as soon as it is to hand to complete the insurance placement.

If there are any changes to the above details, please advise us as failure to do so may invalidate the insurance.

Yours sincerely

Mrs Ruth McFadyen
Insurance Services Manager

Tel: 023 8059 2417
email: hrm@soton.ac.uk

cc: File

Finance Department, University of Southampton, Highfield Campus, Southampton SO17 1BJ United Kingdom
Tel: +44 (0) 23 8059 5000 Fax: +44 (0) 23 8059 2195 www.southampton.ac.uk

Appendix 23 – Therapist Interviews, PIS and Consent Form

UNIVERSITY OF Southampton

Participant Information Sheet

Title: How do different styles of information provision affect learning during early gait re-education post stroke?

Researcher: Louise Johnson MCSP

Ethics Submission Number: 11/YH/0111

Thank you for your involvement with the above research study. Your input has been hugely valuable. As you are aware, we have now completed the recruitment phase, and are in the process of data analysis. For the final part of the study, I am keen to hear your views on the implicit and explicit learning approaches that you have been trialling. I would therefore like to invite you to take part in the final stage of the research. This will involve a one off interview about your experience of applying the implicit and explicit approaches within your clinical practice. For example, how easy you found it to apply them and if there were any particular challenges. This information sheet explains the nature of this final stage of the research, and outlines what you involvement would consist of. I would be grateful if you would take the time to consider this information. If you are happy to take part, or would like to know more, please complete and return the reply slip at the end of this information sheet. *Thank you for taking the time to read this.*

What is the purpose of the interview?

As you are aware, one of the main objectives for this research was to see whether it is possible to apply implicit and explicit learning strategies within clinical practice. One part of the analysis has involved looking at videos of treatment sessions to see how well therapists were able to apply the treatment guidelines for each learning approach. This will help us to further develop and refine the treatment guidelines in preparation for the next stage of the study.

To complement this, we would like to gain insight into therapist’s experiences of applying the treatment guidelines. The results from the interview will be used to inform the next phase of this research – for example, it may help us to understand the training needs of therapists involved in the research, or any areas where the treatment guidelines need to be clearer. The interview will be guided by a set of questions, but there are no right or wrong answers.

Why have I been chosen?

You have been chosen because you have been involved in this study as a physiotherapist delivering the treatment interventions. You therefore have experience of applying implicit and explicit learning strategies in clinical practice.

Do I have to take part?

No - it is entirely up to you to decide. You involvement to date is appreciated and you are not obliged to take part in this final stage. If you do decide to take part, you will be asked to sign a consent form which you will be given a copy of to keep. You are free to change your mind at any time, even part way through the interview, without giving a reason and without prejudice.

What will happen to me if I take part?

You will take part in a one-off interview, which I anticipate will last between 30 minutes and an hour. If you are happy for me to do so, I may show you a few short video clips from the treatment sessions that you provided. These are intended to prompt your memory of the patients you treated; we won't be specifically analyzing the content.

The interview will take part at a time and place convenient to you. In order to make sure that I do not miss any important information, the interview will be audiotaped. However, you are free to ask for the tape to be stopped at any time. During the interview, we will discuss your experience of delivering implicit and explicit learning strategies. The audiotape will be transcribed. The transcripts will be anonymised.

How long will I be involved for?

This is a one off interview lasting up to an hour. There will be no further involvement after this.

What happens if I change my mind?

You are free to completely withdraw at any time, without giving reason, and without prejudice. Unless you ask us not to, we will still use the data collected up to that point.

What are the potential risks or inconveniences of taking part?

I will endeavour to keep any risk or inconveniences to an absolute minimum. If you do decide to take part, then we will arrange a time and venue that is convenient to you. The interview will take place in a private setting and refreshments will be provided.

What are the benefits of taking part?

There are no direct benefits to you of taking part. However, it is hoped that you will find the opportunity to reflect on your involvement in this study interesting.

What will happen to the audio recordings?

Once transcribed, audio recordings will be deleted from the Dictaphone. Transcripts will be fully anonymised.

Will my participation be kept confidential?

Yes. I will not tell anybody whether or not you have taken part in this interview. All information collected through the interview will be kept confidential, and personal data will be held in accordance with the Data Protection Act (1998). Any reporting, including the use of direct quotes, will be anonymised.

