

**AN INVESTIGATION INTO THE IMPACT OF COMPUTER
THERAPY ON PEOPLE WITH APHASIA**

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By

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ABSTRACT

Use of computers by the general population continues to increase and computers are now an integral part of communication, leisure activities and work. The majority of research into use of computers by people with aphasia has focussed narrowly on evaluating effects of computer therapy on specific language impairments. Little is known about the broader impacts of computer use by people with aphasia, in terms of levels of social activity and social participation and little is known of the views of people with aphasia on using computers.

The research in this thesis investigates the outcome of computer therapy from the perspective of people living with aphasia. Outcome was evaluated using the framework of the World Health Organisation *International Classification of Functioning, Disability and Health* (WHO ICF 2001) to investigate impact not just in terms of impairment but on activity and participation as well. The ICF also provided a framework for investigating contextual factors (environmental and personal) which might effect outcome. The investigation took the form of two complementary but contrasting case series studies: an investigation into the outcome of using computers to target word finding abilities (treatment targeting impairment only); and an investigation into the outcome of training to use voice recognition software as a writing aid (treatment aiming to overcome activity limitations but not targeting impairment itself). Both studies comprised a qualitative investigation of the views of participants on the outcome and process of therapy. Both studies supplemented this qualitative data with complementary quantitative evaluations seeking to quantify key aspects of outcome.

Study one findings indicated that all six participants perceived benefits to levels of activity, participation and confidence in addition to benefits to language impairment. Although some of this benefit was attributed to improved language skill, benefits were also attributed to increased confidence associated with acquiring skills. Study two found benefits to levels of activity and participation and confidence for all participants. Benefits were perceived even where there was no measured change to language impairment or quality or quantity of language used.

Computer use by people with aphasia can therefore bring much broader benefits than just to language impairment. Benefits include increases in leisure and social activity, social participation and confidence. Previous computer experience is not necessary and benefits can be shown many years post stroke. These broader benefits should be borne in mind when selecting who may be appropriate for computer therapy.

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AUTHOR'S DECLARATION

The work described in this thesis, except where acknowledged, is that of the author.
All views expressed in this thesis are those of the author and not necessarily of the
University of Sheffield.

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Chapter One: Introduction to the study

1.1 Introduction

Aphasia is a language impairment that can affect any aspect of communication including speech, writing, reading, gesture and understanding of the spoken word (Parr, Byng, Gilpin and Ireland 1997). The impact of the language impairment that aphasia brings has profound effects on all areas of life and these effects are sometimes felt many years post onset of the impairment:

'People who have aphasia describe the dramatic and often traumatic nature of its onset, the sense of bewilderment and fear which loss of language engenders, its impact on their lives, families and work, their day-to-day struggles with interaction, conversation and communication, and the profound and often long-term adjustments which must be made.'

Pound, Parr, Lindsay and Woolf 2000: 1

Despite these far reaching effects, aphasia therapy research has focussed more on investigating the impact of therapy on levels of language impairment and less on investigating the impact of therapy on an individual's ability to engage in everyday activity or social interaction (Avent, Wertz and Auther 1998, Parr and Byng 2000, Pound, Parr, Lindsay and Woolf 2000, Olswang 1998, Sarno 1993). Recent work has set out to redress this imbalance (Pound et al. 2000, LPAA 2000).

The use of computer-provided therapy for people with aphasia has increased steadily over the past 20 years and published research continues to indicate the influence that computerised treatment may have on improving language impairment in aphasia (Wertz and Katz 2004). However, in line with the general bias in aphasia research towards investigating impairment-based therapies, research in computer therapy has focussed on examining the

impact of computer use on specific language skills or impairments, often omitting to examine whether benefits transfer to everyday communication. It has also failed to investigate use of computers from the perspective of people with aphasia.

This thesis investigates the impact of computer therapy on people who have aphasia as a result of stroke. It was conceived in the context of previous research into computer therapy in aphasia that had examined effects on language impairment, but failed to look at the broader impacts of therapy. It was also conceived in the context of little previous existing research examining the use of computers from the perspective of people with aphasia.

1.2 Research objectives and hypotheses

This study therefore set out to examine the broad effects of using computers in therapy from the perspective of people with aphasia themselves. To achieve this objective two complementary but contrasting studies were devised in which people with aphasia used computers. Both studies took the perspective of people with aphasia as the primary focus for evaluating outcome by incorporating a qualitative methodology (in-depth interviews). Both studies supplemented this qualitative evaluation by quantitative evaluation of key aspects of outcome identified as relevant for measuring impact. Both studies used the framework of the World Health Organisation International Classification of Functioning, Disability and Health (ICF, WHO 2001, discussed further in section 1.9 below) in anticipation that this framework would encompass the broad perspective adopted. In both studies the use of technology in these ways with people with aphasia was novel. However, the target of therapy in each study was different. The findings of the two studies could thus be contrasted and compared to determine similarities and differences in outcome.

Study one targeted a specific language impairment commonly found in aphasia, namely word finding. It involved the delivery of word finding therapy

to people with aphasia exclusively via computer without face-to-face contact with a speech and language therapist. Study two targeted a specific language activity commonly affected by aphasia, namely writing. This involved training people with aphasia to use voice recognition software in order to by-pass their writing impairment to facilitate writing via dictation.

For each study the objective was to:

- Investigate in what ways people with aphasia may benefit from using computers in therapy;
- Develop hypotheses as to who may benefit from computer therapy;
- Develop hypotheses as to the key components contributing to a positive outcome.

The following hypothesis was tested:

- Computer therapy for people with aphasia will bring benefits that impact more broadly than simply on impairment.

This chapter introduces the topic and context of the research in this thesis. Context for the study is provided in the form of a brief overview of the epidemiology of stroke and aphasia (section 1.3); recovery in aphasia (section 1.4); living with aphasia (section 1.5); service provision for aphasia therapy (section 1.6); use of computers in aphasia rehabilitation (section 1.7); use of computers by the general population (section 1.8) and a brief introduction to the ICF (WHO 2001, section 1.9). This is followed by a description of the author's (JW) role in the two studies (section 1.10). Details of research in this thesis that has previously been published elsewhere are also given (section 1.11). Finally, an outline of the remaining chapters will provide an overview of the structure of the thesis as a whole (section 1.12).

1.3 Stroke and aphasia

Estimates suggest that the prevalence of stroke in the UK may be as high as 250,000 people at any one time (Hankey 2004, Bonita, Solomon and Broad 1997, Sudlow and Warlow 1997) with at least 35,000 people becoming stroke survivors each year (Hankey 2004). One third of these are likely to have aphasia (Laska, Hellblom, Murray, Kahan, and von Arbin 2001, Pedersen, Jorgenson, Nakayama, Raaschou, Olsen 1995, Wade, Hower, David and Enderby 1986).

Holland, Fromm, DeRuyter and Stein (1996) provide the following definition of aphasia:

'a language disorder that occurs in adults following focal brain damage, typically involving the language-dominant cerebral hemisphere. Although aphasia can occur in children acquiring language, it is predominantly a disorder – a devastating disorder – of adulthood. Individuals who previously communicated and understood what others communicated through speech, sign, reading, and writing suddenly find themselves unable or limited in their ability to participate in the vast range of communicative activities that typify human behavior.'

Holland et al. 1996: S28

1.4 Recovery in stroke and aphasia

Evidence suggests that some 43% of people with aphasia after stroke will continue to have a significant language impairment 18 months after the stroke has occurred (Laska et al. 2001). The greatest period of spontaneous recovery will be in the first three months post stroke (Pedersen et al. 1995). However, there is increasing acknowledgement of potential for improvement beyond this time (Aftonomos, Appelbaum and Steele 1999, Holland 1998, Holland et al. 1996, Werner and Kessler 1996).

1.5 Living with aphasia

The impact of living with a long-term communication impairment has become the focus of increased attention over recent years (Hoen, Thelander and Worsley 1997, Pound et al. 2000, Parr, Byng, Gilpin and Ireland 1997, Van der Gaag, Smith, Davis, Moss, Cornelius, Laing, Mowles 2004). There is a growing body of evidence to suggest that progress with communication can be made well beyond the first year post stroke (Holland 1998). There may also be evidence to indicate that without some form of continued support people living with the effects of stroke will show declining self-esteem or at best no change in functional status (Werner and Kessler 1996). The notion that the period of input for people with aphasia should be a finite one is being challenged. It has been argued that continued input is justified on the understanding that if such treatment were withdrawn, there would be negative consequences (Kagan 2003).

1.6 Existing service provision

Existing service provision, however, falls far short of providing lifelong support for people with aphasia. Current recommendations by the Royal College of Speech and Language Therapists, the professional body for speech and language therapists working in the UK, suggest, on the basis of research evidence (Basso, Capitani and Vignolo 1979, Robey 1998, Katz and Wertz 1997, Wertz, Weiss, Aten, Brookshire, Garcia-Bunuel, Holland et al. 1986) that therapy should consist of at least two to three hours per week to be of measurable benefit to language impairment. Many services offered in the United Kingdom are below this level of provision in the first year after stroke, let alone beyond this period (Royal College of Speech and Language Therapists 1996). In the face of limited resources, however, there is nonetheless recognition by the UK professional body for speech and language therapists that

'Aphasia is a chronic condition. Good practice therefore will offer people with aphasia long-term support mechanisms. These might included maintenance groups, social groups and recall periods of maintenance therapy'

RCSLT 1996: 166

1.7 Use of computers in aphasia rehabilitation

In a context of limited resources, research into the use of computers in aphasia therapy has been motivated by the potential for computers to offer increased opportunity for therapy practice independent of the therapist. The application of computer-assisted therapy has the potential to increase the cost effectiveness of existing service provision or to provide the recommended minimum level of service provision where this has not previously been possible. Another motivating factor has been the possibility that computer assisted therapy may offer a qualitatively different learning environment than that offered by face-to-face therapy (Weinrich 1997). However, use of computers in therapy has not been without controversy. Writing in 1990, Robertson argued:

'Nothing is known at present except that some highly-specific language knowledge can be taught by computers in some cases. It is not known whether computers do this efficiently or whether the observed effects generalize to everyday life. Therefore no basis exists for the routine clinical use of microcomputer-based therapy in clinical settings at present. There is, however, a solid basis for a considerable amount of rigorous evaluative research to be carried out in future'

Robertson 1990: 389

Robertson argues there is little evidence to refute the argument that skills acquired via computer assisted therapy may have little relevance to the everyday life of the user, may divert energy and time from more functional or recreationally relevant skills and may encourage social isolation. Since this critique was written, considerable advances have been made in demonstrating

the efficacy of computer-assisted therapy when targeting very specific language tasks. One of the most significant studies to date (Katz and Wertz 1997) provided strong evidence for the efficacy of computerised reading treatment, for the generalisation of improvements to non-computerised language tasks and for demonstrating that improvements resulted from the specific language content of the software rather than general stimulation provided by the computer. However, the generalisation that is claimed in this study was not to everyday language use but to performance on a standardised assessment of aphasia. Most studies are similar to this one in being able to claim only that improvement on the computer task (for example picture naming) is replicated in picture naming without the computer (Fink, Brecher, Schwartz and Robey 2002, Pedersen, Vinter and Olsen 2001). Given the somewhat artificial nature of a picture naming tasks, this can hardly be taken as evidence of benefit to everyday use of language in conversation. Only one study is known (Aftonomos, Appelbaum and Steele 1999) to have attempted to address the issue of whether therapy gains generalised to everyday language use.

Not only has the issue of generalisation to everyday language use received little attention in the literature; to date no studies have investigated the views of people with aphasia on using a computer in therapy.

1.8 Use of computers in the general population

As access to computers increases in the general population, many functions in society relating to information, communication, leisure and work are increasingly taking place via computer. Whilst this brings benefits to many, there is also the risk of a 'digital divide' opening up between some socio-economic groups in terms of their access to these evolving opportunities. This is particularly an issue for people with disabilities. Waddell (1999) argues that unless the rights of people with disabilities are addressed, these people risk being excluded from involvement in functions that are increasingly being

carried out via computer. There is concern that the digital divide is affecting people with aphasia in particular (Egan, Worrall and Oxenham 2004, Elman 2001, Parr, Moss, Newberry, Petheram and Byng 2004). In this context an investigation into the broader effects of computer use by people with aphasia becomes increasingly important. With the wider range of functions carried out by computer in our society, it is no longer enough to think of computers in terms of a tool for carrying out very specific therapy tasks. Access (or lack of access) to computers may impact on people with aphasia in terms of leisure opportunities, opportunity for communication and access to information and work.

1.9 Introduction to the World Health Organisation International Classification of Functioning, Disability and Health (WHO 2001)

This study set out to investigate the broader impact of using computers in aphasia and to do so from the perspective of people with aphasia. The *International Classification of Functioning, Disability and Health* (ICF, World Health Organisation – WHO 2001) was used as a framework for the study. The ICF is intended to provide a conceptual framework and common language for describing the consequences of disease and the effects of those consequences on the lives of individuals. It does so by conceptualising a multidimensional and dynamic interaction between an individual's level of functioning or disability and their context, both environmental and personal:

'A person's functioning and disability is conceived as a dynamic interaction between health conditions (diseases, disorders, injuries, traumas, etc) and contextual factors'.

ICF WHO 2001: 8

Figure 1.1 presents a schematic representation of the ICF (WHO 2001). Functioning is divided into two dimensions: body structure or function on the

one hand and activity and participation on the other. The health condition can impact on function in the form of impairment to structure or function (for example, word retrieval difficulties in aphasia), by activity limitation (for example, inability to hold conversations) and by participation restriction (for example, a restricted social life). Context also has two dimensions: environmental and personal and the effect of context on functioning is

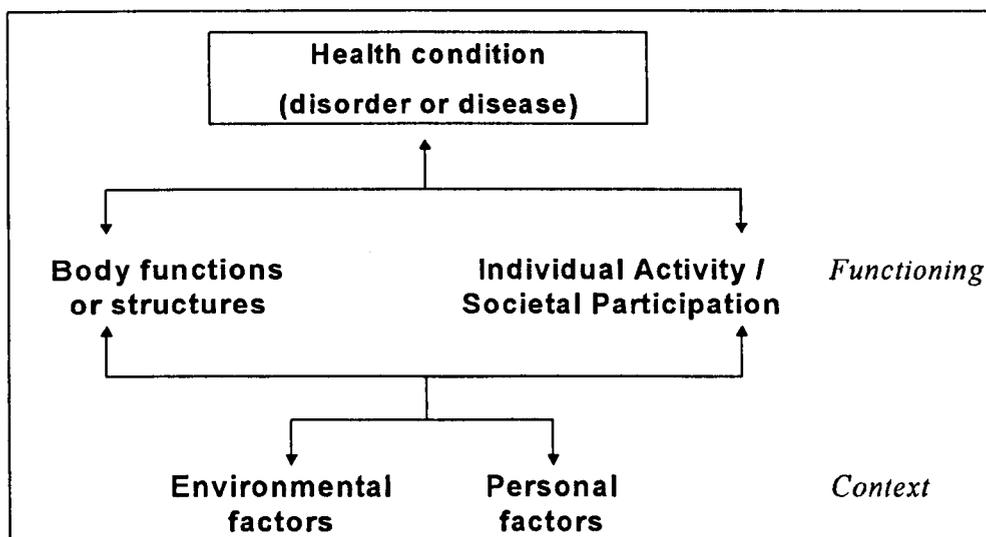


Figure 1.1 International Classification of Functioning, Disability and Health, WHO 2001

acknowledged on equal terms with the health condition itself. The ICF was adopted as a framework for the two studies described in this thesis, because it recognises the interaction between contextual factors and functioning in health related conditions and was expected to accommodate the broad perspective required in this study.

1.10 Role of the author in the studies

Study 1: An investigation into the process and outcome of word finding therapy delivered remotely via computer for people with aphasia.

Study one extends the work of Jane Mortley. The author (JW) was employed on this study as a research assistant. The lead researcher (JM) had determined the basic design of a therapy study which targeted the improvement of word finding using computer therapy, including language assessments for pre and post therapy evaluation and treatment items for therapy targeting impairment (word finding). The lead researcher (JM) was involved in developing the therapy software and delivered all word finding therapy.

The author (JW) conceived, designed and carried out the qualitative investigation to establish the views of participants on the process and broader effects of computer therapy. The aim was to evaluate outcome of therapy from the perspective of study participants in an attempt to capture perceived changes not only to impairment but to activity/participation as well. The aim was then to compare the findings of this broader evaluation with the results of the above study targeting impairment specifically (word finding). In addition to the in-depth interview investigation, the original word finding study was further supplemented by an additional quantitative investigation of language use, that is, an attempt to quantify outcome at the level of activity/participation. The author (JW) determined the scope and specific aims of the broader investigation and the methods and procedures for investigation and analysis. The author (JW) determined aims and procedures for carrying out both interviews and analysis. The author (JW) conducted all post therapy interviews and carried out all transcription and analysis. The author conceived the aims for evaluation of the connected speech data, procedures for analysis of this data and collected the data and carried out the analysis. Procedures for analysis of word finding data and sentence comprehension were determined jointly with the lead researcher.

Study 2: An investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid.

This study was conceived, designed and carried out entirely by the author (JW) and data from this study has not been reported elsewhere.

1.11 Previous publication of data in the thesis

Some of the data from study one has previously been published or accepted for publication elsewhere (Mortley, Wade and Enderby 2004, Mortley, Wade, Davies and Enderby 2003, Mortley, Wade, Enderby and Hughes 2004, Wade, Mortley and Enderby 2003a, Wade, Mortley and Enderby 2003b). An investigative study that helped in the development of procedures for study two has also been published elsewhere (Wade, Petheram and Cain 2001).

1.12 Overview of the thesis

This chapter introduces the topic for investigation in this thesis. Chapter Two will present a review of the relevant literature and outline the theoretical framework adopted. Chapters Three and Four will present the first study, an investigation into the process and outcome of word finding therapy delivered via computer. Chapter Three will detail the methods used and Chapter Four will present the results of this study. Chapters Five and Six will present the second study, an investigation into the process and outcome of training people with aphasia to use voice recognition as a writing aid. Chapter Five will detail methods and Chapter Six will present study results. Chapter Seven will examine the findings of the two studies with reference to previous research, draw the findings of the two studies together and examine the extent to which study objectives have been achieved. Included in this discussion will be a consideration of the limitations of the research. Finally, Chapter Eight will present a summary and conclusions, highlighting implications for clinical practice and future research and indicating the contribution made by the research in this thesis to the body of knowledge.

Chapter Two: Review of the Literature

2.1 Purpose of review

This review will present an overview of previous research of relevance to the topic of this thesis. The research in this thesis comprises two studies in which people with aphasia used computers in two contrasting ways. In both studies, the aim was to investigate the process of therapy and evaluate the outcome from the perspective of participants.

This review will provide definitions of aphasia and explanations of relevant associated deficits (2.2). It will then present a review of key conceptual frameworks that have shaped the study of aphasia and aphasia therapy research and which are relevant to the central theoretical debates shaping this research (2.3). The next section will focus on models of rehabilitation and their relevance to aphasia therapy research and the current study in particular (2.4). The following section will examine current debates regarding methodology and outcome measurement in particular, which are shaping health services research and aphasia research (2.5). This will be followed by a further section on methodology which deals with the debate surrounding the application of quantitative and qualitative methods in health services research and aphasia research in particular (2.6). This section on methodology is followed by a review of the literature on use of computers in aphasia therapy (2.7). The next section provides a review of the literature regarding word-finding therapy in aphasia, which provides background to study one (2.8). A review of the literature on therapy for writing difficulties in aphasia provides background for study two (2.9). Finally, the last section reviews some of the social and psychological implications of living with aphasia (2.10).

2.2 Aphasia: definitions and associated deficits

2.2.1 Stroke and aphasia

Cerebrovascular disease (CVD) is by far the most common cause of aphasia. It is aphasia resulting from CVD, more commonly and henceforth referred to as stroke, with which this thesis is concerned. A stroke results in disruption of the blood flow to the brain. Where the affected areas are involved in language function, aphasia may result. One of the biggest challenges facing aphasiologists is the diversity of presentation of aphasia. The individual pattern of impairment for each person with aphasia will vary according to the area and extent of the brain damage:

'Aphasia can take many forms. Indeed some would argue that there are as many forms of aphasia as there are individuals who suffer from it.'

Lesser and Milroy 1993: 8

Nonetheless, attempts to classify people with aphasia according to aphasia subtypes based on hypotheses about the underlying neurological impairment, patterns of symptoms affecting use of language in different modalities or the underlying linguistic impairments are common in the literature. These will be discussed further in section 2.3.

2.2.2 Stroke and other communication disorders

Aphasia is differentiated from two other communication disorders that may result from stroke, namely, dysarthria and apraxia. Dysarthria is defined as *'difficulty in the articulation of speech sounds, attributable to muscular or neuromuscular defects'* (Lesser 1989:xiii) and is characterised by intact language processing but slurred speech during articulation. Apraxia is defined as an *'impairment in the voluntary and purposive movements which cannot be attributed to any muscular weakness or defects'* (Lesser 1989:xiii). Again the language processing system may be unimpaired, with apraxia affecting only

the articulation of speech. In practice, apraxia may coexist with aphasia. This thesis will restrict itself to investigating the use of computers by people with aphasia. People with apraxia or dysarthria were excluded from the investigation.

2.2.3 Clarification of terms: aphasia versus dysphasia

'Aphasia' in its literal sense means complete absence of speech. Historically in the United Kingdom the more accurate term 'dysphasia' (difficulties with speech) has been more commonly used. However, following North American and European conventions, there is growing preference in Britain for the term 'aphasia'. Here the term 'aphasia' will be used to refer to the full range of patterns of impairment with 'dysphasia' appearing only in quotations or proper names.

2.2.4 Associated deficits

Aphasia is frequently accompanied by further non-language deficits that result from stroke. Most relevant to computer therapy are hemiplegia or hemiparesis (muscle paralysis or weakness affecting one side of the body which may involve the upper limb or both upper and lower limbs); visual field deficits such as hemianopia (loss of vision in one half of the visual field) and memory impairments.

2.3 Aphasiology: conceptual frameworks and theoretical models

Various academic disciplines have influenced the development of the study of aphasia or aphasiology. Many of these are concerned with normal language functioning and use, rather than disordered language functioning and use. In the absence of a model of disordered language processing, aphasiologists look to other disciplines to inform the study of aphasia:

'Aphasia therapists are necessarily obliged to work eclectically, pending the nirvana of the definitive model of language processing and its relationship to brain damage'

Lesser and Milroy 1993: 232

As a result of this eclectic approach, a number of disciplines have had very different impacts on the development of aphasiology. A brief overview of some of the most influential theoretical frameworks and their impact will be given here, and the theoretical framework adopted for this study will be outlined.

2.3.1 Modality framework for classification of aphasia

Language can be divided in the four modalities: spoken language comprehension, speech, reading and writing. In aphasia, performance in these different modalities can be differentially impaired, leaving comprehension of speech relatively intact while speech is relatively impaired or vice versa. A similar differentiation may be found in performance between spoken language and written language.

The most longstanding form of classification of aphasia has been into a simple dichotomy based on characteristics of the person's speech: for example, non-fluent speech (Broca's) and fluent speech (Wernicke's). Non-fluent or Broca's aphasia is characterised by halting, effortful and telegraphic utterances and is associated with relatively unimpaired spoken language comprehension. Fluent aphasia or Wernicke's is characterised by fluent speech-like spoken output, which contains many non-words (neologisms) and word errors (paraphasias) and is often accompanied by severe comprehension deficits. Such classifications dominated aphasiology until the 1970's. Their appeal was reinforced by a link demonstrated between patterns of language impairment and the location of the underlying brain damage causing the aphasia. The patterns of speech associated with non-fluent and fluent aphasia are associated with damage to the anterior regions of the brain (Broca's area, non-fluent) and posterior (Wernicke's area, fluent) respectively (Goodglass,

Quadfasal and Timberlake 1964, cited in Davis 1983). Further sub classification into syndromes was provided by the Boston classification (Goodglass and Kaplan 1972, cited in Davis 1983). The latter maintained the non-fluent versus fluent distinction but identified seven subcategories within the framework of the basic dichotomy. Two of the fluent aphasias, conduction aphasia and anomic aphasia will be relevant in this study. Conduction aphasia mainly affects speech, particularly the ability to repeat words or phrases. Anomic aphasia is characterised principally by difficulties finding words. Use of the Boston classification descriptors is still common in studies of aphasia and outcome in stroke (Laska et al. 2001).

2.3.2 Influence of linguistic theory

The cross-fertilisation of ideas from linguistics resulted in aphasiology developing new ways of describing aphasia. Linguistic theory impacted on aphasiology by suggesting that language was organised according to hierarchical structures and different levels of structure were identified: phonology, the system of rules governing sounds of a language; syntax, the system of rules governing sentence structure of a language; semantics, the system of rules governing meaning; pragmatics the system of rules surrounding use of language (Lesser 1989). Elements of this structure might be differently impaired in different people. Aphasiology as a discipline moved from a position of classifying aphasia according to whether a person showed greater or lesser impairment in the various language modalities (spoken language comprehension, speech, reading and writing) towards a framework of analysing difficulties in terms of whether linguistic systems (for example, phonological, syntactic, semantic or pragmatic) were differentially impaired or intact.

2.3.3 Influence of cognitive neuropsychology

This influx of linguistic theory was followed by developments in theory from particular fields of linguistics. The first has its origins in psycholinguistics and in particular the development of models to represent the mental operations

underlying the processing of single words in various cross modality tasks such as matching words to pictures or reading words aloud. Originally developed from performance on such tasks by people with normal language processing skills, cross-modality models of single word processing have subsequently been tested against the behaviour of people with aphasia (Ellis and Young 1988). The new discipline of cognitive neuropsychology arose and has been particularly influential in the field of research into word finding difficulties. Models of single word processing have undergone considerable revision over the years and remain controversial (Nickels 2002a) in terms of the precise stages of processing involved. All models, however, agree that in word finding there is an early semantic stage (word meaning) followed by a late phonological stage (word form). These issues are discussed further in section 2.8.

2.3.4 Impairment versus functional approaches

Language impairment has traditionally been the dominant focus in aphasia assessment and therapy (Avent, Wertz and Auther 1998, Parr and Byng 2000, Lyons 2004, Olswang 1998, Sarno 1993). The classification of aphasias into classic syndromes is based purely on patterns of impairment and standardised aphasia batteries (for example, the Western Aphasia Battery, Kertesz 1982) are designed to provide a profile of the language *impairment* of each person with aphasia. The advent of linguistic approaches to conceptualising language simply shifted the focus from impairment of language modality (comprehension, speech, reading, writing) to impairment of the language system (phonology, semantics, syntax etc.).

Traditionally, however, impairment based therapies have always been complemented by efforts to ensure that a person with aphasia can function in everyday life to the best of their ability given the constraints imposed by the language impairment. Davis, writing in 1983, defined the role of the clinician as follows:

'Treatment consists of a variety of activities designed to improve specific impaired language functions and to enhance overall communication effectiveness. Efforts are directed toward guiding the patient to becoming the best possible communicator as independent from the clinician as possible. The sudden communication disorder also requires adjustments in familial, occupational, and social roles by the patient and family; and the clinician can facilitate these adjustments.'

Davis 1983: 25

Davis thus emphasised the importance of combining impairment-based therapies with what have been termed functional approaches to therapy. However, the term functional therapy has proved more difficult to define than impairment therapy and considerable debate continues around its definition (Byng, Pound and Parr 2000, Frattali 1998, Frattali 1992, Irwin, Wertz and Avent 2002, Worrall 2000). It is frequently used as a somewhat imprecise umbrella term to refer to a wide range of approaches that target the use of language in context, as opposed to use of language in decontextualised language tasks (for example, picture naming) that might be the target of impairment based assessment and therapy.

Attempts have been made to provide clearer definitions of the range of approaches referred to as functional by the introduction of terms such as pragmatic approaches, psychosocial approaches etc. Adopted from within the linguistic framework (section 2.3.2) pragmatics has been defined as the study of language use, including social interaction (Levinson 1983). Pragmatic approaches which were developed for aphasic language (Green, 1984, Penn, 1988) were thus concerned with situated speech *'the kind of everyday spoken language which is generally collaboratively produced and is embedded in a web of surrounding contextual constraints and supports'* (Lesser and Milroy 1993: p43). However, confusion continues as the terms pragmatic performance and functional language use have come to be used interchangeably in aphasia therapy (Irwin, Wertz and Avent 2002, Davis 1983). Psychosocial approaches, as the name implies, deal with any of the

psychological or social sequelae of aphasia, but clearly this area covers a vast range of problems and approaches to remediation.

Some clarity has been brought by the introduction of ideas from one area of pragmatics or sociolinguistics, in particular, namely conversation analysis. Conversation analysis (CA) aims to study social interaction through detailed examination of conversation. CA uses a qualitative methodology designed to focus on the strategic use of various interactional or linguistic devices and resources that a person may use during conversation. One of the most recent interesting developments from research in CA in aphasia has been to apply the principles of CA in a quantitative evaluation of word finding abilities in conversation. This is discussed further in section 2.8.7.

2.3.5 Theoretical influences on the research in this thesis

The descriptions of the aphasia of participants in this thesis will incorporate all the influences described above insofar as they are useful. The assumption will be that although it is possible to group individuals with aphasia when they have similar difficulties, there will be considerable variation between members of these groups and as a result it is important that individual differences are reflected in assessment and intervention. Classificatory labels will be applied as useful shorthand but will be complemented by further description of language characteristics based on hierarchical levels of language processing and cognitive neuropsychological models of single word processing.

2.3 Rehabilitation in aphasia: conceptual frameworks of disability and rehabilitation

Aphasia therapy after stroke does not take place in isolation. It occurs within the context of multi-disciplinary interventions to maximise function. Rehabilitation medicine has been defined as the

'multi-disciplinary and interdisciplinary management of a person's function and disability. Its goals are to minimize symptoms and disability'

(Stucki, Ewert and Cieza 2003: 628).

A number of different conceptual frameworks, which are exerting increasing influence on policy and delivery of rehabilitation services generally, will be reviewed here. Their relevance to aphasia therapy and the content of this thesis in particular will then be outlined.

2.4.1 Defining disability: medical and social models

The last thirty years has seen an intense theoretical debate surrounding two competing models of functioning and disability, the medical model and the social model. The medical model views disability as a problem of the individual directly caused by disease or other health condition. Disability under this model requires medical or other treatment to 'correct' the problem with the individual. From this it follows that the main focus of health service delivery is to treat the impaired function in order to improve the individual's level of functioning in daily life.

The social model arose in reaction to the hitherto dominant paradigm of the medical model from the work of the *Union of the Physically Impaired Against Segregation* (UPIAS) and the publication of *The Fundamental Principles of Disability* in 1976. Oliver (1996) identifies two themes central to the social model: first that the experience and expertise of people with disabilities was crucial to understanding the phenomenon of disability; second, that the problems faced by people with disabilities were externally located in the disabling barriers and social restrictions that they faced rather than being internally located as the inevitable consequences of living with impaired function. Oliver (1996) has summarised the contrast between the social model and the medical model by highlighting that the former places the locus of responsibility for disability on society whereas the latter places it on the individual. Within the social model framework, the assumption that problems

arise from externally located disabling barriers, leads to the goal of rehabilitation being the removal of these systemic barriers and the increase in people's control over their own lives.

Assumptions underlying the medical or individual model are all-pervasive in our culture and models of health service delivery (Ueda and Okawa 2003). As a consequence, prior to the debates initiated in 1976, traditional aphasia therapy was founded almost exclusively in a medical model of disability (Jordan and Kaiser 1996). This model assumed a linear relationship between impairment and function. From this it followed that the legitimate target of therapy was the impairment and improvements in impairment would result in improvements to function. Proponents of the disability model have criticised existing models of rehabilitation for this focus on impairment and the bias towards impairment based rehabilitation.

2.4.2 Influence of the social model on aphasia therapy research

In aphasia therapy, this criticism has been echoed in the critique of a predominantly impairment based approach to therapy (Avent, Wertz and Auther 1998, Parr and Byng 2000, Pound, Parr, Lindsay and Woolf 2000, Olswang 1998, Sarno 1993). Traditionally in aphasia therapy, impairment based approaches have been perceived as being in opposition or complementary to functional approaches to therapy. However, as discussed above, the term functional is often used in an imprecise way to refer to a wide range of approaches that focus in some way on meaningful communication in context. The adoption of the social model, provides a theoretical framework, that has the potential to lend clarity and theoretical cohesion to the wide range of approaches previously lumped together under the term 'functional' (Worrall 2000).

Byng and colleagues acknowledge the influence of the social model in the development of what they call their 'integrated' framework for therapy

intervention (Byng, Pound and Parr 2000, Pound, Parr, Lindsay and Woolf 2000). This model recognises the importance of two concepts that are key to social model approaches: the disabling barriers or systemic effects of aphasia and issues of disabled identity. However, it also acknowledges the significant impact of the impairment on individual people with aphasia:

'Many people with aphasia are preoccupied with their impairment, and are only concerned to see it improve and to make the best recovery possible. For some people, at certain times, issues of disability may seem irrelevant'.

Pound, Parr, Lindsay and Woolf 2000: 15

Byng, Pound and Parr (2000) place strong emphasis on issues of identity and argue that equilibrium needs to be achieved between working to improve communication skills and working to achieve a satisfactory sense of identity. The aim of their proposed framework is to promote healthy living with aphasia. The framework reflects the multi-dimensional nature of aphasia and hence aphasia therapy goals. It conceptualises the person with aphasia as interacting on a continuum of social levels. The person with aphasia can be seen as a unique individual, as part of their immediate social network or as a member of society as a whole. Six broad goals are identified: enhancing communication; identifying and dismantling barriers to social participation; adaptation of identity; promoting a healthy psychological state; promoting autonomy and choice; health promotion/illness prevention. Specific therapy interventions may target any of these goals at any point on this social continuum.

What is interesting about this model is that it incorporates both an individual perspective on aphasia and a social perspective on aphasia, adopting useful concepts from the social model approach without rejecting the relevance of the individual experience of impairment. It also foregrounds issues of identity and psychological well being in addition to the more traditional aphasia therapy goal of enhancing communication.

This attempt to bridge the conceptual divide between the social and medical models reflects a process that is going on more generally in the development of frameworks for rehabilitation. The most influential of these is the International Classification of Functioning, Disability and Health (WHO 2001). This framework will be described and some of its strengths and weaknesses discussed before considering its relevance to aphasia therapy rehabilitation.

2.4.3 International Classification of Functioning, Disability and Health (World Health Organisation 2001)

One of the most widely used models for conceptualising disablement is the World Health Organisation International Classification of Functioning, Disability and Health (ICF) (WHO 2001) (introduced in section 1.9). The ICF evolved from the original WHO International Classification of Impairments, Disabilities and Handicaps (ICIDH, 1980) that identified three dimensions by which disease might impact on an individual, by resulting in impairment, disability or handicap. Impairment (any loss or abnormality of psychological, physiological or anatomical structure or function) was conceptualised as resulting in disability (a restriction or lack of ability to perform an activity in the manner considered normal for a person as a result of impairment) and in handicap (a limitation in performing a role considered normal for a person caused by disability or handicap). This original model was criticised for being essentially biomedical. It lent itself to being interpreted as showing a linear pathway leading inevitably from a health condition to impairment, disability and handicap, encouraging a medical model perspective and failing to recognise social models of disablement (WCC 1994). In response to this, the ICIDH was revised in favour of a 'biopsychosocial' model, the International Classification of Function, Disability and Health (ICF) (WHO 2001). The revised model emphasises the complex multidimensional interaction between functioning and context that recognises the impact of social (environmental and personal) factors on functioning and encourages a move away from conceptualising a predictable linear progression between levels of impairment, activity restriction and participation limitation.

2.4.3.1 Description of the ICF

The ICF (WHO 2001) was developed to provide a unified, standard language and framework for the description of health and health-related states, which can be applied across disciplines and across cultures. A schematic representation of the model is given in section 1.9 (Figure 1.1). A description of dimensions is given in Figure 2.1. Dimensions are described from the perspective of the body (physical domain), the individual (personal domain) and society (social domain) by means of two classificatory lists: a) Body Functions and Structures; b) Activities and Participation. Activities and participation have been merged into a single list for classification purposes, in recognition of the fact that functioning and disability in individual activities and social participation often interact. Eadie (2003) notes that in communication, social participation is always implicated because communication always involves at least one communication partner. However, a useful distinction between what an individual is able to do (capacity) and what occurs when they are in their usual environment (performance) is retained.

Also recognised in this revised model is the fact that contextual factors such as the environment and personal characteristics influence both each other and level of functioning in the identified domains. Environmental factors comprise the physical, social and attitudinal environment in which people conduct their lives. Personal factors include age, race, gender, educational background, personality, coping styles and lifestyle. This development has been welcomed as it provides a framework for the analysis of how individual beliefs can impact on rehabilitation (Wade, 2000), although controversy continues as the extent to which this has been achieved (Wade and Halligan 2003, Ueda and Okawa 2003, Nordenfelt 2003). In summary, the ICF

'attempts to achieve a synthesis, in order to provide a coherent view of different perspectives of health from a biological, individual and social perspective.'

ICF Introduction 2001: 20

Dimension	Definition
Body functions Impairments	Physiological functions of body systems (including psychological functions) Problems in body function as a significant deviation or loss
Body structures Impairments	Anatomical parts of the body such as organs, limbs and their components Problems in structure as a significant deviation or loss
Activity Activity Limitation	Execution of a task or action by an individual Difficulties an individual may have in executing activities
Participation Participation Restriction	Involvement in a life situation Problems an individual may have in involvement in life situations
Environmental Factors Personal Factors	These make up the physical, social and attitudinal environment in which people live and conduct their lives – may be individual or societal E.g. gender, race, age, lifestyle, habits, social background, behaviour pattern, character, education, life events, coping styles.

Figure 2.1 Definitions associated with the ICF (WHO 2001)

2.4.3.2 Limitations of the ICF

Despite many improvements since the original publication of the ICIDH (WHO 1980) the revised ICF (WHO, 2001) continues to provoke criticism. Despite amendments to incorporate the perspective of the social model, the ICF retains essentially an 'other-than-patient' view of functioning (Wade and Halligan 2003) which reflects its origins as a tool for health care systems to document and plan for consequences of disease. Despite recognition that personal factors as well as environmental factors will impact on functioning,

personal factors are not classified (Arthanat, Nochajski and Stone 2004, Bornman 2004, Ueda and Okawa 2003). It has been criticised for failing to take adequate account of phenomena that arise primarily within the person, such as free will, patient choice and issues concerning personal values and quality of life (Nordenfeldt 2003, Ueda and Okawa 2003, Wade and Halligan 2003, Wade 2000). Although the ICF recognises a distinction between capacity and performance helping to explain that performance in tasks of everyday living may vary, it does not explicitly examine how much direct patient choice influences performance (Nordenfeldt 2003). Free will and motivation may help explain illness behaviour not produced by disease, injury, psychopathology or psychosocial factors (Nordenfeldt 2003, Wade and Halligan 2003).

Critics also argue that, given increasing use of the term quality of life (QOL) in current health research, it should be integrated into the ICF framework (Post, de Witte and Schrijvers 1999, Ueda and Okawa 2003, Wade and Halligan 2003). The WHO developed two instruments for measuring quality of life – the WHOQOL-100 and the WHOQOL-BREF (WHOQOL Group 1993) - available as separate QOL measures and the concept of QOL is not incorporated explicitly into the ICF. Post et al. (1999) suggest that a subjective dimension be incorporated as a separate axis on the domains of body structures or functions and activity and participation. The subjective perceptions in these domains combined with an additional separate domain of happiness and well being would combine under the overarching term QOL.

2.4.3.3 Influence of the ICF on aphasia therapy

This section will review how the ICF domains of impairment, activity and participation can be mapped onto approaches taken previously in aphasia therapy and how reinterpretation of aphasia therapy within the framework of the ICF has the potential to bring theoretical clarity that is currently lacking.

Firstly, the revised model emphasises the way in which the relationship between its component parts is both multi-directional and multidimensional. It illustrates how disease (stroke) can result in impairment (aphasia) but also demonstrates how activity limitation and participation restriction can result from social (contextual) causes. The model also represents how functioning at one level can be independent from another level (Eadie 2003). Enderby (1997) illustrates this principle with two contrasting case studies. A man with a mild expressive and receptive language disorder resulting from aphasia (impairment) may have difficulty making himself understood on the phone, occasionally misunderstand meanings and be dependent on others being patient and attentive listeners (activity limitation). These difficulties result in him being unemployed, withdrawing from social situations, giving up all hobbies and no longer contributing to decision-making (participation restriction). This man is described as having a mild impairment, moderate limitations on activity levels and severe restrictions on participation. The second case, by contrast, is a man with severe impairment (severe athetoid cerebral palsy, quadriplegia, dysarthria), little activity limitation (totally independent with adapted wheelchair, living in adapted accommodation, communicating in all situations with a communication aid and a special adapted telephone), and no participation restriction (employed as a solicitor, active member of the disability movement, with full work and social life).

Worrall (2000) develops these ideas further, arguing that by adopting the ICF, aphasiology can move away from the using the medical model as the dominant paradigm, to incorporating the social model perspective. She argues that the profession should embrace the terminology of the ICF (impairment, activity limitation, participation restriction) as a means of clarifying more precisely those therapy approaches that have previously been indiscriminately referred to under the heading of 'functional':

'The shift from using the term functional communication to more specific terms may not be a popular change, however, if rehabilitation is to embrace the social model as well as the

medical model, a change in terminology may be the catalyst for the process of change.'

Worrall 2000: 16

However, the extent to which the ICF provides aphasia therapy with a useful framework for intervention may be limited. As discussed (section 2.4.3.2), the ICF retains an essentially 'other-than-patient' view of functioning (Wade and Halligan 2003) at a time when it is being argued that the views of people with aphasia (Parr and Byng 2000) and issues of identity (Byng et al. 2000, Pound et al. 2000) are critical in determining goals and priorities for therapy. Cruice, Worrall, Hickson and Murison (2003) therefore propose expanding the ICF into a Communication Related Quality of Life model to accommodate quality of life issues, because of the relevance of issues in this subjective dimension to functioning in aphasia. Cruice et al. 2003 conceptualise quality of life as social health and psychological well being.

2.4.4 Redefinition of rehabilitation

Influenced by social model approaches, some aphasia therapists reject the notion of finite rehabilitation for aphasia (Kagan 2003). Kagan argues that people with aphasia need on-going treatment rather than fixed term rehabilitation in the same way as someone with a chronic condition such as diabetes requires ongoing treatment. This shift in thinking has implications for service delivery and necessitates a rethinking of our concept of what therapy services might offer in order to enable people to take up life with aphasia in new ways.

2.4.5 Proposed theoretical framework for this research

The research described in this thesis took as its theoretical framework that of the ICF (2001) on the premise that this framework would enable the accommodation of a social model perspective in addition to that of the medical model. It seeks to evaluate outcome very broadly in terms of impact on levels

of impairment, activity and participation and in a way that acknowledges the impact of environmental factors on outcome.

2.5 Methodological considerations in aphasia research I: outcome measurement

The research reported in this thesis presents the findings of two studies that investigate the outcome of using computers to deliver therapy in aphasia. This section will define terminology and present some of the methodological issues that influence outcome research.

2.5.1 Outcome measurement in health services research (HSR): implications for aphasia research

The increased political and financial pressures on health care to demonstrate that health care interventions are effective have resulted in a recent increase in interest in evaluating outcomes in aphasia (Enderby and Emerson 1995, Holland, Fromm, DeRuyter and Stein 1996, Greener, Enderby and Whurr 2001, Robey 1998, Robey 1994). Aphasia therapy is inevitably influenced by broader political and cultural trends and this section will review how these trends are impacting on aphasia research and therapy.

2.5.2 Definition of terms: efficacy, effectiveness, efficiency and outcome

Research into communication disorders has been criticised for imprecise use of terminology (Wertz and Katz 2004, Wertz and Irwin 2001, Robey 1998):

'Failure to define the treatment outcome research terminology has led to a general but inferentially naïve impression that all treatment intervention investigations are a test of a treatment's efficacy. The terms 'outcome', 'efficacy', 'effectiveness', and 'efficiency' have been used inappropriately as synonyms.'

Wertz and Katz 2004: 230

In this thesis the following definitions, taken from Robey and Schultz (1998) and based on the definitions provided by the Office of Technology Assessment (1978), are used. *Efficacy* is defined as '*The probability of benefit to individuals in a defined population from a medical technology applied for a given medical problem under ideal conditions of use.*' (OTA 1978: p16). Key constraints in this definition are that inferences about efficacy are applicable to a population not an individual; the treatment and population are clearly specified; and finally, the conditions under which efficacy is determined are optimal, rather than those found in everyday clinical practice.

By contrast, *effectiveness* is defined as '*the probability of benefit to individuals in a defined population for a given medical problem under average conditions of use*' (p16). While treatment efficacy research is designed to determine whether a treatment can work under ideal conditions, treatment effectiveness research is designed to determine whether a treatment does work under everyday conditions.

Efficiency has been defined as '*acting or producing effectively with a minimum of waste, expense, or unnecessary effort, essentially, exhibiting a high ratio of output to input*' Wertz and Irwin (2001:236). An example of an efficiency study would be the comparison of two treatments delivered according to two different schedules to determine whether the same outcome can be delivered with less duration or intensity.