What happens if something goes wrong or if I want to complain?

If you have a concern or a complaint about this study you should contact Susan Rogers, Head of Research and Enterprise Services, at the School of Health Sciences (Address: University of Southampton, Building 67, Highfield, Southampton, SO17 1BJ; Tel: 023 8059 7942; Email: S.J.Rogers@soton.ac.uk). If you remain unhappy and wish to complain formally, Susan Rogers can provide you with details of the University of Southampton Complaints Procedure.

What will happen to the results of the research study?

It is intended that the study findings will be submitted part of a Doctor of Philosophy thesis to the University of Southampton. Results will also be published in relevant peer reviewed journals and may be presented at conferences. A summary of study findings will be available during 2014. If you wish to receive a copy of this, please contact me (Louise Johnson, 07799 65 77 64, lousier.johnson@rbch.nhs.uk). You will not be personally identified in any report or publication.

Who has reviewed this study?

In order to protect your safety, rights, well-being and dignity, all research in the NHS is looked at by an independent group of people, called a Research Ethics Committee This study has been reviewed and given favourable opinion by NRES Committee Yorkshire & The Humber – Humber Bridge.

What do I do next?

If you have any further questions about this research or would like to take part, please complete the attached reply slip and return it to me in the envelope provided. I will then contact you to arrange a time to meet and discuss your potential involvement further.

UNIVERSITY OF Southampton

REPLY SLIP

How do different styles of information provision affect learning during early gait re-education post stroke – THERAPIST INTERVIEWS?

Please complete this reply slip if you are interested in taking part in a one-off interview. I will then arrange to come and meet with you to discuss the study further. This does not commit you to taking part.

I ____ (name) am interested in finding out more about this stage of the above research study. I would be happy for the researcher to contact me to arrange a time to meet.

Signed: ____ Date: ____________

Thank you

Please return to:

Louise Johnson

Neurotherapy Team

Rehabilitation Department

Royal Bournemouth Hospital

Castle Lane East

Bournemouth

BH7 7DW

Appendix 24 – Interview Guide (Patients)

Purpose: To determine the extent to which participants were aware of what was being learnt during the treatment sessions.

Interviewer: Louise Johnson – Chief Investigator

Example Questions:

I'd like to ask you some questions about the physiotherapy sessions that you have been attending over the past three days.

- Can you tell me about what you have been doing in physiotherapy over the past three days:
- What you have mainly been working towards during these sessions?
- When you have been practising [insert activity]:
  - What are you thinking about as you practice [standing, stepping, walking etc]?
  - Is there anything in particular that you have focussed on?
  - Do you use any particular techniques to help your performance?
- Do you focus on/think about similar things when you practise outside of physiotherapy?
- Did you notice anything about the way in which your physiotherapist has been treating you over the past three days? Did this seem different to normal?
- If you remember back to the beginning of the week, you were randomly put into one of two groups. In the first group, you would have received lots of instructions and feedback from your therapist, telling you exactly how to perform the tasks that you were practising. In the second group, you would not have received as much instruction/feedback, and would have just been encouraged to practice – focussing on the overall goal of the task. Which of these two groups do you think you were in?

Appendix 25 – Interview Guide (Therapists)

IMPLICIT AND EXPLICIT LEARNING

Therapist Interview Guide

- Tell me about your experience of delivering the implicit and explicit approaches.....
  - Did you find one more difficult than the other?
  - What made it difficult?
- Were there any circumstances in which this was particularly difficult [type of patient; other impairments etc]
  - Specifically, what was hard?
- Did you notice any differences in how patients responded to the different approaches?
- Do you have any thoughts on the relative benefits of an
  - Implicit approach
  - Explicit approach
- And what about the disadvantages of an
  - Implicit approach
  - Explicit approach
- Is there anything about either approach that you feel is unclear?
- If you were to continue to apply these approaches as part of a research trial, what would you need to support your training?
- Would you perceive any challenges about applying the approaches
  - Over a longer timeframe
  - Within different areas of stroke rehabilitation – e.g. upper limb rehab
- Is there anything else that you would like to add?