Outcome is the most general term. Treatment outcome is determined by comparing performance between two points in time, pre- and post-treatment. Outcome can only indicate whether a treatment was active or inactive. Unless specific conditions are met, a treatment outcome indicates nothing about the efficacy, effectiveness, or efficiency of the treatment provided. If outcome measures used are valid and reliable and performance of those receiving treatment improves, the treatment may have been active. If the performance does not improve the treatment would be considered inactive. Olswang

(1998) differentiates between outcome research and efficacy research, stating that treatment efficacy research *proves* treatment benefits whereas treatment outcomes research *identifies* treatment benefits.

This thesis presents research into the *outcome* of therapy delivered via computer. Although there will be discussion of efficacy and efficiency of treatment, the main focus of the thesis will be to identify evidence of the treatment having been active and in what ways.

2.5.3 Hierarchies of evidence in HSR and aphasia research

A number of hierarchical frameworks have been developed to conceptualise levels of evidence in the development of a treatment (for example, Robey and Schultz 1998, Medical Research Council – MRC - 2000). Both of these adapt the five-stage frameworks used in drug trials to be applicable to the evaluation of complex healthcare interventions generally (Medical Research Council 2000) or aphasia therapy in particular (Robey and Shultz 1998).

2.5.3.1 Robey and Schultz framework (1998)

Wertz and Irwin (2001) provide an interpretive summary of the Robey and Schultz (1998) framework^a. The framework has five phases. Phase I objectives are to determine whether treatment is active and develop hypotheses as to what the optimum intensity and duration is and what the most suitable target population may be. Small group studies and single-subject experiments are appropriate at this stage. Phase II objectives include refining the primary research hypothesis and developing an explanation for why the treatment may be efficacious and effective and determining what is optimal as regards treatment, target population, outcome measures, intensity and duration. Again small group studies and single-subject experiments are appropriate. Phase III involves testing the efficacy of the treatment developed

^a Robey and Schultz (1998) use the term 'model' whereas here the term 'framework' will be applied to both. Framework is used here to refer to a theoretical conceptualisation, which implies no prediction. The term model is reserved for a theoretical conceptualisation, which has predictive power.

under optimal conditions, typically a randomised controlled trial (RCT) where participants are randomly assigned to a treatment or no treatment group. If efficacy is demonstrated at Phase III then it is appropriate to proceed to testing effectiveness by examining outcome under ordinary conditions – typical patients, typical clinicians, typical intensity and duration (Phase IV). Large samples are required but external controls such as a no treatment group are not. Finally Phase V continues the effectiveness research and may include exploration of efficiency.

This framework is biased towards the use of quantitative methods of evaluation and clearly sees the RCT as the gold standard of efficacy studies. It includes the evaluation of participant satisfaction and influence of treatment on quality of life for the first time only at Phase V.

2.5.3.2 Medical Research Council framework

The framework proposed by the Medical Research Council (MRC, 2001) is described in a discussion document entitled '*A framework for development of Randomised Controlled Trials for complex interventions to improve health*'. Complex interventions are defined as being built up from a number of components, which may act independently and inter-dependently. The attraction of this model is that it recognises the complexity in identifying the key or active ingredient(s) in interventions, which on the surface appear deceptively simple. For example, the package of care to treat knee injury may appear straightforward, easily definable and reproducible: a specified set of exercises, in a specified order, with specified frequency for specified duration. However, the therapist may have additional influences, for example in a counselling role in rebuilding the patient's confidence, a training role teaching their partner how to help with care or rehabilitation and potentially significant influence via advice on the future health behaviour of the individual. All of these elements are likely to be influencing factors in a speech and language therapy intervention.

A second attraction of this model is that while recognising that the randomised controlled trial (RCT) is the optimal study design for minimising bias and providing the most accurate estimate of a complex intervention, it also recognises circumstances where an RCT is not possible and accepts that observational studies may be possible in their place.

The five phases of this framework differ subtly from those of Robey and Schultz (1998) as illustrated in Figure 2.2. Although the first two stages are separated conceptually, in reality refining theory through modelling activities is liable to be iterative and these two stages are considered together.

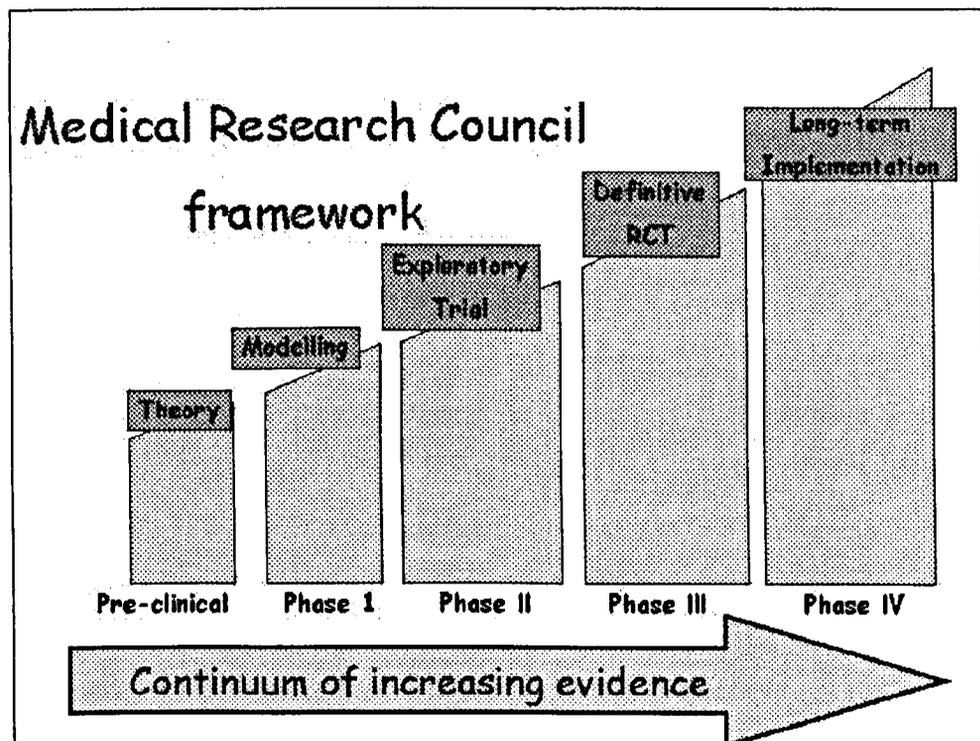


Figure 2.2 MRC framework for development of Randomised Controlled Trials for complex interventions to improve health

Theory building is likely to rest on findings from reviewing existing research. Modelling may be theoretical or involve data collection and qualitative data is likely to be useful at this stage in determining the critical components of the intervention and how they relate and impact on each other. The purpose of an exploratory trial is to determine, for example, how much of the intervention is required and how often. It will also determine whether it is possible to deliver

the intervention in a standard way and to what extent the key variables can be controlled. Individualisation of treatment delivery is accepted practice in many healthcare interventions: the limits of acceptable individualisation must be defined and checked for validity. For the purposes of the main trial decisions must be made regarding the content of the intervention. At one end of the spectrum is the position of tightly standardising the intervention to ensure it maximally contains the 'active ingredients'. This may be at the cost of substantial effort and resources and the generalisability of findings to general health care delivery where this degree of standardisation is not feasible. At the other end of the spectrum is the choice to design a very pragmatic trial where intervention varies as it would in real world practice, thus maximising the generalisability of findings. Key in helping the decision-making is the fact that intervention has to be feasible within the health service.

This thesis describes two studies that are both exploratory and small scale. The studies are both located at the modelling phase of the MRC framework, that is, determining the critical components of the intervention and how they interrelate and impact on each other. As such they take as their theory base (the pre-clinical phase of the MRC framework) pre-existing theory and research in two areas, both of which will be summarised in this review. Study one builds on the large amount of theory already generated to explain the mechanisms of word finding in aphasia, how this may be impaired and how impaired word finding may be treated (reviewed in section 2.8 below). Study two builds on theory arising from research into the use of voice recognition software by people with a range of speech and/or language difficulties including dysarthria, delayed language development and aphasia: previous research into the use of voice recognition by people with aphasia is limited so it is necessary to base modelling on existing research with a broader population. The benefits and barriers to use that may arise for people with a range of speech and language difficulties are reviewed in section 2.9.7 below. Both studies share some Phase 1 aims of the Robey and Schultz framework: to determine whether treatment is active and develop hypotheses as to what

the key components in bringing about change and the most suitable target population may be.

2.5.4 Outcome measurement in aphasia research

2.5.4.1 Evidence for efficacy and effectiveness in aphasia therapy

A number of reviews have investigated outcomes of aphasia therapy in published studies (Greener, Enderby and Whurr 1999, Holland et al. 1996, Robey 1998, Robey 1994). Findings have been limited. Although outcomes for treated individuals are superior to those for untreated individuals in all stages of recovery, there have been too few studies examining the differential effects of treatments for different types of aphasia (Robey 1998). Systematic review of the evidence of effectiveness of aphasia therapy has shown that aphasia therapy has not been shown to be clearly effective or clearly ineffective using the RCT as a methodology (Greener, Enderby and Whurr 1999). Greener and colleagues urge researchers to examine other forms of evidence, as described within the MRC framework above, in order to base decisions about therapy.

2.5.4.2 Impairment versus activity or participation

A recent review of the key issues for consideration in treatment efficacy research in aphasia (Olswang 1998), suggests that typically treatment efficacy has focussed on impairment as opposed to activity limitation or participation (WHO, 2001, section 2.4.3 above). This need not and indeed should not be the case and more recently efficacy research has expanded its focus to include activity limitation and participation restriction in response to health care reform. The latter has encouraged health-professionals to demonstrate significant and cost-effective change in client behaviour. The focus is less on how an intervention alters behaviour at the level of impairment and more on establishing that treatment is associated with important changes in a person's life.

2.5.4.3 Analytic versus systemic studies

Olswang (1998) distinguishes between analytic and systemic studies, two contrasting perspectives within treatment efficacy research. The analytic or experimental approach focuses on how specific treatment affects specific behaviour change for individual clients. The analytic perspective has primarily focussed on impairment level behaviour (for example the ability to find words in aphasia), perhaps in part because these behaviours are easier to define and manipulate in treatment. The assumption in the analytic approach is that it is possible to isolate and measure these behaviours out of context. The systemic approach, by contrast, focuses on behaviours in context. This perspective lends itself more closely to examination of behaviour at the level of activity or participation (WHO, 2001), for example the ability to enjoy satisfactory conversation with friends and family. Behaviours are more broadly defined, must be evaluated in context and ideally from the perspective of people with aphasia. They therefore lend themselves to qualitative methodology (Parr and Byng 2000, discussed further in section 2.6). Olswang (1998) suggest a continuum exists between efficacy research and outcome research. Systemic approaches are located most closely on the continuum to outcome research and distinctions here can easily become blurred. The onus on the researcher is to provide the proof of treatment benefits rather than simply to identify their presence.

'At the heart of proof is replication, either within or across subjects. The more replications, the more powerful the proof.'

Olswang 1998: 139

2.5.4.4 Study designs: Group studies versus within subject or single case studies

Howard (2003) argues strongly in favour of case series design for studying the efficacy of treatment in aphasia therapy. The single case study design can be based on an analytic or experimental approach applying principles of behavioural analysis: the research manipulates the environment in systematic

predetermined ways (the treatment) and critical behaviours are measured repeatedly over time. If the question posed is how a particular treatment alters behaviour over time, this is best addressed through within subject/time series designs. The strength of this design is that it

'yields extraordinary insight into the therapeutic process, by revealing how treatment interfaces with particular disorders and subject/client characteristics'.

Olswang 1998:139

Given the variation in presentation of symptoms in aphasia, this insight into individual's responses to treatment can be extremely valuable. The value of single case study designs has been particularly emphasised by people working within the theoretical framework of cognitive neuropsychology (Caramazza 1986, Howard 2003, Nickels 2002b, Shallice 1988). Although group designs are favoured as being a 'higher level of evidence' in hierarchies such as the MRC framework (MRC 2000, Robey and Schultz 1998) their application to aphasia therapy research can be misleading (Howard 2000). Group studies in aphasia almost always involve diverse treatments applied to a diverse group of participants. It is often unclear what the treatment really was (Robey 1998) and impossible to conclude with confidence that similar results would be found with other subjects. The group results are meaningless unless treatment effects are homogeneous, yet treatment effects in group studies rarely are. The solution proposed to this dilemma is the case series study in which individual differences between study participants and their influence on outcome can be captured (Howard 2003).

2.5.5 Relevance to this research

This thesis discusses the outcome of two studies in which computers were used to deliver therapy in aphasia. Both studies set out to investigate outcome from the perspective of people with aphasia. Both therefore use the term outcome in its broadest sense to include impacts on impairment, activity and participation. This research recognises the continuum between efficacy

research and outcome research and the value of both analytic and systemic approaches to evaluation. It also recognises the value of case study series research in aphasia. Located at the exploratory stage of the MRC model, the research does not make claims for demonstrating effectiveness or efficiency of therapy. However, findings will be discussed in terms of implications for possible effectiveness and efficiency.

2.6 Methodological issues in aphasia research: the qualitative/quantitative debate

Reference has been made to the value of incorporating qualitative methodology alongside quantitative (analytic or experimental) methodology when evaluating the broader impacts of aphasia therapy (MRC 2000, Olswang 1998). The differing ontological and epistemological bases of qualitative and quantitative approaches raise philosophical and practical challenges for those seeking to combine the two. These issues will be described in this section and the implications for applying qualitative methods to aphasia research will be summarised.

2.6.1 Qualitative and quantitative methodologies: competing paradigms

One of the key assertions in the debate about theory and application of qualitative and quantitative methodologies has been that the two approaches are based on two antithetical and incommensurable theoretical paradigms. If the view is taken that method is secondary to the philosophy on which method is based (Guba & Lincoln 1994) this fundamental antithesis between the theoretical paradigms renders the combination of their use in a single study a theoretical aberration.

‘There is some debate about whether mixing methods across paradigms may lead to a lack of analytical clarity because each method relies on different assumptions in data collection and

produces different types of data which may be difficult to reconcile'

Snape & Spencer 2003: p17

However, others take a more pragmatic approach arguing that there is no necessary theoretical opposition between the two methodologies and that choice of methods should be made on instrumental grounds (Murphy, Dingwall, Greatbatch, Parker & Watson 1998, Snape and Spencer 2003). The differing philosophical positions associated with qualitative and quantitative approaches will be considered first, followed by an outline of the theoretical position taken in this study.

2.6.2 Quantitative versus qualitative: ontology and epistemology

Ontology is defined as belief about the nature of the world and what it is possible to know about it. Epistemology is defined as belief as to the nature of knowledge and how it can be acquired. Quantitative and qualitative approaches are associated with very differing ontology and epistemology and these will be reviewed here along with implications for methodologies adopted.

Quantitative approaches are associated with the ontology of realism, which argues that an external reality exists, independently of social beliefs or understanding. The assumptions underlying the ontology of realism lead logically to the epistemology of positivism: if the world is independent of and unaffected by the researcher, this makes objective enquiry possible and assumes that the methods of the natural sciences (hypothesis testing, causal explanations and modelling) are appropriate methods to apply in the process of objective enquiry (Murphy, Dingwall, Greatbatch, Parker and Watson 1998, Snape and Spencer 2003, Williams and May 1996).

Qualitative approaches are associated with the ontology of idealism, which argues that no external reality or absolute truth exists independently of social

beliefs and understanding. In its most extreme manifestation this becomes the position of relativism, which assumes reality is only knowable through socially constructed meanings and that there is no single shared social reality, only a series of alternative social constructions. These assumptions lead to the epistemology of interpretivism, whereby it is assumed that the researcher and the social world impact on each other. As a result, completely value free objective research is not possible. This renders the methods of the natural sciences inappropriate, as the world does not comprise an independent reality whose governing laws can be uncovered by research but instead is mediated through human interpretation. The goal of the researcher becomes to explore and understand the meanings attached to the world through the participant or the researcher's understanding (Murphy et al. 1998, Snape and Spencer 2003, Williams and May 1996).

2.6.3 Critique of realism and idealism

Relativism creates problems for those arguing for a body of knowledge over which there is inter-subjective agreement (Murphy et al. 1998, Snape and Spencer 2003). Realism fails to recognise the impact of the investigators' perspective on the process of the investigation:

'Neither naïve realism nor naïve idealism do justice to the complexities which confront those who engage in social researchnaïve relativism renders social research pointless. Naïve realism fails to recognise the sheer impossibility of unmediated contact between the investigator and the object of his or her investigations'

Murphy et al. 1998:85

However, between these two extremes can be found a middle ground offered by the epistemological stance of subtle realism (Hammersley 1992). Subtle realism accepts the existence of independent knowable phenomena, but assumes these are only accessible mediated through representations. This enables the researcher to retain the idea of independent truth as an ideal yet accommodate some elements of social constructivism. It recognises that all

knowledge is a human construct based on assumptions yet rejects the notion that knowledge must be defined as beliefs whose validity is known for certain. The objective instead is the search for knowledge about which it is possible to be reasonably confident. Research can represent reality but not reproduce it.

This opens up the possibility of multiple, non-competing, valid descriptions and explanations of the same phenomenon and enables the methods of both quantitative and qualitative approaches to be seen as equally appropriate and accommodated within one study without creating an ontological or epistemological contradiction or as different parts of a researcher's toolkit (Bryman 2001, Murphy et al 2003, Pope Ziebland and Mays 2000, Snape and Spencer 2003). Pragmatism and instrumental considerations will be relevant in determining which method to use (Murphy et al. 1998). The stance of subtle realism is the philosophical position, which underlies the choice of methods in this research.

The research presented in this thesis set out to investigate the views of people with aphasia on using computers in therapy. As such methodology that facilitates the exploration and understanding of the world through the eyes of the person with aphasia is likely to be highly appropriate. Some of the other key strengths of qualitative methods will be examined below.

2.6.4 Strengths of qualitative methods

Controversy continues as to the defining characteristics of qualitative research. Some authors arguing that qualitative approaches are identified by key characteristics, distinguishing them from quantitative approaches (Bryman 2001, 1998, Guba and Lincoln 1994, Hammersley and Atkinson 1995, Mason 2002, Miles and Huberman 1994, Patton 2002). Others have argued that some of these so-called distinguishing characteristics can be equally associated with quantitative methodologies (Murphy et al. 1998). However, there is agreement in the literature that qualitative approaches have particular strengths and these will be considered here.

General consensus exists that qualitative methods are highly suited to research that is exploratory, seeks to create an understanding of events and behaviours holistically in the context in which they occur and for providing an understanding of the processes by which such events and behaviours come about (Marshall and Rossman 1995, Murphy et al 1998 Pope and Mays 1995):

'The most compelling argument is to stress the unique strengths of this paradigm for research that is exploratory or descriptive, that assumes the value of context and setting, and that searches for a deeper understanding of the participants' lived experiences of the phenomenon.'

Marshall and Rossman (1995: p39).

Due to these strengths, qualitative methodologies are being applied increasingly within health services research both in their own right and as a supplement to quantitative methodologies (Marshall and Rossman 1995, Murphy et al 1998, Pope, Ziebland & Mays 2000, Pope & Mays 1995, Ritchie 2003). Various authors have provided frameworks for the manner in which quantitative and qualitative methods can be combined, all of which are based essentially on the idea that different sequential relationships may exist between the conduct of qualitative and quantitative studies (Bryman 1988, 2001, Hammersley 1996, Morgan 1998): qualitative enquiry may precede quantitative enquiry, accompany quantitative enquiry or follow quantitative enquiry.

2.6.5 Combining qualitative and quantitative methods

The aim in the research in this thesis was to capture both the nature and measure the extent of the impact of computer therapy on people with aphasia. Combining qualitative and quantitative approaches is beneficial when the aim is to capture both the nature and the number of the named phenomenon. It may also be possible via qualitative research to identify dimensions of a phenomenon for subsequent quantitative measurement (Pope and Mays 1996). Alternatively the phenomenon may be too complex or delicate to be

captured fully in statistical enquiry with qualitative research being required to provide the full detail required.

A combination of methods is also useful when qualitative methods are brought together in the same study, but used to explore different phenomena. For example quantitative methods may be more appropriate for measuring changes in language impairment, whereas it has been argued that qualitative methods are more appropriate for capturing changes in levels of activity and participation if this is to be done in a way sensitive to the wide variation in individual experiences (Worrall 2000, Parr and Byng 2000).

The term 'triangulation' is frequently used when describing the benefits of combining quantitative and qualitative approaches. This has been defined as the use of quantitative research to corroborate qualitative research or vice versa (Hammersley, 1996). However, the need for different methods to converge to tell one coherent story has been questioned by some as a 'false trail' (Snape and Spencer 2003). Different methods may produce different findings that reflect the different forms of evidence used. This is not a problem: it can build greater understanding and insight than if one approach alone is used.

2.6.7 Application of qualitative methods in aphasia research

An analysis of the strengths and weaknesses of qualitative methods with particular reference to aphasia research is provided by Damico, Simmons-Mackie, Oelschlaeger, Elman and Armstrong (1999) and Sorin-Peters (2004). Both these papers highlight the strengths of qualitative data in focussing on the perspective of people with aphasia and for examining the functional, social and psychological implications of language impairment. Aphasia research has a rapidly developing tradition of application of qualitative methods in the form of conversation analysis (Damico, Oelschlaeger and Simmons-Mackie 1999, Perkins 1995), ethnography (Simmons-Mackie and Damico 1999) and in-

depth interviews (Parr, Byng, Gilpin and Ireland 1997, Pound, Parr and Duchan 2001, LeDorze and Brassard 1995, Van der Gaag et al. 2004).

In aphasia research, qualitative methods such as the in-depth interview offer the added advantage of enabling access to data that would be potentially inaccessible if the investigation were carried out using a standardised questionnaire format. In particular, methods such as the in-depth interview and to some extent, the focus group, may facilitate access to views that, precisely because of their communication impairment, would be difficult to access by more standardised means (Le Dorze and Brassard 1995, Parr and Byng 2000, Parr et al. 1997).

2.6.8 Relevance to this research

One of the primary aims of the research in this thesis was to investigate the outcome of computer therapy for people with aphasia from the perspective of people with aphasia. As such the application of a substantial qualitative evaluation was perceived to be critical in order to capture individual variation in experience and illuminate the complex processes by which impacts occurred. It also enabled the identification of phenomena for parallel quantitative measurement in an attempt to capture both the number and the nature of impacts.