Appendix 26 – Activity Log

Activity Log

Patient ID: ____ Therapist ID: ____

Session (please circle) 1 2 3 Session start time: _____:_____ Session finish time: _____:_____

Exercise[ǂ] – *give details of each specific exercise completed for each category. Include progressions and variations as new exercises (use codes below)*	Purpose(s)*	Repetitions/Time	Comments *Provide information regarding how well the patient managed, what feedback/instruction was given and when, environment, aids and equipment, comments from the patient etc.*
e.g. *i. Mini squats in standing*	*2, and 8*	*3 x 12 reps*	*Hands on guidance at knee; verbal feedback regarding speed and degree of squat; control improved with practice*

CODES:

ǂ ACTIVITY

1. Sit to stand – e.g. from high plinth, from low plinth, from chair. NB: only record as an exercise if repeated consecutively for more than one repetition
2. Asymmetrical sit to stand – e.g. with non-hemiplegic foot placed forwards or placed on a step
3. Other sit to stand activity – please describe
4. Standing, weight bearing and stepping
5. Static balance activities in standing (e.g. standing with eyes open/eyes closed)
6. Dynamic activities in standing (e.g reaching out of base of support, throwing and catching ball)
7. Lateral weight transfer practice (e.g. with mirror, with reference point at side, with facilitation)
8. Lateral weight transfer with reaching
9. Lateral weight transfer and stepping with non-hemiplegic leg (e.g. stepping non-hemiplegic leg forwards and back, stepping non-hemiplegic leg onto step)
10. Strengthening exercises in standing – e.g. squats
11. Strengthening exercises in single leg stance – e.g. single leg squats, inner range knee control
12. Practice of swing phase for hemiplegic leg – e.g. stepping forwards and back, tapping hemiplegic foot onto step
13. Stepping up and down onto block with hemiplegic leg.

14. Stepping up and down onto block with non-hemiplegic leg
15. Stepping – 1 gait cycle.
16. Other exercise in standing (< 1 gait cycle) – please describe
17. Walking – state use of aids/orthoses, assistance required, distance etc.

* **PURPOSE** – *provide an indication of the main components of gait that each exercise was primarily aimed at addressing using the codes below:*

a. Stance/Weight Shift

b. Knee control during stance

c. Hip extension during terminal stance

d. Alignment during swing (e.g. minimising circumduction; minimising hip hike)

e. Knee flexion during swing.

f. Toe clearance.

g. Heel strike.

h. General lower limb strength

i. Other – please state.

Appendix 27 – SPSS Output

```
GET
  FILE='C:\Users\Johnson\Documents\Research Project\Experimental
Study\DATA\Video Analysis - SPSS.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.

SAVE OUTFILE='C:\Users\Johnson\Documents\Research Project\Experimental
Study\DATA\Video Analysis '+
    '- SPSS.sav'
  /COMPRESSED.
UNIANOVA Total.Statements BY Intervention WITH Minutes
  /METHOD=SSTYPE(3)
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  /CRITERIA=ALPHA(0.05)
  /DESIGN=Minutes Intervention.
```

Univariate Analysis of Variance

Notes

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Comments		
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	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	18
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		UNIANOVA Total.Statements BY Intervention WITH Minutes /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /CRITERIA=ALPHA(0.05) /DESIGN=Minutes Intervention.
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.05

```
[DataSet1] C:\Users\Johnson\Documents\Research Project\Experimental
Study\DATA\Video Analysis - SPSS.sav
```

Between-Subjects Factors

		N
Intervention	EXPLICIT	7
	IMPLICIT	11

Tests of Between-Subjects Effects

Dependent Variable: Total.Statements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38248.498[a]	2	19124.249	26.153	.000
Intercept	12818.621	1	12818.621	17.530	.001
Minutes	5297.153	1	5297.153	7.244	.017
Intervention	36401.906	1	36401.906	49.781	.000
Error	10968.613	15	731.241		
Total	183034.000	18			
Corrected Total	49217.111	17			

a. R Squared = .777 (Adjusted R Squared = .747)

```
UNIANOVA IF.Total BY Intervention WITH Minutes Total.Statements
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  /CRITERIA=ALPHA(0.05)
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```

Univariate Analysis of Variance

Notes

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Comments		
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	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	18
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		UNIANOVA IF.Total BY Intervention WITH Minutes Total.Statements /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /CRITERIA=ALPHA(0.05) /DESIGN=Minutes Total.Statements Intervention.
Resources	Processor Time	00:00:00.03
	Elapsed Time	00:00:00.03