2.7 Use of computers in aphasia rehabilitation

Both studies in this thesis involved use of computers by people with aphasia. This section briefly reviews broad issues surrounding use of computers in rehabilitation. It is followed by more detailed sections reviewing issues specifically relevant to study one (section 2.8) and issues specifically relevant to study two (section 2.9).

2.7.1 Evidence for outcome, efficacy and effectiveness

Despite the increasing body of literature on the use of computers in aphasia, computer use in aphasia therapy remains controversial (Robertson 1990, Wertz and Katz 2004). The potential of computers to provide people with aphasia with a tool for practice additional to that carried out in therapy sessions was recognised early on in the development of computers and quickly motivated investigations into the use and outcome of computerised therapy tasks (Katz 1987, 1994, Loverso, Prescott and Selinger 1992, Wertz and Katz 2004). Over a decade ago, Robertson (1990) argued that the efficacy of computerised treatment in aphasia had yet to be demonstrated and warned against potential unanticipated negative effects of computer-assisted therapy. Since then, Katz and Wertz (1997) have provided evidence for the efficacy of computer-provided reading treatment for people with chronic aphasia. Wertz and Katz (2004) suggest that some of the controversy regarding outcome stems from a failure to have defined terminology (outcome, efficacy or effectiveness, section 2.5.2) failure to specify appropriate research designs and failure to employ a level of evidence scale to evaluate reports of computerised treatment studies for aphasia.

Wertz and Katz (2004) present a review of published studies with reference to Robey and Schultz' phase five model (1998) (section 2.5.3.1 above). They conclude that while several Phase 1 and 2 studies imply that computer-provided treatment is active in the treatment of people with aphasia, evidence to support the efficacy of computerised treatment for adults with aphasia is based on a single Phase 3 study (a longitudinal group study of the efficacy of computerised reading therapy, Katz and Wertz 1997).

None of the studies reviewed by Wertz and Katz (2004) targeted spoken word finding in particular. Limits of computer technology constrained early studies to investigating benefits of computer therapy to auditory comprehension, reading comprehension, written naming and sentence processing. Only

recently have studies examining the benefits of computer therapy for word finding been published and these will be reviewed in section 2.8.9 below.

2.7.2 Use of computers as augmentative or alternative communication (AAC) in aphasia

Augmentative or alternative communication (AAC) is defined as a means of communication, which may offer an alternative to or an aid to usual modes of communication. Systems may be high tech (for example electronic or computerised means) or low tech (for example, sign language, gesture systems, communication charts and boards). There have been more studies examining use of computers to deliver therapy for impaired language than there have been studies examining the augmentative or assistive role computers may play in aphasia (Van de Sandt-Koenderman 2004). It has been suggested that this reflects the concomitant non-linguistic impairment often found in aphasia, which may impair performance using computer aids on language tasks. Physical impairment in the form of hemiplegia may affect upper limb use, visual deficits may affect ability to see what is on screen and memory difficulties may impair ability to learn complex routines.

Successful use of AAC depends on all of these factors not just the type and severity of the aphasia. As a result time taken for training must not be underestimated (van de Sandt-Koenderman 2004). Van de Sandt-Koenderman suggests an AAC user with no aphasia will typically receive 40 hours of training per year. A user with aphasia and additional non-linguistic impairments, in particular memory difficulties, may require longer than this. The most significant area of aphasia treatment where computers have been explored as a form of AAC is in the application of word processing as an aid to writing in aphasia. Studies in this area are reviewed in section 2.9.3.

2.7.3 Broader effects of computer rehabilitation

To date little is known about the broader effects of using a computer in aphasia therapy as very few studies have done more than examine the

outcome of therapy targeting impairment and few have attempted to do more than examine effects on impairment. Two exceptions will be highlighted here. The first (Aftonomos, Appelbaum and Steele 1999) demonstrated that benefits to language impairment were reflected in benefits to functional communication as measured by the Communicative Effectiveness Index (CETI, Lomas, Pickard, Bester et al. 1989). Treatment in this study was in hour-long individual therapy sessions with a clinician present, with a mean of 41.7 treatments session per person. There was no therapy that explicitly targeted the carryover of benefits into functional communication. The second study (Mortley, Enderby and Petheram 2001) a single case study investigation, reported benefits to functional writing in the context of therapy explicitly targeting the carryover of benefits. These issues are discussed further below (section 2.8.9 and 2.9.3). No studies are known to have investigated the perspective of people with aphasia on using computers in therapy.

2.7.4 Implications of aphasia for accessing technology

Access to computer technology and the Internet is becoming more critical for the purposes of communication, access to information, access to health care, access to learning, the conduction of business, access to work and access to government. As access becomes more important for all of these functions, concern is increasing that people with aphasia are being excluded from information and computer technology (ICT) (Egan, Worrall and Oxenham 2004, Elman 2001, Elman Parr and Moss 2003). Egan et al. note that to date there has been little research on the training needs of people with aphasia.

2.8 Therapy for word finding difficulties in aphasia: a review of the literature

This section reviews background literature relevant to study one, an investigation into the process and outcome of word finding therapy delivered remotely via computer for people with aphasia. The literature and issues

relevant to word finding therapy in general are reviewed first (sections 2.8.1-2.8.8) before examining previous investigations of use of computers in word finding therapy (section 2.8.9).

2.8.1 Word finding difficulties in aphasia

'Of the symptoms associated with aphasia, none are more pervasive than anomia, a difficulty finding high information words, both in fluent discourse and when called upon to identify an object or action by name'.

Goodglass and Wingfield, 1997:3

Most people with aphasia have some degree of difficulty finding words when speaking. This can be one of the most distressing and frustrating symptoms in aphasia, particularly if it results in being unable to find important words such as the names of family and friends. A large amount of therapy and research time has therefore been spent on the remediation of word finding in aphasia.

2.8.2 Models of single word processing in aphasia

Since the mid 1980's the assessment and treatment of word finding difficulties in aphasia has been strongly influenced by the field of cognitive neuropsychology and the development of models of single word processing (Ellis and Young 1988). These models are cross modality models and hypothesise a system of independent modules to explain the stages of processing which occur between seeing a word written and reading it aloud or hearing a word spoken and understanding or writing it, or most relevant to this study, thinking of an object and retrieving its name. Controversy continues as to the precise number of modules or stages of processing posited (Nickels 2002a) and as to the direction of flow of information between the stages, namely whether information from later stages may feedback into the processing of earlier stages. However, a general consensus exists that an 'early' lexical semantic level (access to meaning information) is followed by a

'late' phonological level of processing (access to word form and sound information, Nickels 2002a).

2.8.3 Approaches to therapy: compensation versus reactivation

Approaches to remediation of word finding difficulties generally take one of two approaches. One is to compensate for impaired function by making use of spared function (also known as a strategic or re-organisation approaches, Lesser and Milroy 1993, Nickels 2002b). The most common example is to make use of ability to write a word in cases where writing words is less impaired than ability to speak words (Bachy-Langedock and De Partz 1989, Bruce and Howard 1987, Best, Howard, Bruce and Gatehouse 1997a, 1997b, Howard and Harding 1998). However, the success of this approach depends on the strength of the compensatory mechanisms, for example the ability to write a word and then to be able to read it aloud. Where these compensatory mechanisms are equally impaired there may be no alternative but to reactivate or repair word finding itself. Compensatory approaches have the advantage of frequently showing generalisation to the naming of non-treatment items as the use of the strategy generalises to all word finding.

The alternative is to reactivate or reteach access to each word (also known as repair or facilitation approaches, Lesser and Milroy 1993). A number of different tasks have been demonstrated to be effective in reactivating word finding. Nickels (2002b) provides a comprehensive overview of these tasks. However, as Nickels comments, these tasks are not always uniformly effective. The same treatment tasks have been shown to have differing effects for different individuals. This has led to the currently widely accepted hypothesis that these differences in response to treatment reflect different underlying levels of breakdown in word production and that each different level of breakdown is best remediated by a different type of treatment (Nickels 2002b, Nettleton and Lesser 1991). For example a word finding difficulty that has its cause in impaired word meaning (semantics) requires a treatment,

which focuses on meaning (for example matching a word to one of a choice of pictures). By contrast, difficulty retrieving the sounds of a word (phonology) will require treatment focusing on word sounds.

2.8.4 Semantic versus phonological therapy tasks

Nickels (2002b) makes a distinction between semantic tasks whose aim is to improve impaired semantic processing and semantic tasks whose aim is to improve word retrieval in the absence of severe semantic impairment. The former, often involving analysis of the semantic features of a word, will not be discussed here. These did not form any part of the computer therapy delivered.

Tasks whose aim is to improve word retrieval via stimulation of semantic processing are in practice often more difficult to distinguish from tasks aiming to improve word retrieval via stimulation of phonological processing than is often assumed and separation of the two as distinct approaches is potentially misleading (Howard 2000, Nickels 2002b). Many tasks that explicitly target semantic processing will in practice involve representation of the word form, whether spoken or written, thus stimulating phonological processing simultaneously with semantic processing. The commonest examples are spoken or written word to picture matching tasks, where the person is required to select the appropriate picture in response to a stimulus written or spoken word. The target picture must be chosen from a selection of semantically related pictured items (distracters). Clearly these tasks incorporate both a semantic element and the word form thus requiring phonological processing. There is evidence from the literature that these tasks are widely effective and can have long lasting effects, which are (Marshall, Pound, White-Thomson and Pring 1990, Nickels and Best 1996a, Pring, White-Thomson, Pound, Marshall and Davis 1999). Effects are likely to be item-specific (Howard 2000). Their effective use has been shown to benefit not only people with significant semantic impairment but also those who have clear phonological deficits

(Nickels and Best 1996b). Very few studies have examined the effects of semantic therapy where no word form is provided (Nickels 2002b).

Similarly 'phonological' therapy tasks will involve semantic processing even when the explicit focus is phonology. Common examples include repetition of the target, phonological and orthographic cueing of the target, segmentation of the word form into sounds (phoneme segmentation tasks), tasks combining orthography and phonology using reading and anagrams. These tasks have also been used to facilitate word retrieval and not necessarily only with people with phonological impairment (Nickels 2002b). Given the degree of overlap between traditional 'semantic' and traditional 'phonological' tasks, Howard (2000) has argued that the difference between semantic and phonological tasks has been overstated and in fact both tasks take effect in the same way, namely by strengthening mapping between semantics and the phonological form when both are simultaneously active.

2.8.5 Relationship between impairment, therapy task and efficacy

Given the assumption that differences in response to treatment reflect different underlying levels of breakdown in word production and that each different level of breakdown is best remediated by a different type of treatment, the question arises with what form of underlying impairment does the person with word finding difficulties present (that is primarily semantic or phonological) and what form of therapy would be most appropriate to target the repair of this impairment. To complicate the picture further, it is widely accepted that several levels of processing may be simultaneously impaired in one individual (that is, both semantics and phonology may be contributing to the word finding difficulties).

Within constraints of current knowledge, it is not possible to predict which therapy task will be effective for which impairment (Nickels 2002b). Some generalisations can be drawn from available data. The majority of people with

impaired word finding as a result of impaired semantic or phonological processing appear to benefit from therapy that combines semantic and phonological activation. This includes tasks traditionally labelled 'semantic', for example word to picture matching and 'phonological', for example repetition, phonemic cueing, reading aloud with the picture present. These tasks have long-lasting item specific benefits. There is also increasing evidence that tasks which combine phonology and orthography in the form of letter and sound cueing and/or identification with semantics in the form of the picture, appear to be successful in improving word finding (Best, Howard, Bruce and Gatehouse 1997a, 1997b, Hickin, Best, Herbert, Howard and Osborne 2002a, Robson, Marshall, Pring and Chiat 1998).

2.8.6 Generalisation of therapy effects to non-treatment items

The most successful treatment will clearly be that which not only brings improvements in items targeted in therapy, but also shows generalisation to untreated items and generalisation to use in other contexts. Some studies have reported generalisation to untreated items (Nickels and Best 1996b, Robson et al. 1998). However, controversy continues as to whether generalisation effects that have been claimed for these studies, actually reflect treatment effects (Howard 2000). Howard argues that whenever an item is by chance successfully named, both the semantic representation and the phonological representation for the item are simultaneously active, which in turn will strengthen the mapping for that item and make it more likely that the word will be produced correctly on subsequent naming attempts. This hypothesised mechanism for how improvements take place suggests that treatment effects will in fact be item specific since it is the mapping between the semantic representation and phonological representation of each item, which must be strengthened, to bring improved naming of that item. It is therefore argued (Howard 2000, Nickels 2002b) that the reported generalisation to non-treatment items observed in some studies, is in fact the result of successful naming, for example where multiple distracters are used in tasks and the person has successfully named these distracters or simply

through successful naming by chance during repeat baseline or assessment measures.

2.8.7 Generalisation of therapy effects to everyday communication

Demonstration of generalisation of use to other contexts is also a challenge, which has not been fully addressed in many studies. Reorganisation approaches to therapy have shown generalisation effects (Howard and Harding 1998) but the picture is less clear with reactivation approaches. The most that many studies can claim is improved naming of a small set of treated items as measured in one context (picture naming). Whether there is any evidence of generalisation to use in everyday communication is much harder to demonstrate. Studies are increasingly addressing this issue. Hillis (1998) reported a case study where, following therapy and without any training explicitly targeting functional use of therapy items, the person spontaneously began using the items in the appropriate functional context. Hickin, Herbert, Best, Howard and Osborne (2002b) attempted to measure generalisation of improvement from treatment of word-retrieval disorders into connected speech and conversation for two individuals. Both individuals showed improvements in naming treated items but only one showed generalisation of benefits to conversation samples. These benefits were detected before therapy to target use of treatment words in conversation was introduced. Herbert, Best, Hickin, Howard and Osborne (2003) reported a study where five out of six participants showed gains in terms of both picture naming and a task designed to assess noun production in everyday communication. The latter task outlined situations that were personally relevant in which using the target word would be appropriate and useful communicatively. Responses were scored for whether the target was achieved and whether the response was communicatively appropriate. Herbert et al. acknowledged that the ideal outcome of therapy would be a demonstration of effects generalising to everyday conversation. Two obstacles prevented them doing so. First, given the variability inherent across conversations, it would be essential to establish

the reliability of those elements of conversation chosen as outcome measures and this was yet to be established at the time of writing. Second the improvement was restricted to 100 treated items. It may be that a randomly selected sample of conversation would not include production of a large proportion of these treated items, making conversational samples a relatively insensitive measure to small changes in word finding. Work is ongoing (Herbert, Best, Hickin, Howard and Osborne in progress) to develop a reliable and valid quantitative measure of word retrieval in conversation developed from principles of conversation analysis (CA section 2.3.4).

2.8.8 Priorities of the researcher and the clinician

Given the current limited understanding of which treatment will benefit which impairment, Howard (2000) recommends that a series of single case studies be carried out which can compare how different individuals with different impairments respond to identical treatments. There are those, however, who argue that the expectation that a one to one relationship between impairment and treatment task can be obtained, is a naïve one. Not only must account be taken of how an individual's preserved language skills affect both word finding and other language tasks. Other factors such as memory, learning style and psychological state will impact on an individual's response to therapy. These factors lead some to argue for a more pragmatic approach to therapy of the kind typically used in clinic:

'For the clinician a task that has successfully improved naming for a wide variety of people with differing types of spoken word production impairments is often the most sensible choice. As we have seen these are often multicomponent approaches such as cueing hierarchies or multimodality/multitask therapies.'

Nickels 2002b: 957

2.8.9 Use of computers in word finding therapy for aphasia

Much of the early work applying computers in aphasia therapy focussed on improving reading or writing skills (for example, reading comprehension Katz

and Nagy 1982, 1985 Scott and Byng 1989, written naming Deloche, Dordain and Kremin 1993, Katz, Wertz, Davidoff Schubitowski and Devitt 1989). Moreover, the computer has often been used with the clinician present (Aftonomos et al. 1999) with less attention paid to its use for independent practice (Petheram 1996). With the advent of multimedia there has been more opportunity and hence interest in targeting spoken word production (Fink, Brecher, Schwartz and Robey 2002, Pedersen, Vinter and Olsen 2001). With the advent of increased access to home computers there has been increased interest in the use of computers for unsupervised home practice. These latter two studies will be considered in detail as the only studies to date that both explicitly target spoken word finding using computer therapy and incorporate unsupervised therapy practice as part of the treatment protocol.

Fink et al. (2002) used picture stimuli combined with multiple spoken and written cues to facilitate picture naming via computer therapy in six single case studies. The authors describe cues used as predominantly phonological but orthographic information was also given. Participants were selected to show phonological impairment more than semantic impairment and ranged between 2 years 3 months and 7 years 5 months post onset. Cues ordered in cueing hierarchies from the least powerful (least likely to elicit the target) to the most powerful included: initial sound or phoneme, sentence completion cue and whole word cue for repetition. Written cues were identical but presented in print. The therapy task involved presentation of a picture for naming. If unsuccessful after 20 seconds a low power cue was selected, followed by a higher power cue until the target word was produced correctly. Once the target was produced, the person was encouraged to repeat the target five times. The hierarchy was then reversed, so that a person produced the target with progressively less powerful clues until able to respond to the question 'What is this?' Therapy took place three times a week, typically for 30-45 minutes over a maximum of four weeks (12 treatment sessions in total). The study conformed to procedural guidelines to maximise quality of study design outlined by Nickels (2002b). A cross-over design was used to monitor for

generalisation effects to untreated stimuli: stimuli were divided into two sets of equal difficulty based on pre-treatment performance. Treatment to set one only (20 items) was followed by reassessment of both sets. Treatment to the second set (20 items) was followed by immediate reassessment of both sets and reassessment after four weeks to determine maintenance. Items chosen for therapy were those that participants had failed to name correctly on at least two of the four baseline assessments. Participants were assigned to one of two treatment groups, clinician guided (three participants working on the computer under clinician guidance in all three sessions) and partially self-guided conditions (three participants working with the clinician once a week then following the cueing procedure established by the clinician unsupervised with the computer in remaining sessions). Findings showed that all subjects in both conditions demonstrated measurable improvement of Set 1 and Set 2 targets during therapy. Moreover performance on Set 2 remained low during treatment phase 1 then improved when therapy was introduced to these items suggesting improvement was due to treatment and not spontaneous recovery or other non-specific factors.

Pedersen et al. 2001 report three single case studies, six months, 10 months and 1 year 6 months post stroke respectively. Computer therapy activities included both 'semantic' and 'phonological' tasks. The semantic tasks required word to picture matching with the target being presented initially both as a spoken word (via digitised recording of the picture name) and written word presented on screen and subsequently presented via the spoken word or written word only. Phonological tasks included: (1) picture presentation and choice of target and a phonologically related foil. Foils were not included in the training or control set. (2) A written word is shown with the initial letter missing. The target letter must be selected from a choice of two letters. First both the written letter and its sound are supplied, then only the sound and finally only the letter. (3) Written naming: a picture is shown. The written name has then first to be copied, then assembled as an anagram task and finally written without help. The authors argue that although neither of these

tasks required spoken naming, previous research has shown that written naming exercises presented by computer may have results that generalise to spoken naming (Deloche et al 1992). Words for therapy comprised 101 items selected from amongst those which participants were unable to name on the first assessment, divided into two sets. Treatment to set one was followed by assessment of both sets to monitor improvement to non-treatment items. Control training of auditory comprehension of anagrams was carried out during the follow up periods. The authors decided to train therapy items not for a predetermined period of time but instead to train them until they reached criteria, namely three consecutive correct responses. All three participants showed improvements post therapy but significant gains were maintained for only one participant at the time of the follow up assessment (follow up being between one and two months post withdrawal of treatment).

Neither of these two studies incorporated either an evaluation of whether improvements in picture naming generalised to spontaneous speech nor an evaluation of participants' views of the software or the therapy process and outcome. Both of these issues were addressed in the objectives of study one.

2.9 Therapy for writing difficulties in aphasia

This section reviews the background literature relevant to study two, an investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid. Broader context is provided by considering the social and psychological implications of writing difficulties associated with aphasia and the therapeutic potential of facilitating writing. An overview of therapy approaches is then presented, before examining compensatory or strategic approaches to writing therapy in more detail. Use of computers in a compensatory approach to therapy is then discussed. The final section introduces voice recognition software and its use by people with dysarthria or aphasia.

2.9.1 Social and psychological implications of writing difficulties

Written language disorders and particularly writing impairments have traditionally received less attention in the literature than therapy for spoken language disorders, despite the fact that most people with aphasia have some impairment to written skills (Beeson and Hillis 2001, Rapp and Beeson 2003). In the past this may have reflected the prominence of spoken communication in daily living, relegating written communication to a lower priority. In today's society, however:

'Face to face communication is increasingly replaced by written communication in forms such as electronic mail, automated banking machines, and on-line mail-order catalogues. Thus, the functional consequences of reading and writing impairments can be quite significant'

Beeson and Hillis 2001: 572

The implications of losing literacy skills are not immediately obvious to those able to take these skills for granted. Parr et al. (1997) describe how the apparently insignificant effects of being unable to write a personal and private letter to a relative or a friend can lead to a damaging loss of control over the maintenance of a relationship. Being unable to settle down with a book affects enjoyment of leisure time. Being dependent on others for help with writing contributes to a sense of loss of control.

2.9.2 Therapeutic potential of writing

A growing body of literature describes the benefits that writing can bring to those coping with illness. Much of this literature stresses the value of writing in affirming a sense of self in the face of terminal illnesses.

'Writing is a process of social interaction. In writing we imagine our reader, we write to someone or something...as

with all presentations of the self, the writing re-creates a self...I begin to see myself 'anew' as the writing develops.'

Stuart 1998: 149

'Stories have to repair the damage that illness has done to the ill person's sense of where she is in life, and where she may be going. Stories are a way of redrawing maps and finding new destinations.'

Frank 1995: 53

Arthur (1998) identifies a range of benefits associated with writing experienced by people facing terminal illness. Writing may be a diversion. It may help the person to live fully in the present and cherish the final chapter of life. It may open up a form of communication that would otherwise be difficult face to face. It offers the opportunity to summarise the most vivid highlights from a life story. It can be an act of self-presentation. It can function to hand things on. Finally it can act as a catharsis. Many of these functions are equally applicable to people with aphasia in facing the consequences of chronic language impairment.

For some people confronting terminal illness, the need to write becomes an imperative:

'For some people, the attempt to construct a personal narrative is seen not just as helpful but as necessary and expressed with all the urgency that they can command.'

Killick 1998: 107

Writing difficulties associated with aphasia may preclude engagement in this writing process and may close an important avenue in recreating or reconnecting with a sense of self. Some of the benefits to writing therapy in aphasia are being recognised (Ireland and Pound 2003). Although the writing discussed is poetry, many of the functions and benefits associated with poetry are transferable to narrative writing. Ireland and Pound describe benefits of

writing in terms of creating a new identity and dignity, sense of ownership and self-respect. Other benefits include enabling people to tell their personal stories, or writing as an art form to engage in the pleasures of using words. These benefits echo those identified by Arthur (1998) above.