```
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Study\DATA\Video Analysis - SPSS.sav
```

Between-Subjects Factors

		N
Intervention	EXPLICIT	7
	IMPLICIT	11

Tests of Between-Subjects Effects

Dependent Variable: IF.Total

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26429.441[a]	3	8809.814	42.260	.000
Intercept	.121	1	.121	.001	.981
Minutes	126.188	1	126.188	.605	.450
Total.Statements	1977.139	1	1977.139	9.484	.008
Intervention	1270.127	1	1270.127	6.093	.027
Error	2918.559	14	208.468		
Total	56726.000	18			

Corrected Total	29348.000	17				

a. R Squared = .901 (Adjusted R Squared = .879)

```
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Univariate Analysis of Variance

Notes

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	N of Rows in Working Data File	18
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		UNIANOVA EF.Total BY Intervention WITH Minutes Total.Statements /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /CRITERIA=ALPHA(0.05) /DESIGN=Minutes Total.Statements Intervention.
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	Elapsed Time	00:00:00.03

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Study\DATA\Video Analysis - SPSS.sav
```

Between-Subjects Factors

		N
Intervention	EXPLICIT	7
	IMPLICIT	11

Tests of Between-Subjects Effects

Dependent Variable: EF.Total

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1898.788[a]	3	632.929	9.189	.001
Intercept	89.891	1	89.891	1.305	.272
Minutes	6.939	1	6.939	.101	.756
Total.Statements	946.648	1	946.648	13.743	.002
Intervention	1152.234	1	1152.234	16.728	.001
Error	964.323	14	68.880		
Total	12570.000	18			
Corrected Total	2863.111	17			

a. R Squared = .663 (Adjusted R Squared = .591)

```
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  /CRITERIA=ALPHA(0.05)
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Univariate Analysis of Variance

Notes

Output Created		25-JUL-2013 15:32:08
Comments		
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	Active Dataset	DataSet1
	Filter	<none>

	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	18
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		UNIANOVA UF.Total BY Intervention WITH Minutes Total.Statements /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /CRITERIA=ALPHA(0.05) /DESIGN=Minutes Total.Statements Intervention.
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.02

```
[DataSet1] C:\Users\Johnson\Documents\Research Project\Experimental
Study\DATA\Video Analysis - SPSS.sav
```

Between-Subjects Factors

		N
Intervention	EXPLICIT	7
	IMPLICIT	11

Tests of Between-Subjects Effects

Dependent Variable: UF.Total

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3471.544[a]	3	1157.181	10.085	.001
Intercept	77.769	1	77.769	.678	.424
Minutes	173.081	1	173.081	1.508	.240
Total.Statements	813.921	1	813.921	7.093	.019
Intervention	.086	1	.086	.001	.978
Error	1606.456	14	114.747		
Total	14326.000	18			
Corrected Total	5078.000	17			

a. R Squared = .684 (Adjusted R Squared = .616)

Appendix 28 – Sample Size Calculation

Statistical considerations for a parallel trial where the outcome is a measurement

---

Request

0.05 Significance Level — 2 sided *(default is 0.05, two-sided)*

11.35 Standard Deviation of the outcome variable *(if known)*

Enter two of the following three values and the remaining value will be calculated

1. Total number of patients
2. 0.9 Power (usually 0.8 or 0.9)
3. Minimal detectable difference (specify one of the following):
   a. 6 Difference in means
   b. % Location of the mean of one treatement group in terms of a percentile of the other treatment group.

Calculate

Response

Calculation performed at: 12 August 2013 10:20:36

The provided parameters were: significance level (adjusted for sidedness) = 0.025, standard deviation = 11.35, number of patients = undefined, power = 0.9, difference in means = 6, location of mean in one group as a percentile of the other group = undefined.

The variable calculated was the total number of patients.

A total of 154 patients will enter this two-treatment parallel-design study. The probability is 90 percent that the study will detect a treatment difference at a two-sided 0.05 significance level, if the true difference between treatments is 6.000 units. This is based on the assumption that the standard deviation of the response variable is 11.35.

This software developed by David Schoenfeld, Ph.D. (dschoenfeld@partners.org), with support from the MGH Mallinckrodt General Clinical Research Center. Javascript version developed by REMorse.

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