2.9.3 Therapy approaches to writing disorders

This section will review current therapy approaches to remediation of writing disorders, including the use of computers in therapy for writing disorders. These can be divided into those that aim to maximise the return of premorbid skills and those that focus on compensatory strategies to maximise residual skills.

The act of expressing ideas in writing involves a complex series of stages involving a range of cognitive, linguistic and perceptual-motor processes: clarifying ones thoughts, formulating sentences, and sequentially translating each word to its written form in keeping with the spelling conventions for the language. However, despite the complex range of processes involved in writing, much of the literature on writing disorders in aphasia focuses on the processes that are specific to single word spelling only. Treatment for writing disorders may include direct stimulation of the linguistic or motor processes necessary for writing in order to relearn item-specific associations and/or the incorporation of compensatory strategies (Rapcsak and Beeson 2000). There is relatively little literature on the processes involved in clarifying thoughts and translating those thoughts into sentences, in part, no doubt due to the complexity of such processes and the huge challenge of attempting to define models to explain them. Despite the literature on single word processing dominating the field, this literature will be only briefly reviewed here. In addition to approaches based on single word processing, other therapy approaches have used strategic or compensatory approaches to maximise residual function rather than target the impairment itself and these will be reviewed. Therapy for writing difficulties is one area in which computer use was an obvious solution both for impairment-based therapies and for more

functional, compensatory or strategic approaches. The use of computers in writing therapy is therefore considered in a separate section.

2.9.4 Impairment based approaches

Much of the literature on writing disorders (agraphia) in aphasia is based on the same models of single word processing developed in cognitive neuropsychology and described above in relation to word finding difficulties (section 2.8.2). As is the case with word finding, models continue to be controversial (Rapcsak and Beeson 2000, Tanturier and Rapp 2003) and the therapy based on these models controversial in terms of predicted outcome (Raymer, Cudworth and Haley 2003). However, in parallel with the processes involved with word finding, it is generally agreed that single word processing involves an early semantic stage in which a word is activated in the mental dictionary. This semantic activation then activates a written word in the mental dictionary of written words (orthographic output lexicon). While preparing to write a word, it is held in short term storage in the graphemic output buffer, which contains abstract representations of letters. Spelling then requires the correct selection of appropriate written forms via handwriting or typing. These different modes of realising writing in turn require different skills. Handwriting requires the performance of complex motor movements with the preferred hand to produce the appropriate letters whereas typing requires hitting the keys representing the appropriate letters in correct order. From this model a distinction can be made between central agraphias and peripheral agraphias. In the former, the processes required for semantic activation, the activation of the written word in the orthographic output lexicon and storage in the graphemic output buffer may be disrupted, whereas in peripheral agraphias it is the graphic motor processes involved in writing that are impaired.

As in the treatment of word finding, impairment based therapy for single word production can involve compensation or reactivation. Central agraphias are generally treated by attempting to reactivate or reteach impaired representations (semantic or orthographic) and/or the access to these

representations. Alternatively, intact processes may be used to circumvent impairments (compensatory strategies). For example, if a person is able to convert the individual sounds of words directly to their equivalent letter, this strategy can be used to compensate for spelling impairment. However, this strategy is of no use for words with irregular spelling (Beeson and Hillis 2001, Rapcsak and Beeson 2000).

2.9.5 Compensatory approaches

In contrast to the extensive literature documenting impairment-based writing therapies, little has been written on compensatory approaches that aim to circumvent barriers to writing. A review of recent key articles summarising recent research in the field of writing therapy in aphasia (Beeson and Hillis 2001, Rapp and Beeson 2003, Rapczak and Beeson 2000) revealed only brief mention of compensatory or strategic approaches.

Peripheral agraphias may be treated using some form of compensatory strategy (Rapcsak and Beeson 2000). In cases where the person is right handed and has a right hand weakness secondary to hemiplegia, it may be necessary to form letters with the non-dominant left hand. The selection of appropriate letters from a keyboard may circumvent impaired graphic motor processes, thus in theory a person with intact central language and spelling processes, but impaired peripheral processes could compensate by using word processing.

Just as healthcare research has been influenced by the advent of social models of intervention, literacy research has been influenced by social models, which in turn have impacted on the debate surrounding approaches to written language difficulties in aphasia (Parr 1996a 1996b). Parr's (1992) investigation of the literacy practices of non-aphasic adults led her to conclude that everyday literacy practices cannot be prescribed because of the variability and the range that are undertaken.

'Any attempt to measure the functional use of written language in aphasia must anticipate variability, must take into account the social organization of written language use and be based on description, rather than prescription of the practices of the individual'

Parr 1996a: 472

Parr questions the application of standardised tools in the assessment of language activities post stroke (Parr 1996a, Parr and Byng 2000) and advocates the application of qualitative methodologies, which are more suited to capturing individual variation and priorities.

In her study of everyday reading and writing practices in mild/moderate aphasia (Parr 1995, 1993) Parr lists a range of possible writing activities that could form the focus of compensatory or facilitative approaches to writing therapy. These included writing shopping lists, writing cheques, writing letters or cards to family, filling in forms, writing phone messages and keeping a calendar of engagements. Parr identifies three approaches to therapy: implementing help from the person's social network, developing drafting, editing and proof reading techniques and application of technical aids in writing. Parr stresses that independence in writing is often less of a priority than autonomy. The premise is not that people with aphasia should aim to be able to write independently but that they should have the control, backed up by support as outlined in the three approaches above, to function as they choose (Parr 1995).

2.9.6 Use of computers as a writing aid

One of the approaches to writing therapy identified by Parr was the application of technical aids. Computers are one of the technical aids that have been applied, most obviously in use of word processing software to facilitate writing in aphasia (Armstrong and MacDonald 2000, MacDonald and Armstrong 1998, Newell, Arnott, Booth, Beattie, Brophy and Ricketts 1992, Wood, Rankin and Beukelman 1997).

Studies have shown that various forms of software may have a facilitative effect on written language production. Use of predictive word processing systems has led to improvements in sentence structure as well as spelling (Newell et al. 1992). King and Hux (1995) investigated use of *Write:OutLoud*^b, a text to speech facility, on word selection and spelling by a client with mild aphasia and reported a significant change in quality of writing with the most striking change occurring immediately after introduction of the talking feature. Wood et al. (1998) argue that text to speech can benefit reading skills (impairment): sight word recognition can improve if speech feedback is given.

Armstrong and MacDonald (2000) report a single case study, in which a simple word processing programme with spelling monitor was used. The programme provided auditory feedback through synthesised speech at the end of a letter, word, sentence or paragraph for the user to hear output as well as see it (*Write:OutLoud*[®]). An intelligent word prediction programme was used in conjunction with the word processing programme (*Co:Writer*[®]) that provided lexical and grammatical prediction to support writing processes. Use of these aids led to improved grammatical accuracy, increased quantity and fewer spelling errors. Twelve sessions were required to learn to use the two programmes. However, the more sophisticated tools of the word-processor proved too difficult to learn.

MacDonald and Armstrong (1998) argue that use of text to speech and word prediction software facilitates written sentence production by providing combined visual and auditory feedback on appropriate use of function words in sentence context, providing visual feedback on correct spelling of words via multiple choice options using word prediction and synthetic speech confirmation of choices and offering opportunities for the production of

^b Appendix 1 contains a list of all software referred to in this thesis and details of suppliers.

modelled spoken output at sentence level. Barriers to being able to benefit from these facilitative effects include unfamiliarity with computers or the QWERTY keyboard, the need to be able to access the first letter of a word to benefit from the word prediction facility, slow output and difficulties generalising to independent use. Benefits observed from using this software included increased confidence and a greater willingness to attempt written output; increased self-esteem through feedback of printed word looking more adult than writing; and increased self-esteem through visual evidence of achievement.

2.9.7 Use of Voice Recognition software by people with speech or language impairments

The advent of voice recognition software (henceforth referred to as VR: office dictation software that transcribes what the user dictates onto screen) has raised the question of whether some of the barriers encountered using word processing software (in particular the need to access the first letter of a word to benefit from the word prediction facility) can be circumvented by means of the new technology. This section will introduce voice recognition and its use by people with speech and language difficulties.

2.9.7.1 Introduction to voice recognition software

Voice recognition or speech recognition software has shown dramatic improvements in both accuracy of recognition and usability in recent years. These improvements have encouraged investigation of how the software can be applied to the benefit of people with physical difficulties including those with disordered speech and/or language skills (Venkatagiri 2002, Koester 2001). In the past, interest has focussed on potential benefit to users with speech difficulties such as dysarthria (Rosen and Yampolsky 2000, Manasse, Hux, and Rankin-Erickson 2000) and those with speech and language difficulties associated with learning difficulties (De La Paz 1999). Only more recently have investigations examined use of VR by people with aphasia (Bruce, Edmundson and Coleman 2003, Wade, Petheram and Cain 2001).

2.9.7.2 Use of VR by people with dysarthria

Much of the literature on use of VR by people with dysarthria has examined the effects of impaired intelligibility on VR accuracy levels (Doyle, Leeper, Kotler, Thomas-Stonell, O'Neill, Dylke, and Rolls 1997, Ferrier, Shane, Ballard, Carpenter and Benoit 1995, Thomas-Stonell, Kotler, Leeper and Doyle 1998). Thomas-Stonell et al. 1998 also investigated the relationship between perceptual rankings of speech consistency and recognition accuracy, on the assumption that a higher perceived consistency would impact on recognition accuracy levels achieved. Findings suggested that the more intelligible the speaker, the greater his or her success with the voice recognition system. However, perceptual rankings of speech consistency did not correlate significantly with recognition accuracy. Thomas-Stonell et al. 1998 conclude that:

'clinicians should use speech recognition on a trial basis to evaluate a client's potential success with a system and avoid a priori assumptions based on perceptions of speech consistency'

Thomas-Stonell et al. 1998: 55

A study by Hux, Rankin-Erikson, Manasse and Lauritzen (2000) compared the performance of three different VR systems for one individual with dysarthria and found that *Dragon NaturallySpeaking®* was significantly better and more consistent in terms of accuracy achieved than a couple of rival products. These findings have been confirmed by the experiences of organisations supporting the use of VR technology with children with learning difficulties (AbilityNet 2004, CALLCentre 2000).

2.9.7.3 Use of VR by people with aphasia

In contrast to dysarthric speech, aphasic speech offers potentially greater challenges to VR. Aphasic speech may be characterised by syntactic errors or omissions, word finding difficulties reflected in failures to find the target or semantically related errors (for example *dog* for *cat*) and speech sound errors or substitutions (for example *cot* for *cat*). All of these pose challenges to the

voice recognition system, which is designed to expect normal speech. Speech sound errors pose the most obvious threat to intelligibility and intelligibility has been found to correlate with success using voice recognition. However, it is far from clear how other aspects of aphasic language may impact on recognition accuracy. To date only one single case study of a person with aphasia who has been taught to use VR successfully has been published (Bruce et al. 2003). One further case study describes a user with dysarthria and literacy difficulties as a result of head injury (Manasse et al. 2000). The limited nature of the data and the variation between studies in the manner in which language skills are described make it difficult to extrapolate what characteristics of aphasic language are likely to facilitate or hinder use of VR. Bruce et al. 2003 provide a detailed descriptive account of the speech characteristics of a participant who progressed to become a very successful user. No attempt to describe or to quantify the intelligibility of the participant's speech is included. Description of the spontaneous speech of the participant in Manasse et al. 2000 is less detailed, but intelligibility is relatively high level (98% for sentence level production). For this participant the picture is somewhat obscured by her speech showing characteristics of dysarthria (reduced intelligibility, slow speech rate, breathy voice quality, reduced loudness and imprecise articulation) rather than the language processing difficulties associated with aphasia, which affected her written language. Her spoken language processing appears to have been largely intact.

In addition to these linguistic factors, issues highlighted by van de Sandt-Koenderman 2004 with reference to teaching people with aphasia the use of AAC (section 2.7.2) are likely to influence use of VR, in particular visual deficits may affect ability to see what is on screen and memory difficulties may impair ability to learn complex routines.

2.9.7.4 Evidence of benefit to written language

Evidence from the literature on use of VR with students with learning difficulties (De La Paz 1999) suggests that the use of VR may allow people to

circumvent transcription or text production problems (for example, handwriting, spelling, punctuation difficulties) that in turn allows greater concentration on higher-order processes such as planning and content generation. There is also evidence that the text to speech facility included in VR is likely to facilitate detection of errors in the text (Raskind and Higgins 1995) and may aid elimination of errors. These findings echo some of the findings relating to use of word processing software in aphasia (section 2.9.6).

Of the two studies investigating use of VR by people with acquired reading and writing difficulties, one study, Manasse et al. 2000, concluded that no substantial differences were found in the frequency of structural writing errors between samples generated using word processing and VR for their participant. There was a downward trend for VR in the number of words produced (number of words produced via word processing was actually greater) and an upward trend for VR in the percentage of complex sentences produced were noted. The authors suggest that, with such a small trend towards improvement using VR, the overall impact is questionable. Bruce et al. 2003 by contrast carried out a descriptive comparison of language samples. They report an increase in the number of words, improvement in use of capitalisation and punctuation (equivalent to marking of sentences in this study) and an improvement in number of verb phrases and embedded sentences. The positive impact of VR on writing, based on descriptive evidence from this study, is therefore clearer.

2.9.7.5 Evidence of benefit to spoken or written impairment

Bruce et al. 2003 raise the possibility that use of VR might have a positive impact on spoken and written language production. However, this work has yet to be published at the time of writing and this issue remains open for debate.

2.9.7.6 Evidence of benefit to writing activity

Bruce et al. (2003) report their participant unexpectedly started to keep a diary. He also achieved his goal of keeping in contact with his children via

email and achieved a style of writing appropriate for letters to friends. However, his writing was not error free and he still needed assistance from others to write formal letters, in particular to ensure punctuation was appropriate and check for spelling and grammar errors. Manasse et al. 2000 report their participant expressed a preference for using VR over word processing despite having shown little quantifiable benefit to language produced.

2.9.7.7 Summary of research on VR

Evidence from research with people with dysarthria and learning difficulties indicates that access to use of VR software may be possible for some people with aphasia and may bring positive benefits to writing produced with VR as compared to alternative modes. However, the use of VR by people with aphasia remains a relatively unexplored field despite some positive initial findings (Bruce et al 2003). The latter summarise the uncertainty surrounding use of VR by people with aphasia by concluding their report with the statement that in the context of people with aphasia, it is still not clear what VR is good for, for whom and under what circumstances.

2.10 Social and psychological implications of living with aphasia

2.10.1 Personal identity and aphasia

'As the knowledge base in aphasiology continues to expand, it is increasingly obvious that information about specific language processes does not enhance our understanding of the aphasic's personal predicament'

Brumfitt 1993: 569

Brumfitt identifies three ways in which aphasia is particularly threatening to a sense of self. It is argued that part of one's sense of self is knowledge about one's own physical being. The disruption of this sense of self-knowledge

follows any sudden onset of disability and requires adjustment accordingly. In aphasia the disablement is largely invisible and intangible, making this adjustment more difficult. Moreover, language itself is disrupted in aphasia, yet language is the very medium through which our potentially chaotic experience of life can be made more coherent. Finally, speech forms a central part of self-concept and its loss may be one of the most difficult conditions to accept.

It has been observed that part of the process to adapting to impairments that are suddenly acquired and are long lasting involves the development of a new sense of self or personal identity (Khosa 2003, Byng, Pound and Parr, 2000, Parr et al. 1997). This is often a long process, going on for many years after stroke. Bound up in this process can be the search for a new sense of purpose (Hewitt and Byng 2003). The importance of positive relationships with others is crucial in this process.

'To develop a positive sense of self after becoming aphasic, the person therefore needs to function within a social context where close personal relationship confirm competency and adequacy.'

Brumfitt, 1993: 573

2.10.2 Meaningful participation or engagement

Much of the literature on restrictions in everyday communication caused by aphasia focuses on situations which involve the communication of essential information or the communication of basic needs, requirements or emotions, for example the *Communicative Activities of Daily Living* (CADL) (Holland 1980) and the American Speech-Hearing Association *Functional Assessment of Communication Skills* (ASHA FACS Frattali, Thompson, Holland, Wohl and Ferketic 1995). Much less attention has been paid to some of the effects of aphasia on communication situations that are part and parcel of people's social and personal relationships or leisure time. Research investigating living with aphasia from the perspective of those experiencing it, indicates

these losses are felt as keenly. Losses include being unable to write a personal card or letter to a relative or friend, feeling unable to focus and concentrate on one topic, being unable to sit down and enjoy reading a book, having to wait for others to write something on their behalf, missing out on gossip, being unable to make complaints, losing track of a group conversation.

'Difficulties such as these might at first sight, seem insignificant or trivial perhaps because they do not concern the transmission of important information or the basic communication of needs, requirements and emotions. But they indicate how aphasia can wipe out the nuances and subtleties of communication and much of the intrinsic enjoyment of using language.'

Parr et al. 1997:132

The framework of the ICF (WHO 2001), although marking progress by its recognition of new attitudes to living with disability, still assumes that the goal of all people with aphasia will relate to doing rather than being (Hewitt and Byng 2003). Hewitt and Byng question whether 'doing' may be necessary but not sufficient in order to make people feel more alive and to be more themselves (p52). They argue for the concept of engagement to replace that of participation. Engagement is defined amongst other things as being involved in something that has a real purpose, feels personally meaningful and valuable and provides a real sense of connection to other people with whom it is possible to identify, confronting real challenges and seizing opportunities. Hewitt and Byng argue that the concept of engagement challenges our concept of what 'therapy' means and entails broadening our understanding of what therapy services might offer.

2.11 Summary of literature review

This review has highlighted some of the key issues influencing the research presented in this thesis. Definitions of aphasia and key theoretical debates to have influenced aphasia research in the past have been reviewed, alongside some of the conceptual frameworks, which are currently influencing

how outcomes are evaluated in research health services research (HSR) in general and aphasia research in particular. In particular, attempts to reconcile social model and medical model approaches within one framework have been discussed with reference to the ICF (WHO, 2001) and this conceptual framework will be referred to in evaluating the findings of the research in this thesis. The debates surrounding the application of qualitative and quantitative methodologies in HSR were reviewed and their implications for aphasia research and the research in this thesis highlighted. An introduction to the use of computers in aphasia was followed by a review of therapy for word finding difficulty in aphasia and the application of computers in this field (study one). A further section reviewed therapy for writing difficulties in aphasia, with specific focus on use of computers and voice recognition software in particular to facilitate writing (study two). Finally, issues surrounding identity in aphasia were summarised, having emerged earlier in the review as being increasingly recognised as influential in determining outcome.

Chapter Three

Study One: Background and Methods

An investigation into the process and outcome of word finding therapy delivered remotely via computer for people with aphasia

This chapter will outline the background, purpose and methods used in study one, an investigation into the process and outcome of word finding therapy delivered remotely via computer for people with aphasia.

Key background issues pertinent to the delivery of word finding therapy remotely via computer will be summarised first (3.1) followed by an outline of study aims, theoretical stance and rationale for methods chosen (3.2). A detailed section on methods follows (3.3). The final three sections will outline methods used to evaluate the outcome: a qualitative evaluation of participants' views (3.4) a quantitative evaluation of language skills (3.5) and a quantitative evaluation of computer usage (3.6). Findings of the study will be presented separately in Chapter Four.

3.1 Background

3.1.1 Remote delivery of therapy

With advances in telecommunications, the delivery of healthcare services remotely, for example via telephone or teleconferencing, is becoming increasingly feasible and common. Previous research has investigated the potential for assessing and diagnosing people with neurogenic communication disorders remotely using telephone and television technology (Wertz,

Dronkers, Bernstein-Ellis et al. 1992) and found that video conferencing could be substituted for traditional face-to-face consultations to assess and diagnose people who would not otherwise have easy access to such services. The feasibility of providing therapy remotely, whereby a therapist delivers therapy via computer, and collects results, monitors progress and updates exercises via the Internet, has been established in a previous study (Mortley, Wade, Davies and Enderby 2003). Remotely delivered therapy has the potential to offer the opportunity for increased independent practice and remove the need for travel either by the therapist or person with aphasia, whilst enabling the therapist to monitor progress.

3.1.2 Theories of therapy and delivery of therapy via computer

However, remote delivery of word finding therapy remains to a large extent an unknown quantity. It is not clear whether effects, noted from face to face therapy in the treatment of word finding, are replicated when therapy is delivered via computer. Recent research has highlighted the problem of identifying precisely what the key components of the interaction between therapist and person with aphasia may be in order to effect change:

'Therapy takes place at the interaction between the aphasic patient and the speech pathologist. The patient is not a passive recipient of therapy and the therapist is not a machine. They must continually adapt their behaviour to what the partner does and says.'

Basso and Marangolo 2000: 228

Attempts to analyse and make explicit the process of interaction between the therapist and the individual with aphasia during therapy, have demonstrated that to do so is far from easy (Horton and Byng 2000). More research is needed before the question of whether the way in which a task is carried out has a significant impact on outcome can be answered. One way of investigating this, however, is to replicate therapy tasks on computer in order to investigate whether similar effects are found as in face-to-face therapy.

3.1.3 Independent use of computers by people with aphasia

Studies have suggested that a minimum of three sessions per week for not less than five months may be required for any positive impact on speech and language skills following stroke (Wertz, Weiss, Aten et al. 1986, Basso, Capitani & Vignolo 1979). Current therapy resources are rarely sufficient to meet the demands this would place on a service. The potential for computers to increase the opportunity for therapy practice has been recognised for some time and has been a key motivating factor in research investigating computer use by people with aphasia.

There have been a number of studies indicating that people with aphasia are able to use the computer unsupervised for independent practice. As early as 1983, there was evidence that people with aphasia could use a computer unaided (Katz and Nagy 1983, Katz and Nagy 1984). More recent studies have confirmed this evidence (Fink, Brecher and Schwartz 2002, Katz and Wertz 1997, Mortley, Enderby & Petheram 2001, Pedersen, Olsen and Vinter 2001) and demonstrated that people with aphasia are not only motivated to practice specific therapy tasks, but show considerable learning potential when performing computer tasks (Katz and Wertz 1997). Most recently Fink et al. (2002) demonstrated that there was no difference in results between two conditions, one being entirely clinician guided and one being where patients worked independently for two-thirds of the sessions. Pedersen et al. (2001) demonstrated improvements in word finding for three single case studies where all therapy was carried out in the person's home without any supervision. However, response to therapy was different in each case with two of the three cases showing very limited improvement given the number of hours of practice. Pedersen et al. note that, for one person, therapy proved extremely frustrating, as he had very severe difficulty carrying out the tasks and therefore little opportunity to gain from them. Clearly there are risks associated with assigning a fixed programme of activities to an individual for unsupervised practice. In face-to-face therapy, a clinician can quickly adjust

the demands of the task in response to individual difficulties. The use of remote monitoring of therapy tasks might counter some of the reported problems associated with unsupervised home practice.

3.1.4 Impact of computer therapy on impairment, activity and participation

Few studies have investigated whether computer therapy targeting impairment has any effect on communication at the level of activity or participation. One study targeting writing incorporated therapy tasks designed to encourage generalisation of gains to use in everyday writing activities, with positive results demonstrated. (Mortley et al. 2001). However, such studies are rare, with most focussing exclusively on targeting impairment and evaluating effects only at the level of impairment (Fink et al. 2002, Pedersen et al 2001). The literature investigating the effects of word finding therapy delivered conventionally is increasingly seeking ways to evaluate and demonstrate benefits to conversation (Herbert 2004, Herbert, Best, Hickin, Howard and Osborne 2003, Hickin, Best, Herbert, Howard and Osborne 2002b). The same questions must also be asked of computer therapy targeting impairment if computer therapy is to have any broader relevance to everyday communication: does computer therapy which targets an impairment such as word finding have any effect beyond the level of impairment?

3.1.5 Empowerment and concept of participation in therapy

The study reported in this chapter was conceived as an exploration of a novel mode of therapy delivery that had the potential to promote shared decision making in aphasia therapy. The self-help approach to therapy, whereby people with aphasia were enabled to carry out as much practice as they wished at home, whilst still retaining regular contact with the therapist and receiving regular updates of new exercises as necessary, had the potential to shift some of the locus of control from the therapist to the person with aphasia.

In the UK, the principle of involving people in their care has been enshrined in government policy for a number of years (NHS Executive 1996). This shift in policy has been reflected in the establishment of a new Commission for Patient and Public involvement in Health in 2003 and more recently by the publication of a report on the NHS Health in Partnership Research Programme (Farrell 2004).

Development in government policy has been mirrored by a change in research priorities and a paradigm shift in which the concept of 'shared decision making' is replacing the old notion that 'doctor knows best' (Coulter 1997). Coulter commented that it is often assumed that shared decision-making will lead to improved health outcomes, but the evidence to date is far from conclusive. More recently, Farrell (2004) conceded that as yet few patients have experienced shared decision-making in their health care and acknowledged that the precise character of shared decision making is hard to define and people may have different expectations of the responsibility they want to accept. Yet Farrell argued increased patient satisfaction is reported to be a clear outcome of involvement in healthcare. Reported benefits have included greater confidence, reduction in anxiety, greater understanding of personal needs, improved trust, better relationships with health professionals and positive health effects (Farrell 2004).

This study sought to determine whether therapy, carried out without the subtleties of face-to-face interaction between therapist and person with aphasia, would effect change not only at the level of impairment, but at the level of activity and participation as well. It was uncertain how people would react to having no face-to-face contact with the speech and language therapist and being able to determine the frequency and duration of practice sessions themselves. The study also sought to investigate the views of people with aphasia on receiving therapy in this novel way.

3.2 Purpose of the study

3.2.1 Study Aims

This study was an investigation into the process and outcome of computer therapy, which targeted word-finding skills (impairment) for people with aphasia. All therapy practice was carried out without the speech and language therapist present and therapy was monitored remotely. The aim of the study was primarily to evaluate the outcome of therapy from the perspective of people with aphasia as a means to determine the extent of the impact of therapy and illuminate the processes by which impact occurred. The key question was whether therapy, which specifically targeted impairment, was perceived to have had any impact not only on impairment itself but also beyond the level of impairment and if so what this impact was and how it came about. In addition to this, the aim was to determine whether quantitative measures confirmed or contradicted the perceptions of participants. Specifically the study:

- Investigated what evidence there was that computer therapy targeting impairment (word finding) had any impact on impairment, and whether there was evidence of impact extending beyond the level of impairment
- Developed hypotheses about which people with aphasia may benefit from such therapy
- Developed hypotheses as to the key components bringing about a positive outcome in the intervention and the potential barriers to success

The following hypothesis was tested:

- Computer therapy targeting impairment (word finding) will result in broader benefits than simply to the impairment itself

For this study there was therefore particular interest in whether improvements demonstrated at the level of impairment impacted on levels of communication activity and social participation.

3.2.2 Rationale for method

This study was conceived as an exploratory case series study, located at Phase 1 or the modelling phase of the Medical Research Council framework (MRC 2000) for development of Randomised Controlled Trial's for complex interventions to improve health (MRC 2000, section 2.5.3.2). The aim was to explore the full range of potential effects of therapy, investigate for whom such therapy might be appropriate, and identify what the active ingredients might be.

Given the exploratory and developmental nature of the topic (use of computers to deliver word finding therapy without face to face contact with a therapist) a strong qualitative component was likely to be highly beneficial in developing an understanding both of the views of participants in the study and the processes by which people might benefit or fail to benefit from the intervention (Marshall & Rossman 1995, MRC 2000). Qualitative research can be useful in generating hypotheses for further investigation or as an adjunct to quantitative inquiry (Ritchie 2003, Murphy & Dingwall 1998, Morgan 1998) and it was with both these applications in mind that a substantial qualitative component was built into the methodology in the form of in-depth interviews.

However, an instrumental or pragmatic approach was taken to enable the combination of this qualitative investigation with additional quantitative methods (Bryman 2001, Murphy et al. 1998, Pope and Mays 1995, Ritchie 2003, Silverman 1997). The aim in this study was to investigate whether computer treatment that targeted impairment (word finding) showed evidence of effects to impairment, activity or participation. A quantitative approach was used to complement the qualitative methods in evaluating the benefits to language skills and use, this approach building on a long tradition in aphasia

of quantifying language skills and use in general (Murray and Chapey 2001) and a large body of literature evaluating investigations of word finding skills in particular (reviewed by Nickels 2002b) and these will be discussed further below (section 3.5.2).

Given the current limited understanding of which treatment will benefit which impairment, it is conventionally recommended that a series of single case studies be carried out which can compare how different individuals with different impairments can respond to identical treatments which are clearly delineated so as to be precisely replicable (Howard 2000). Alternatively, a more pragmatic approach can be taken, whereby therapy tasks are multi-component and multi-modal, aiming to activate semantic and phonological processing simultaneously and also making use of tasks, which emphasise the links between orthography phonology and semantics. The latter approach was adopted for this study, with a range of tasks incorporated that have been found to be beneficial in treatment of naming disorders arising from impaired semantic or phonological processing. The aim was to determine whether word-finding therapy of this kind was indeed an active treatment bringing significant change despite no face-to-face contact with the speech and language therapist. This approach was in part influenced by concerns regarding motivation in a study where participants would determine their own levels of practice. It was not clear at the outset of the study that motivation would be maintained throughout the six month therapy period and it was argued that a variety of tasks would be more likely to sustain motivation than the repetition of a single, very clearly delineated task.

However, this study attempted to remedy the weakness of many previous studies evaluating the impact of word finding therapy. These have been increasingly criticised for having failed to evaluate whether improvements to word finding skills generalised to more functional communication (Herbert et al. 2003, Hickin et al. 2002b). It was assumed that a connected speech sample would have stronger 'ecological validity' (Holland 1991: 199) that is,

replicate more closely than a picture naming task how language is used in everyday life. The quantitative evaluation of picture naming before and after therapy was therefore complemented by a quantitative evaluation of word finding in connected speech before and after therapy. Finally, a further quantitative component was added to the study both because and as a result of the novel form of therapy delivery. It was hypothesised that individual variations in intensity, duration or frequency of practice might impact on outcome. Data capture facilities in the therapy software enabled figures on the exact timing, intensity, duration and frequency of practice to be calculated as well as giving information on the number of attempts at each task or even each question within a task. Detailed information on patterns of practice could be compared to other outcome measures.

3.2.3 Theoretical stance

The methodology used in this study therefore rests on the assumption it is not possible to establish truth claims with absolute certainty whatever methodology is employed (Murphy, Dingwall, Greatbatch, Parker & Watson 1998). On this premise, no single method (for example, quantitative or qualitative) is more privileged in accessing the 'truth' than any other. In common with the position outlined by Mason (2002), this study assumes that a multi-method approach enables research questions to be approached from a number of angles and thus explored in a multi-faceted way, as is appropriate for the investigation of phenomena which are themselves likely to be multi-dimensional.

3.3 Method

3.3.1 Study design

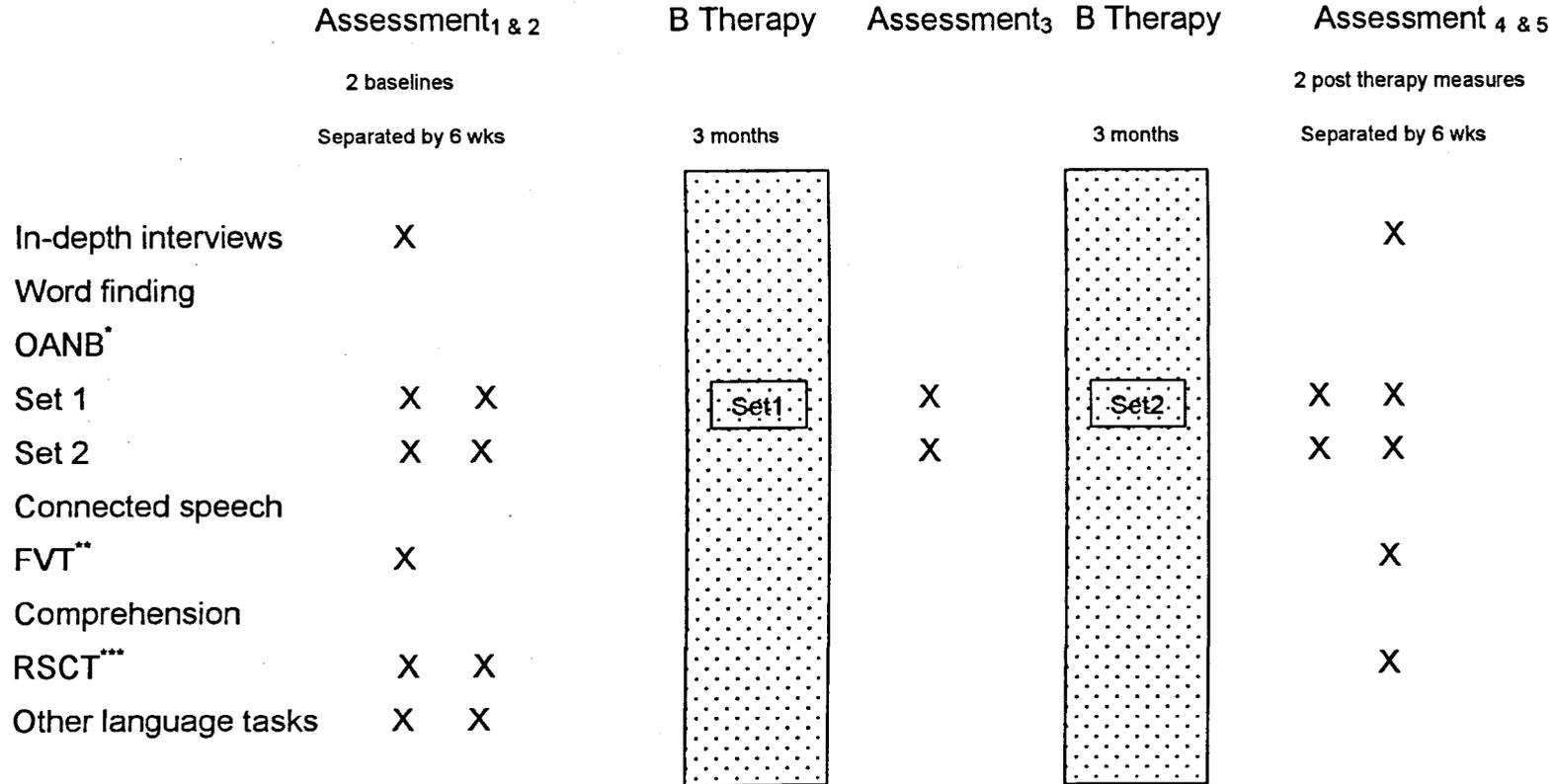
The study was a case series study using an AB_1AB_2A design in which A represented assessment with no treatment and B_1 and B_2 represented therapy. Therapy targeted word-finding skills via a series of computer

exercises. Figure 3.1 provides an overview of the study design, showing the timing of therapy and the nature and timing of baseline assessments and outcome measures used. A broad outline of the study design is given here. Therapy exercises are described further in section 3.3.6 and assessments and outcome measures are described in detail in sections 3.4 – 3.6.

Baseline assessment (A_1 and A_2 – see Figure 3.1) determined performance on word finding of items to be targeted in therapy. Two measures were taken, at least 6 weeks apart, to establish stability at baseline. Two baseline measures were also taken on a control measure assessing sentence comprehension ability, a function of language processing that was not anticipated to show change as a result of word finding therapy. During the baseline assessment period, in-depth interviews were conducted to determine people's views and aspirations for communication pre therapy and connected speech samples were obtained to evaluate pre therapy word finding in connected speech.

This baseline assessment was followed by a period of therapy (B – see Figure 3.1), which targeted word-finding skills for half of the therapy items (*Set 1*). Interim assessment (A_3) reassessed word finding on all items to determine levels of change to treated and non-treated items respectively. No other outcome measures were reassessed at this point. A second period of therapy (C) targeted word finding of the remaining items (*Set 2*). This was followed by reassessment (A_4 and A_5) of word finding of all items targeted in therapy both immediately following completion of therapy and six weeks after therapy had been withdrawn. All other outcome measures (in-depth interviews, connected speech samples, control measure of sentence comprehension) were repeated once post therapy.

Figure 3.1 Study one: timing of assessment and intervention



* Object & Action Naming Battery, Druks & Masterson 2000

** Functional Video Tool, Mortley 1998 *** Reversible Sentence Comprehension Battery, Byng & Black 1999

3.3.2 Role of the author in the study

Study one extends the work of Jane Mortley. The author (JW) was employed on this study as a research assistant. The lead researcher (JM) had determined the basic design of a therapy study which targeted the improvement of word finding using computer therapy, including language assessments for pre and post therapy evaluation and treatment items for therapy targeting impairment (word finding). The lead researcher (JM) was involved in developing the therapy software and delivered all word finding therapy.

The author (JW) initiated, designed and carried out the qualitative investigation to establish the views of participants on the process and broader effects of computer therapy. The aim was to evaluate outcome of therapy from the perspective of study participants in an attempt to capture perceived changes not only to impairment but to activity/participation as well. The findings of this broader evaluation could then be compared with the results of the above study targeting impairment specifically (word finding). In addition to the in-depth interview investigation, the original word finding study was further supplemented by an additional quantitative investigation of language use, that is, an attempt to quantify outcome at the level of activity/participation. The author (JW) determined the scope and specific aims of the broader investigation and the methods and procedures for investigation and analysis. The author determined aims and procedures for carrying out both interviews and analysis. The author conducted all post therapy interviews and carried out all transcription and analysis. The author conceived the aims for evaluation of the connected speech data, procedures for analysis of this data and collected the data and carried out the analysis. Procedures for analysis of word finding data and sentence comprehension were determined jointly with the lead researcher.

3.3.3 Ethical issues

People were recruited to this study in early 1999 at a time when formal ethical approval was not required for people recruited to a community-based study. Nonetheless, the study was carried out in accordance with the ethical guidelines of the speech and language therapy department. Informed written consent, obtained with the support of spoken explanations and written information made accessible for people with aphasia, was recorded for all assessment, intervention and video and audiotaping and strict confidentiality of data was maintained within the team. Data were anonymised in all reporting. An aphasia friendly report on study findings was discussed individually with study participants after completion.

3.3.4 Sampling and recruitment

Seven people were recruited, all with word finding difficulties associated with aphasia following stroke. Participants were at least 18 months post stroke, discharged from therapy and medically stable. Local therapists contacted about the study were asked to refer clients who fitted these criteria and who were interested in trying a computer assisted approach to word finding therapy. People were purposively recruited to represent a broad range of time post onset (TPO) of stroke and to include people with and without previous computing experience and previous computer assisted therapy experience.

3.3.5 Procedures

Baseline assessments (see Figure 3.1 above) were administered face-to-face, during clinic or home visits as preferred by each participant. A home visit was then carried out to load the therapy software onto the person's computer (or deliver the computer with software if loaned) with the first set of exercises assigned for independent practice. Therapy exercises were demonstrated and people were invited to use the system as often as they wished.

3.3.6 Software

StepByStep[®] software (Steps[®] Consulting Ltd^a), developed specifically for this study, was designed with the specific needs of users with aphasia and speech and language therapists in mind. It incorporated not only a user interface with access to therapy tasks, but also had an Internet update facility to enable transfer of results data to and from the user, and a therapist interface to enable remote monitoring of therapy. Appendix 2 shows sample screen shots of exercises described in more detail below and the update screen.

3.3.6.1 Presentation and design of user interface

The user interface was designed to maximise the possibility that a user with aphasia could use the software independently. To do so, the user needed to access and carry out exercises independently, and when ready, transfer results to the therapist and download newly assigned exercises unaided. Screen presentation was therefore as simple as possible. The software was opened by clicking on a single icon on the desktop and opened immediately to the 'Exercise' screen. Each exercise could then be accessed via an icon representing the type of exercise (for example a microphone for naming) accompanied by a written name meaningful to the user (for example 'Naming foods'). A maximum of fifteen exercises were available to the user at any one time. Appendix 2 shows screen shots of sample exercises.

From the exercise screen, the user was able to access a summary of exercise results via the 'Progress' screen, (represented by a graph icon, see Appendix 2). Feedback comprised a bar graph representation of percentage responses correct for each exercise over repeat attempts.

The software was designed to enable the therapist to monitor results and progress remotely, therefore the therapist needed to be able to access all results from a remote computer. In order for this to happen, the user first forwarded

^a Appendix 1 contains a list of all software referred to in this thesis with suppliers details

results of all exercises carried out since the previous update to the therapist via an Internet connection by clicking on a single icon (the traffic light) on the 'Update' screen (see Appendix 2). This activated a series of automated steps. Steps included retrieving latest results; transferring them to a safe server on the Internet; and notifying the therapist via email that results were available. The user decided when to forward results, having been advised to practice exercises until they felt their performance was reaching a plateau and told that this was expected to take about three to four weeks of practice. Following analysis of results and phone discussion between therapist and participant and carer, the therapist assigned new exercises to be collected from the server. The user downloaded new exercises by clicking on the traffic light icon again and when the exercise screen was next opened, new exercises were displayed. The process of analysing results and assigning new exercises generally took an average of two hours for the therapist to complete.

3.3.6.2 Nature of therapy exercises

The wide range of therapy tasks reproduced by the software included spoken and written word to picture matching tasks, semantic association, repetition, naming, reading and spelling tasks (see Appendix 2 for sample screen shots of exercises). Tasks used multimedia, that is photographs, sound and text as appropriate. The response required from the user varied according to task, e.g. multiple-choice selection in word to picture matching; spoken response in naming; keyboard entry or selection from on-screen choice of letters for spelling. Exercises were tailored to individual needs before being assigned to each participant by adjusting a range of different parameters, e.g. number of foils displayed, whether foils were written, pictured or both and the psycholinguistic variables of the target and foils in terms of imageability, frequency, age of acquisition.

The software responded to user errors by automatically giving additional support, dependent on task type, to make tasks easier. For example in word to picture matching tasks, if an incorrect item was selected, the response choice was

automatically narrowed from eight to three possible responses. If a further error was made, the target was identified. No automatic software feedback was given on repetition or naming tasks, but the user was able to record as many attempts as they wished at repetition or naming for listening and self-monitoring via a playback facility. Once satisfied with the quality of production, they saved this recording for subsequent transfer to the therapist (JM), and the therapist was able to listen to this recording when accessing results.

The user could also request additional information from the software, if finding a particular item difficult. This might involve requesting information from another language modality, for example in order to hear the name of a picture or a written word spoken aloud. In naming tasks, the user was able to request any one of a hierarchy of clues ranging from hearing the initial letter, initial sound or initial syllable to the whole word for repetition. The software was therefore designed to respond automatically in a constructive way to user errors, and simultaneously allow the user some choice in the nature of support s/he could request.

3.3.6.3 Therapist interface

The therapist was able to monitor clients remotely. Results data were summarised during transfer and presented to the therapist in the form of a report of exercises carried out, what errors had been made for each target response, as well as how many attempts had been made at each exercise and how long each attempt had taken. Results data included recordings of attempts at naming words by the user for the therapist to listen to when analysing results. The therapist also had data on how many hours of practice had been carried out, the frequency of practice sessions and the length of each session.

3.4 Evaluation of outcome I

Qualitative evaluation of participant and carer views

Outcomes were evaluated using a combination of qualitative and quantitative methods. The qualitative methodology (in-depth interviews) provided the primary

focus of the evaluation in keeping with the objective of investigating outcome from the perspective of study participants. However, it was supplemented by additional quantitative analyses of language skills and computer use, the results of which could be compared and contrasted with qualitative findings.

This section will describe the qualitative evaluation of outcome. Sections 3.5 and 3.6 will describe the quantitative evaluations of language skills and computer use respectively.

3.4.1 Purpose of in-depth interview evaluation

The objective of the qualitative evaluation (in-depth interviews) was to investigate the views of participants on receiving remotely delivered word-finding therapy in order to:

- Explore participant views on what ways people with aphasia may benefit from therapy targeting improvement of word finding delivered by computer in this way
- Develop hypotheses as to which people with aphasia may benefit from computer therapy targeting word finding delivered in this way;
- Develop hypotheses as to the key components contributing to a positive outcome in this novel mode of therapy delivery;
- Identify parameters to focus supplemental quantitative evaluations of outcome.

The following hypothesis was tested:

- Computer therapy for people with aphasia will bring benefits that impact more broadly than simply on impairment.

Outcomes were to be evaluated from the perspective of the participants. Findings could then be compared to quantitative data regarding benefit to language impairment and activity (section 3.5) and quantitative data regarding

computer use (section 3.6). Data were obtained by carrying out in-depth interview investigations with people participating, and where appropriate, their partners.

3.4.2 Rationale for methodology: in-depth interviews

Aphasia research already has a tradition of applying qualitative methodologies in the form of conversation analysis (Damico, Oelshlaeger and Simmons-Mackie 1999, Lesser and Milroy 1993, Perkins 1995) ethnography (Simmons-Mackie and Damico 1999) and in-depth interviews (Parr, Byng, Gilpin and Ireland 1997, Pound, Parr and Duchan 2001, Le Dorze & Brassard 1995, Van der Gaag, Smith, Davis et al. 2004). The use of in-depth interviewing is particularly appropriate for exploring the experiences and views of people with aphasia for two reasons. First, although structured by a topic guide, the interview process nonetheless allows the interviewee to raise issues of particular relevance to them and allows the interviewer to be able to focus on the perspective of the person with aphasia (Damico et al. 1999), a perspective, which by the very nature of aphasia, can easily be obscured. As noted above (2.2.1) aphasia is far from being a uniform disorder: levels of impairment and range of language modalities affected for each individual vary hugely. Experiences of aphasia can therefore vary considerably, both as a result of this huge variation in degree and pattern of impairment and due to the impact of additional personal and environmental factors. Standardised assessments and questionnaires for measuring individual functional benefit from therapy may fail to capture this variation (Frattali 1998, Parr & Byng 2000, Worrall, 2000). Such instruments may also represent the professional's view rather than the view of the person with aphasia. One of the premises in this study was that experiences and acceptability of remote-based therapy might be related to factors not foreseen by researchers, and these could best be accessed via in-depth interviews whereby the interviewee is able to introduce topics of relevance to them personally. The one-to-one interview format also allows the communication of experiences and views in whatever manner is easiest, given the constraints imposed by the person's communication difficulties. In-depth interviews were selected with these benefits in mind.

3.4.3 Interview procedures

The author (JW), who was not involved in delivering therapy, developed the topic guides, conducted interviews and carried out the analysis. Pre-therapy interviews investigated people's views on their communication difficulties in general, previous experience of computer use, current motivation for wanting to receive computer therapy and benefits people were hoping to gain. Post-therapy interviews investigated experiences of using the computer and software, how this differed from expectations, perceived benefits and negative effects of computer use, views on the therapy process with suggested improvements and views on the nature of progress made. Topic guides were developed for interviews, based on the findings of previous investigations into views of people with aphasia (Parr et al. 1997) and hypotheses based on clinical observations made by the therapist providing the remote based therapy during the therapy period. The topic guides are included in Appendix 3.

Interviews lasted between 45 and 90 minutes. All participants were encouraged to end the interview at any time if they wished to; none did so. All interviews were videotaped with the written consent of people involved for subsequent review and analysis. Videotape rather than audiotape was used so as to capture non-verbal communication. Drawing and writing were used by both interviewer and interviewee whenever helpful. Pre therapy interviews were carried out in the person's home or at the Speech and Language Therapy Research Unit, Bristol, according to individual preference. Post therapy interviews were all carried out at the Speech and Language Therapy Research Unit.

The topic guide was used to explore these key areas whilst allowing the interviewee to introduce novel issues of particular relevance to them. The interviewer applied the principles and techniques outlined by Patton (2002). The precise wording of questions varied, as did the order in which issues were raised. However, throughout the process the interviewer sought to ensure that only open questions were posed. At times, comprehension difficulties meant that open

questions needing to be followed up by closed questions requiring a yes or no response. Where this happened, a series of closed questions were posed to avoid either misunderstandings due to comprehension problems or the temptation for people to simply agree with the first suggestion. If, despite these efforts, meaning could not be clarified to the satisfaction of the participant, this fact was noted and relevant material was omitted from subsequent analysis or interpreted with caution. Wherever people responded by making only very general statements not supported by examples, the author (JW) encouraged elaboration, if necessary by prompting.

3.4.4 Data analysis

The analytic approach used followed the principles of 'Framework', a matrix based method for ordering and synthesising data (Pope, Ziebland and Mays 2000, Ritchie, Spencer and O'Connor 2003, Spencer, Ritchie and O'Connor 2003). Five stages in analysis are identified within Framework: familiarisation; identification of a thematic framework; indexing; charting; and mapping and interpretation of data. Although these stages are separated conceptually, in practice analysis was not linear but iterative, involving constant movement between stages of analysis.

3.4.4.1 Familiarisation, identification of thematic framework and coding

In order to become familiar with raw data, videotapes were viewed and reviewed and detailed notes made on the content of each interview. This included verbatim transcript of key sections, key word transcripts of other sections and notes on use of gesture, drawing or writing. During the process of familiarisation, a preliminary thematic framework was identified and transcripts were scanned repeatedly to identify all material pertinent to a particular theme, for example, all material relating to expectations of therapy, experiences of therapy and effects of therapy were identified and coded in the margins of transcripts for each participant. If appropriate, passages were coded as relevant to more than one theme. During the process of identifying material relevant to these broad themes, sub-themes were identified. Some sub-themes emerged directly from

the data obtained and had not been anticipated or specifically targeted in the topic guide, for example, 'partner's role in practice' and 'effects of therapy on mood'. Others corresponded to issues introduced via prompts on the topic guide, for example, 'role of speech and language therapist'.

3.4.4.2 Charting

Having established a preliminary thematic framework (comprising the broad themes and sub-themes) each participant transcript was analysed using the procedure of charting (Ritchie, Spencer and O'Connor 2003). This involved the transfer of material from all the transcripts onto a series of charts, where each chart represented a broad theme subdivided into sub-themes. Thus the chart detailing perception of contact with the speech and language therapist had sub-themes detailing the nature of contacts, frequency of contact, reasons for contact, feelings about the contact and an 'other' sub-theme for relevant data not covered elsewhere. The chart displayed all data relevant to this theme organised person by person. Emergent patterns for each case were repeatedly revisited to compare patterns and explanations for similarities and differences across the participants. As themes emerged from transcripts that could not be accommodated within the thematic framework, the thematic framework was adjusted, incorporating the new sub-theme. This new framework was then reapplied systematically across each transcript. The charting process also incorporated notes on themes that appeared to be linked in some way. For example, a link emerged between the perceived intensity of practice and perceived progress made.

3.4.4.3 Mapping and interpretation

Once the data had been laid out in charts, the process of mapping and interpretation began. With the original objectives in mind (namely to determine participants' views on the processes and outcome of therapy) data was summarised in the form of a detailed descriptive account (Spencer, Ritchie and O'Connor 2003). All information pertinent to a theme was drawn together. The process of creating a detailed descriptive account drew attention to the range of experience sampled on key parameters and identified commonalities and

contrasts between people's experiences. The creation of this detailed account facilitated the next stage of analysis, namely the process of developing higher-level themes, more abstract and more generalisable to theory than those found at the level of each individual case study. This was done by comparing and contrasting the range and nature of experiences within the initially identified themes, finding associations and developing possible higher-level themes, which were then tested against other cases. As a result of this process, the themes and sub-themes outlined under findings below were identified and described in the form given below.

3.4.4.4 Quality control in analysis

Throughout the process, the author used the charts, the descriptive accounts but also returned to the original interview transcript to ensure interpretation did not move too far away from the original data. The author and an independent researcher independently identified themes and sub-themes arising from one transcript then compared notes to crosscheck levels of agreement. Any material which had been omitted by one was discussed and a joint decision was made as to whether this be assigned to the theme or not.

3.5 Evaluation of outcome II

Quantitative evaluation of language skills

3.5.1 Purpose of evaluation

Two quantitative evaluations supplemented the qualitative evaluation described above, a quantitative evaluation of language skills and a quantitative evaluation of computer use. The quantitative evaluation of language skills will be described in this section. The quantitative evaluation of computer use will be described in section 3.6.

Quantitative evaluation of language skills was carried out with two objectives in mind. The first objective was to investigate using quantitative measures the key primary effects of the intervention on language skills that were identified by participants (improved ability to find words in assessment or therapy tasks and in conversation) in order to establish whether quantitative data confirmed participants' perceptions regarding outcomes.

The second objective was to profile the language skills of each participant in order to examine how participants' language skills related to their success using the software and generate hypotheses as to what profile of language skills is likely to facilitate successful use.

3.5.2 Rationale for methodology

This evaluation therefore set out firstly to determine whether there was quantitative evidence of change in people's ability to find words following therapy. A large body of literature exists in aphasia research on the evaluation of the effects of word finding therapy of which Nickels (2002b) provides a recent review. Nickels argues that the following six key features are central in ensuring an optimum chance of evaluating the efficacy of therapy. First, the same assessments need to be repeated before and after therapy. These assessments must include enough examples of items for naming to be able to demonstrate a significant change. Ideally pre therapy baselines should be performed more than once to establish degree of variability or spontaneous recovery. The 'to be treated set' should be divided into two sets of equal difficulty based on assessment performance, one set should be treated first, then all reassessed, then the second set treated and all reassessed (cross-over design). A control task, not expected to be affected by treatment, should be assessed before and after therapy. Any change in the control task will suggest spontaneous recovery or non-specific treatment effects. Finally, results should be analysed objectively to determine whether any change in performance is greater than might be expected by chance.

Nickels (2002b) also highlights the fact that very few studies address the issue of whether impairment based treatments for word finding, which demonstrate improvements at the level of impairment, actually impact on functional use of language. Hickin, Best, Herbert, Howard and Osborne (2001) address this issue:

'It can be argued that finding words to name pictures bears little resemblance to the real life situation of finding words in everyday speech. Very few of the studies reported have attempted to identify the effect of gains in picture naming on other speech situations. While anecdotal reports suggest such gains may not occur, this aspect remains to be investigated.'

Hickin et al. 2001: 13.

Recent studies by Hickin and colleagues included evaluations of connected or conversational speech samples in addition to picture naming (Herbert 2004, Herbert et al. 2003, Hickin et al. 2002b, Hickin et al. 2001). Two case studies by Hickin et al (2002b) found that although one person who demonstrated improvement at the level of impairment did also show improvements in measures of conversational speech, the other showed no evidence of change.

With these issues in mind, this study set out to evaluate whether there was quantitative evidence of change at the level of impairment (picture naming) but also whether there was quantitative evidence of change in ability to find words in connected speech. It was hypothesised that the more substantial the improvement at the level of impairment, the more likely this was to be reflected in improvements in connected speech. Two methods were therefore used to evaluate word finding, one examining performance in picture naming of words targeted in therapy and the other examining evidence for improved word finding in connected speech samples elicited via video description. Finally, an assessment of sentence comprehension determined whether any changes occurred in language skills not expected to be affected by therapy during the period of intervention (control assessment). This might indicate spontaneous recovery during the therapy period, independent of any therapy effect.

The second objective was to profile the language skills of each participant in order to examine how participants' language skills related to their success using the software and generate hypotheses as to what profile of language skills is likely to facilitate successful use. As stated above (section 2.8.5) the question arises with what form of underlying impairment does the person with word finding difficulties present (that is primarily semantic or phonological) and what form of therapy would be most appropriate to target the repair of this impairment? The majority of people with impaired word finding as a result of impaired semantic or phonological processing appear to benefit from therapy that combines semantic and phonological activation. Relevant data to provide information on the relative strengths and weaknesses of language processing in a range of tasks requiring semantic and/or phonological processing were selected from among the baseline language assessments determined by JM for the original study design.

3.5.3 Methods of evaluation

3.5.3.1 Picture naming

Word finding was assessed using the Object and Action Naming Battery (Druks and Masterson 2000). This battery assesses naming of 162 nouns and 100 verbs. Each object and verb is pictured using a black and white line drawing on a separate page and each page is presented individually to the person for naming. The battery has the advantage of providing a rating for each item on the parameters of printed word frequency, age of acquisition, familiarity and imageability. These parameters have been identified as impacting on word finding in aphasia (Masterson and Druks, 1998).

Figure 3.1 above illustrates the timing of naming assessments. Two baselines for picture naming were taken, six weeks apart, before therapy started (A_1 and A_2). Battery items were then targeted for naming therapy. The total battery contents were divided into *Set 1* and *Set 2*, with equal numbers in each set. The items in the two sets were equally matched on the parameters of printed word frequency, age of acquisition, familiarity and imageability so by matching items

for these parameters every effort was made to ensure that the two sets would be equal in terms of difficulty for naming. Following treatment (*B*) to *Set 1* only, both sets were reassessed (*A₃*) to determine whether any improvement to treated items had generalised to non-treatment items (*Set 2*). *Set 2* items were then treated (*C*). The study was completed by reassessment of all items treated (*A₄*) and a final post therapy assessment (*A₅*), six weeks after treatment had finished to establish whether performance had maintained after therapy was withdrawn.

3.5.3.2 Connected speech samples

Connected speech samples were elicited before and after therapy to determine, for each person, whether evidence of change in ability to name object or verb action pictures as assessed by the Object and Action Naming Battery (Druks & Masterson 2000) was accompanied by evidence of change in ability to retrieve names of objects or verbs in connected speech samples.

A sample of speech was elicited by asking people to provide a spoken description of a short video, the Functional Video Tool (FVT; Mortley 1998) showing a woman engaged in everyday activities such as gardening, watching television, knitting and reading. The content of the video had been determined with the aim of eliciting common vocabulary and included objects or actions targeted in therapy. People were able to familiarise themselves with the content by watching the silent video a couple of times first. They were then asked to describe the content from memory and their description was videotaped or audio taped for subsequent transcription and analysis. Two speech samples were taken as illustrated in Figure 3.1, one prior to therapy being introduced and one following completion of therapy.

3.5.3.3 Control assessment: sentence comprehension

This evaluation was a control measure to establish whether language abilities not targeted in therapy had changed post therapy and was intended to capture evidence of spontaneous improvement of language skills that could not be attributed to therapy. Sentence comprehension was chosen as a control assessment as it was not anticipated to show an effect following treatment to

word finding. It was assessed using the Reversible Sentence Comprehension Test (Byng and Black 1999).

3.5.3.4 Other formal language assessments

A range of other language assessments also investigated auditory comprehension and reading comprehension of single words (PALPA 47 and 48, Kay, Lesser and Coltheart 1992) and the ability to read aloud, write or indicate the first letter of the object names from the Object and Action Naming Battery (Druks and Masterson 2000). These assessments were used at baseline to provide an indication for each participant as to the level or levels of processing implicated in word retrieval difficulties.

3.5.4 Data analysis

3.5.4.1 Picture naming & sentence comprehension

A test of difference between two proportions (two-tailed) giving a z-score and a *p*-value was used to determine whether there was significant change between pre and post therapy measures of picture naming and sentence comprehension. In this way, stability of baseline measures was established. If the baseline measures proved stable, the composite value for the baseline measures was subsequently compared to each of the two post therapy measures to determine evidence of significant change.

3.5.4.2 Connected speech samples

Purpose and method of analysis

Numerous methods have been proposed for the analysis of aphasic narrative. Cherney, Shadden and Coelho (1998) provide a recent review of methods and stress that the choice of method will be governed by the specific objectives of the analysis. Shadden (1998) identifies three key objectives that generally motivate analysis of the informativeness of a connected speech sample: amount of information, quality of information and efficiency of information.

The objectives in this analysis were closely related to the objectives outlined by Shadden:

- To quantify change in the amount of information conveyed,
- To quantify change in the quality of information conveyed
- To quantify change in the efficiency with which information was conveyed.

Methods of analysis

Three methods of analysis were applied to the connected speech data. First, in order to quantify the number of nouns and verbs retrieved in connected speech, a simple noun and verb count was carried out for pre and post samples. In this analysis, a total noun and verb count was obtained first then the number of nouns or verbs produced per minute was also calculated as pre and post samples were not necessarily equal in terms of length of time taken to produce them. This analysis gave an indication of any change in the range of nouns and verbs produced and the rate at which they were produced pre and post therapy. The counts followed the conventions outlined in the Profile of Word Errors and Retrieval in Speech (POWERS, Herbert, Best, Hickin, Howard and Osborne, in progress; rules for what to include in the noun and verb counts are given in Appendix 4). The resulting analysis gave a measure of the number of nouns and verbs produced before and after therapy, but did not give information regarding appropriateness of those items in this context.

Further analysis aimed to evaluate amount of information conveyed, quality of information and efficiency with which information was conveyed. Nicholas and Brookshire's (1993) proposed system for quantifying the informativeness and efficiency of the connected speech of adults with aphasia was chosen as being most appropriate. It was designed for application to connected speech samples (that is, discourse or narrative rather than conversation). It also claims to quantify information conveyed consistently, irrespective of the stimuli used to elicit the sample (in this case the FVT video description). The procedure follows a rule-based system to determine the total number of words and total number of

correct information units in a sample of speech. Words are defined as intelligible in context to someone who knows the topic. Context is what the scorer knows about the topic from the elicitation source or from the speaker's prior words. Words do not have to be accurate, relevant or informative relative to the topic being discussed to be included in the word count. Correct information units (CIU's) are words that are intelligible in context, accurate in relation to the topic and relevant to and informative about the content of the topic. Words did not have to be used in a grammatically correct manner to be included in the CIU count. Each CIU consists of a single word and only words included in the word count can be considered for inclusion in the CIU. Rules for determining what could be included in the word count and count of CIU's taken from Nicholas & Brookshire 1993 are given in Appendix 5. Speech samples were timed so that three further measures could be calculated: words per minute (WPM), percentage of words that were CIU's (%CIU's) and CIU's per minute (CIU's/m). Nicholas and Brookshire (1993) reported good intra and inter-rater reliability figures for using this method of analysis in a study involving 20 people with aphasia and 20 controls. Inter-judge reliability exceeded 98% for words and 90% for CIU's for the sample of 12 people selected to determine reliability. Intra-judge reliability exceeded 99% for words and 95% for CIU's for six people with aphasia in the study. Session to session stability was high for the three calculated measures (WPM, %CIU's and CIU's/min) and particularly so for the % CIU's.

Finally, Herbert et al's (in progress) Profile of Word Errors and Retrieval in Speech (POWERS) was applied to the connected speech data. Although originally designed for analysis of conversation material, only those parameters of the POWERS analysis relevant to discourse samples were selectively applied in this analysis. Many of the parameters for quantification in early versions of the POWERS (Herbert in progress) were initially perceived as likely to be applicable in evaluating a discourse sample produced by someone with word finding difficulties as they included counts of common trouble indicating behaviour associated with word finding problems, for example phonological errors, semantic errors, neologisms and other indications of word retrieval difficult in

connected speech. However, these parameters have been found to have poor intra- and inter-rater reliability (Herbert 2004) and were therefore omitted from this analysis. The analysis therefore comprised four parameters:

- number of speech units
- number of content words
- number of nouns
- number of filled pauses

Rules for applying the analysis are found in Appendix 4. Once values had been calculated for these parameters, three proportional values were also calculated:

- content words/speech units
- nouns/speech units
- filled pauses/speech units

The POWERS analysis assumes samples for analysis and comparison are the same length in terms of time taken for production. The pre and post therapy samples used for analysis for each participant were therefore matched for length of time to enable a meaningful within-case analysis for each person.

3.6 Evaluation of outcome III

Computer usage data

3.6.1 Purpose of evaluation

The purpose of this part of the evaluation was to provide quantitative data on how individuals used the software and crucially, how much it was used. The aim was to capture individual variations in the amount of time spent using the software and individual variation in patterns of practice relating to individual exercises. This quantitative data could then be compared to qualitative data

regarding patterns of practice (section 3.4) and quantitative data regarding benefits to word finding (section 3.5).

3.6.2 Method of evaluation

Of the large amount of usage data captured automatically by the software, data on a number of parameters were selected to provide a profile of differing patterns of use. Two types of data were collected, namely time spent using the software and number of exercises attempted. Time spent using the software could be profiled as average time spent per month, per week or per session and it was also possible to identify weeks during which the software had not been used at all to monitor for inactive periods (due to holiday, sickness or technical difficulties). Data on exercises attempted could be broken down into the average number of attempts per exercise, average number of exercises per week and average number of exercises per session.

3.6.3 Data analysis

Results were generated for total time spent using the software, average time per month, per week and per session, number of active days and number of active weeks, total number of exercises assigned, average number of attempts per exercise, average number of exercises per week and average number of exercises per session. These were analysed in raw form to determine contrasts and commonalities between study participants.

3.7 Summary of methods

The purpose of this study was to investigate who was likely to benefit from word finding therapy delivered entirely via computer and what range of effects resulted from therapy, that is, was therapy impact limited to impairment or was a broader impact demonstrated. It also set out to investigate what the key components facilitating benefit might be. A case series study, involving six participants with aphasia, it used an *ABABA* design to evaluate the effects of therapy for word finding. Outcome was evaluated using in-depth interviews investigating

participants' perception of the process and outcome of therapy. This investigation was supplemented by quantitative language outcome measures included an evaluation of word finding in both a picture-naming task and in connected speech. A test of sentence comprehension provided a control measure to determine spontaneous improvement in impairment. Quantitative data on computer use captured the timing and frequency with which participants used the software. Findings from these three forms of outcome evaluations could then be cross-compared. The next chapter, Chapter Four, will describe study findings.

Chapter Four

Study One: Results

An investigation into the process and outcome of word finding therapy delivered remotely via computer for people with aphasia

This chapter presents the results of the investigation into the process and outcome of word finding therapy delivered remotely via computer, the background and methodology of which were described in Chapter Three. Information on the speech and language profile of participants is presented first (4.1). The following three sections outline results: section 4.2 describes the findings of the qualitative evaluation of views of participants on the process and outcome of therapy; section 4.3 describes the findings of the quantitative evaluation of language skills; section 4.4 describes findings of the quantitative evaluation of computer use. A final summary will draw qualitative and quantitative findings together (4.5).

4.1 Participants

Table 4.1 summarises background information on study participants. Participants were aged between 53 and 66 years and all were between 19 months and 11 years time post onset (TPO) of stroke. All except P4 lived with a partner. Four had had previous computer therapy, one had been a computer user prior to the stroke and one had had no previous computing experience. Two had received speech and language therapy during the 12 months prior to recruitment to this study but had since been discharged; the remainder had been discharged from therapy for over a year.

Of the seven, six people and five partners were involved in the study reported here (one participant had no partner at the outset). One person and his

partner could not be interviewed after therapy due to sickness. Participants were generally from middle to higher socio-economic groups with previous occupations including running their own business (three participants), insurance salesman, personal assistant and coach driver. By nature of their involvement in the study, all were motivated to try a computer-assisted approach to therapy.

Table 4.1 Background information on study one participants

	P1	P2	P3	P4	P5	P6
Age (yrs)	63	53	58	63	66	63
Sex	M	M	M	M	F	M
TPO (yrs)	1;7	1;10	2;10	8;1	11;0	2;8
Aphasia type	Anomic	Anomic	Broca's	Anomic	Broca's	Wernicke's
Hand use (dominant)	Partial	Normal	Partial	Partial	None	Normal
Social situation	With partner	With partner	With partner	Alone	With partner	With partner
Computer use pre stroke	Yes	Yes	No	Yes	No	No
Previous computer SLT	No	No	Yes	Yes	Yes	Yes
SLT in year pre study	Yes	No	Yes	No	No	No

Participants showed both fluent and non-fluent patterns of aphasia. All had word finding difficulties of varying severity as shown by the language assessment data in Table 4.2. As might be expected in a group of people with word finding difficulties, performance on different language tasks varied considerably across the group, implying differing degrees of impairment to semantic and phonological/orthographic processing underlying the word finding difficulties in each case.

Table 4.2 Background language assessments

Test	<i>N item</i>	P1	P2	P3	P4	P5	P6
<i>Picture Naming</i>	<i>N</i>	%	%	%	%	%	%
Object Naming A ₁ & A ₂ mean	162	28	42	53	43	43	34
Action Naming A ₁ & A ₂ mean	100	22	22	19	34	33	22
<i>Sentence comprehension</i>	<i>N</i>	%	%	%	%	%	%
RSCT A ₁ & A ₂ mean	40	58	45	58	75	47	42
<i>Semantics</i>	<i>N</i>	%	%	%	%	%	%
Spoken word - picture match	40	100	95	91	99	89	98
Written word - picture match	40	95	95	90	98	75	94
Picture naming: semantic errors as % errors on A ₁		27	28	55	45	27	23
<i>Phonology & orthography</i>	<i>N</i>	%	%	%	%	%	%
Oral reading objects names	81	72	84	61	64	58	50
Writing object names	81	06	19	11	64	04	12
Writing object names: 1 st letter correct	81	98	94	54	96	51	59
Picture naming: phonological errors as % errors on A ₁		00	08	09	15	31	29

No participant scored substantially more than 50% in the naming assessment. More impaired performance on word to picture matching for P3 and P5 indicated the possibility that underlying semantic impairments contributed to word finding difficulties in these cases. In addition, for P5 involvement of phonological processing was also evident as demonstrated by the number of phonological errors in naming. For the remainder, difficulties accessing the phonological form in naming or oral reading indicated some degree of impairment to either phonological forms themselves or in access to them and the additional possibility of subsequent phonological encoding difficulties. The relative ease with which P1 and P2 were able to read words aloud orally and the relatively few phonological errors produced by them indicated that these difficulties most likely arose from access problems. For P4, P5 and P6 there

was greater difficulty with phonological encoding as shown by the greater number of phonological errors. Participants also varied in terms of their writing abilities: P4 showed substantially superior writing ability. This strength at the level of impairment was reflected in his strategy of writing down words he was unable to say during conversation.

4.2 Evaluation of outcome 1

Qualitative evaluation of participant and carer views

4.2.1 Purpose

The objective of the qualitative evaluation (in-depth interviews) was to investigate the views of participants on receiving remotely delivered word-finding therapy in order to:

- Explore participant views on what ways people with aphasia may benefit from therapy targeting improvement of word finding delivered by computer in this way.
- Develop hypotheses as to which people with aphasia may benefit from computer therapy targeting word finding delivered in this way.
- Develop hypotheses as to the key components contributing to a positive outcome in this novel mode of therapy delivery.

The following hypothesis was tested:

- Computer therapy for people with aphasia will bring benefits that impact more broadly than simply on impairment.

Outcome was to be evaluated in its broadest sense, from the perspective of the participants. Findings could then be compared to quantitative data regarding benefit to language impairment and activity (section 4.3) and quantitative data regarding computer use (section 4.4). Data were obtained by carrying out in-depth interview investigations with people participating, and

where appropriate, their partners. Findings are reported in terms of the following themes:

- Effects of therapy
- Expectations of therapy
- Experiences of therapy
- Beliefs regarding aphasia and aphasia therapy

4.2.2 Use of quantification in reporting qualitative data

Some quantification has been included in the following description by indicating participants to whom themes apply in brackets in the text. However, applying numbers to data is not the aim when carrying out research within the framework of the qualitative paradigm: questions posed seek to describe the nature of processes and how they occur and interrelate rather than quantify their occurrence. Expressing results in terms of relative frequencies may be misleading where sampling strategies used have not aimed to identify a statistically representative set of respondents (Pope, Ziebland and Mays 2000). The intention here is to highlight insights gained when employing qualitative methodologies alongside quantitative data collection. As such, a pragmatic approach has been taken which assumes that quantification of data is likely to be helpful in the context of a small case series study of this kind.

4.2.3 Perceived effects of remote based therapy

This section will present views of participants on the effects of therapy. To determine the perceived effects of therapy was one of the key objectives of the qualitative investigation and these findings were of central importance to this research in that they enabled comparison to be made with quantitative data regarding measured effects. The theme of perceived effects was therefore introduced via the topic guide.

Perceived effects were predominantly positive. Figure 4.1 provides a schematic representation of how benefits were perceived to interrelate and impact on one another. Specific primary benefits ascribed to therapy (e.g. improvement on therapy task, in word finding and spelling skills, in computing

skills/phone use and increase in the specific occupational activity of computer therapy) were perceived as having a secondary impact on levels of activity and participation, and on confidence, self-esteem and mood. Relationships between primary and secondary benefits were not perceived as linear, but rather as a cyclical two-way interaction in which improvements in one area contributed to benefits in the other. It was also clear that improvements at the levels of activity and participation were not attributed solely to improvements to language impairment but to the more general effects of therapy as well, including improved computer skills, improved confidence and mood.

Specific primary benefits will be presented first with an analysis of the processes by which these took place, followed by a summary of secondary benefits, including an illustration of how these mapped onto the domains of the activities and participation information matrix (ICF, WHO 2001).

4.2.3.1 Specific primary benefits

Improvement on therapy tasks (impairment)

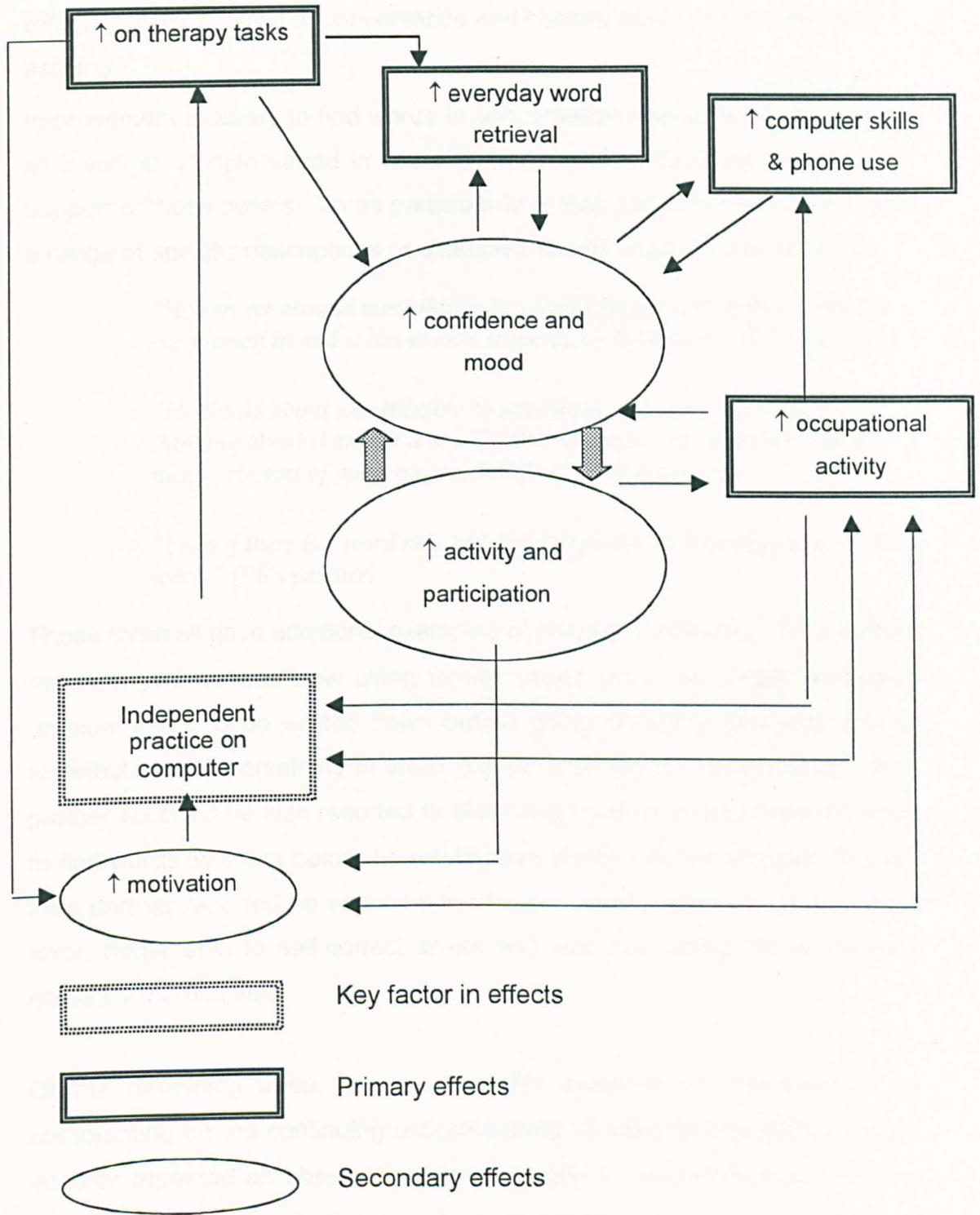
All perceived their performance on therapy exercises to have improved in terms of accuracy and speed. When prompted to explain this belief, all cited watching their scores on exercises or on post therapy reassessment improve as proof and all described a sense of pleasure and increased confidence that this had brought with it.

*“He really enjoyed it, he’d say after a couple of days, ‘Oh, I can do them’”
(P2’s partner)*

*“Well double Dutch here in the beginning, double Dutch, but in speaking words and phrases and lots of exercises and lots of...again and again and again, a little bit more speed and maybe alright and slowly, but alright’
(P4)*

The belief, expressed by all participants, that performance on picture naming tasks had improved, was confirmed by quantitative data (reported in section 4.3.2 below).

Figure 4.1 Interrelationship of perceived therapy effects



Effects on word finding in conversation and spelling ability (impairment and activity).

Improvement in ability to find words in conversation was likewise reported by all involved. People varied in terms of what level of evidence they gave in support of these beliefs. Three participants or their partners were able to give a range of specific descriptions or examples to add weight to the assertion:

“He can get around most things to say and he can sort of find a word or cue himself in and it has made a tremendous difference.” (P1’s partner)

‘He thinks about words before he says them. I can see him actually thinking about it and he’ll say “Yeah...uh...the...the roses are looking nice”. He sort of plans his words before.’ (P2’s partner)

“Even if there is a word he’s had difficulty with, by thinking he’ll recall a word.” (P6’s partner)

These three all gave additional examples of changed behaviour. P1’s partner reported that he was now using family names more, no longer requested unusual items to be written down before going shopping and was able to contribute to conversations in small groups in a way not seen before. P2’s partner reported he also resorted to skywriting much less and made an effort to find words whereas before he would have simply pointed and said ‘Those’. P6’s partner reported he was now much more aware when he produced an error, better able to self-correct errors and was now using his son-in-law’s name for the first time.

Of the remaining three, one qualified his assertion of improvements by commenting on the continuing unpredictability of word finding (P5’s partner); another repeated an observation already made in the pre-therapy interview that her partner was starting to put words together (P3). As this had been claimed pre-therapy it was not felt it could be attributed to the therapy process, despite her perception post-therapy that therapy had contributed to it. For the remaining participant, (P4) examples were interpreted with caution, as there was no partner interview in this case to corroborate assertions. Three people (P1, P5, P6) also reported improvement in spelling ability.

Thus although the qualitative evidence for improvements in conversational word finding were strong for three participants, the evidence was more equivocal for the remaining three. However, irrespective of ability to provide examples, all participants reported an increase in confidence in their communication skills as a result of perceiving an improvement in word finding in conversation and this is discussed further in section 4.2.3.2. Quantitative evaluation of benefit to word finding in connected speech showed equivocal results for all participants as will be reported in section 4.3.3 below.

Effects on computer skills & phone use (activity & participation)

Effect on computer skills was a theme introduced by the topic guide but some participants themselves introduced discussion of effects on phone use. All but one described how they perceived their computing skills to have improved as a result of the computer-based therapy (the exception, P4, having been a confident computer user prior to therapy). Three people reported having started to use the Web and/or email (P1, P2 and P6). One had overcome a particular dislike of computers attributed to childhood experience of being dyslexic (P6). One had enrolled on an introductory word processing course in an Adult Education Centre and was finding that he could keep up with course participants who did not have aphasia (P1). Another was using the computer more for recreational games (P5).

P1 and P6 became confident users of the phone, a change attributed specifically to use of the phone to discuss progress with the therapist during therapy.

'Suddenly when I rang her it suddenly shot up here (gestures to indicate a substantial improvement) I was quite a time speaking, I was surprised, I thought, 'I'll try it' and it was OK' (P6)

For P6, the change involved overcoming considerable aggression towards the phone, the result of finding himself unable to use his mobile phone to call help at the time of his stroke. A third participant (P2) was now confident to answer calls, but did not initiate them. Others showed no change in phone use. P4 had been a confident user of the phone prior to therapy. P3 and P5 remained

dependent on others in phoning, a fact possibly linked to the severity of their aphasia.

Occupational benefit (activity)

This theme was introduced by participants themselves and included as a separate theme due to the importance it was given by these people. Three participants and their partners (P2, P3 and P5) reported finding computer therapy to be beneficial simply in providing an occupation to pass the time. Computer therapy was valued as being a more beneficial occupation than other available occupations, the most common alternative being television. Computer therapy was contrasted favourably with television because it required more active engagement:

'It's you to decide' (P3)

'It's occupational as well as educational or therapy' (P5's partner)

'It's something for him you know, it gives him an occupation so to speak, something to do with his time' (P2's partner)

In contrast to these views, two participants explicitly stated that they did not experience computer therapy as occupational (P4 and P6). These people felt they already had no difficulty filling time.

4.2.3.2 General secondary effects

Effects on confidence and/or self-esteem (personal context)

All reported an increase in general confidence and/or self-esteem attributed to therapy. The increase was ascribed not only to the perception of improved word finding ability or improved everyday communication ability described above (section 4.2.3.1 Specific primary effects). Other factors such as learning new skills in computer use and experiencing improvements on therapy tasks had contributed to improvements (Figure 4.1).

'She is much happier when she is confident and she gets this confidence back that she can make herself understood' (P5's partner).

'It was something he was achieving...and it wasn't just the speech like I say, the Internet and email was something he could do, he felt proud that

he could do - and something he could do better than me and so I think it raised his self-esteem quite considerably' (P2's partner)

'Last January, I didn't know really and I thought to myself 'It's too hard or too...too difficult' or...or I just didn't know and doing it is...is um frightening but now it's a hundred percent fine' (P2)

'It was hard first of all, but it was...and um...first of all I wondered whether I could do it, but then when I tried it, it was wonderful...Because I can do it and do it a lot and then it goes better and better and normally at the end of it I can do everything' (P1)

One partner (P5's partner) specifically reported that he had noted an improvement in P5's communication as soon as baseline assessments began and before therapy was initiated. This may indicate a perception of benefit comparable to a placebo effect.

Effects on mood and sense of self (personal context)

Perhaps the most fundamental effect consistently reported by all partners was a perceived improvement in mood, described in terms of the person being *'much more like his old self' (P1's partner)*. One partner summed up the whole effect of therapy by saying *'It's giving me my husband back' (P3's partner)*. Another commented that since the stroke her partner had regularly had times when he had been depressed, yet for the first time this had not occurred at all within the six months of therapy (P6's partner). Another partner described the perceived change as comparable to improvements seen in the past, when medication was reduced:

'The doctor decreased her dosage and she was a different person, she was responding, she could comprehend almost everything. This time is similar to that, she's generally improved and more herself' (P5's partner).

Table 4.3 Summary of qualitative effects of therapy mapped onto ICF domains of activity and participation

Domain	Learn/apply knowledge	General tasks and demands	Communication	Domestic Life	Interpersonal interactions	Major life areas	Community, social, civic life
Activity	Problem solving learning to write learning to read	Simple tasks multiple tasks	Understanding, speaking, conversation	Shopping, cooking, housework	with family, friends, strangers	Education, Paid employment	Recreation and leisure
P1	Spelling *		Naming * Conversation *	Shopping without list	Phoning * Interaction * Independent socially *	Word processing course Confidence & skills with computer	
P2	Reading *	↑ Ability to cook dinner	Understanding* Naming *	Gardening/ DIY with manual Shopping alone	With strangers & neighbours * with son * with partner *	Advertised machine repairs to earn money	Voluntary work understanding Watching TV leisure opp
P3			Understanding * Naming * Conversation *		with family * with strangers	Now has basic computing skills	Understanding Watching TV Leisure opp
P4	Reading *		Naming				
P5	Reading Writing	Ability to carry out therapy independently	Understanding Naming *		with family *		Leisure opp
P6	↑ Writing/ spelling *	Download software	Understanding* Naming* Conversation *		with strangers*	Looks up info on web	

If claimed improvement was backed up by specific examples this has been marked by "*" after the claimed benefit.

Effects on activity and participation

All reported a range of changes in communication activities and social participation, which they attributed to therapy and which fell within the ICF (WHO 2001) dimension of activity and participation (see Table 4.3). It was not possible to separate changes that were the direct result of improved communication skills and those that were the result of increased confidence (Figure 4.1) and some of the increase in activity or participation was attributed to improved confidence, rather than to specific change at impairment level. This explained the large range and extent of the perceived changes in activity/participation. Apparently dramatic improvements may have been the result of an increase in confidence allowing existing competence to be revealed:

'Suddenly when I rang her it suddenly shot up here (gestures to indicate a substantial improvement) I was quite a time speaking, I was surprised, I thought, "I'll try it" and it was OK'. (P6)

Reported changes which were associated by participants with effects of therapy (see Table 4.3) included initiating conversations with strangers, engaging more actively in family conversations, reading the newspaper, initiating and maintaining discussion of current news events and being able to give directions to a stranger. Newly undertaken activities which were attributed to increased confidence included shopping alone, learning to drive again, decorating and rewiring the house, carrying out car maintenance and DIY tasks by following a manual and cooking meals independently. Although these activities were clearly far removed from the target of therapy (improving word finding), in the minds of participants and carers alike the confidence to undertake these new activities was attributed to therapy.

4.2.3.3 Cyclical nature of effects

This theme arose from the analysis of the data and had not been anticipated in the topic guide. Figure 4.1 illustrates how therapy effects were experienced in a cyclical way. One partner reported her perception that a positive cycle had been

created by improved communication ability which had led to increased participation in social situations and a return to social roles within the family that had existed before the stroke. The cycle was completed by this in turn facilitating more opportunities for communication:

'Now he's understanding, he's not such a bore to keep having to repeat to...so they (his family) are not finding it so hard to talk to him. They are making him think...they are making the brain work, and asking for things and asking him questions now, that he's got to answer and I think that's one of the greatest things... He's always been the talker and he's always been the person they've gone to for advice and now albeit small, it's taking shape again...and he's answering, coming up with solutions, which is great' (P3's partner).

Another positive cycle was created to maintain motivation and practice and this will be discussed further (sections 4.2.4.2 and 4.2.4.3).

4.2.3.4 Negative effects

Very few negative effects of therapy were reported despite people being repeatedly encouraged to be critical in their feedback. The perceived negative effects associated with using the software all related to the amount of time spent in practice and the fact this reduced time available for other activities. This is perhaps unsurprising in the context of people choosing to engage in almost daily or at times twice daily practice. Three people (P1, P2 and P5) reported that there was a temptation to sit for too long in one session at the computer without stretching and this was particularly an issue for people who had a hemiplegia. Two reported trying to discipline themselves to interrupt their practice to stretch. The desire to maintain intensive practice on the computer also led to less time generally being available for other activities, examples of which were surfing the Web and engaging in regular physical activity.

4.2.3.5 Summary of effects

Benefits were reported that had impacted on communication skills (including word finding and a range of communication activities and social participation).

Benefit was also reported to confidence and mood. Some reported specific benefits to computing skills and phone use and some reported increase in occupational activity. All emphasised that any benefit was highly valued no matter how small. Negative benefits all related to the amount of time spent in practice.

4.2.4 Expectations of therapy

This topic was introduced via the topic guide to provide a context within which perceived benefits could be interpreted. Responses indicated that people generally started therapy with rather vague hopes for improvement in communication skills of any kind and with a degree of anxiety about their ability to cope with the fact that therapy was to be delivered remotely and via computer.

People varied in the degree to which they specified what they expected from therapy. Two mentioned improvements to speaking (P1 and P5). One reported he hoped computer therapy would help him write better (P6). The others reported that they simply did not know what to expect (P2, P3 and P4) but stated their belief that engaging in computer therapy could only be beneficial. Two reported anxiety that computer therapy might prove too difficult for them, because of their aphasia and lack of confidence with computers (P2 and P6). Both reported this fear proved unfounded in retrospect.

In contrast, partners generally gave more specific details of their expectations and hopes for therapy and cited possible effects that were broader than simply improved ability to find words. One partner expected spelling ability to improve (P5's partner). Others reported that they hoped for benefits to word finding or speech generally and anticipated this would lead to increased confidence in communication (P3's partner, P6's partner) or were hoping that participation in the therapy process would lead to increased confidence in general (P2's partner, P3's partner). One partner specifically identified that she hoped that

improvements in speech skills would lead to an increase in activities (for example reading newspapers, writing letters) and an increase in social participation as a result of therapy (P2's partner) and one hoped for increase in confidence using the computer (P6). Partners also anticipated that computer therapy would be a valued occupation and an enjoyable way of passing large amounts of spare time some people had on their hands (P2's partner, P5's partner). Not all partners had assumed that therapy could only bring positive effects. One (P1) reported major concern that using a computer in therapy would simply compound social isolation that had resulted from the communication impairment and for these reasons compared computer therapy unfavourably to face to face therapy with a speech and language therapist.

Three partners interviewed reported having had doubts about their partner's ability to use a computer independently (P2, P3, P6). Of those couples expressing doubts, two had had previous computer therapy (P3, P6) and one had experience of computer use prior to his stroke (P2), so such doubts were not linked solely to previous computing or computer therapy experience, but appeared to relate to not knowing what level of independence might be required in remote delivery of therapy. In all three cases, this anxiety was regarded as unfounded in retrospect (see 4.2.5.2 below). Partners did not see prior experience of using a computer as a prerequisite for success and one partner (P2) described the software as "easy to use" independently by people with aphasia. In direct contradiction to this, another partner reported that partner help was essential in facilitating access by the person with aphasia and this contradiction will be discussed further under 'Partner role' (4.2.5.2).

One constantly reiterated theme from all participants and all partners was the belief that even a small change would be perceived as a positive result. P6's partner summed this up when she said:

'Any sort of improvement would have been obviously very acceptable' (P6's partner)

In summary, people with aphasia appeared motivated more by non-specific aspirations for any improvement to communication than by specific aspirations regarding word finding or computing skills. Their partners expressed hopes and aspirations in much broader terms to include benefits at the level of activity and participation and to computing skills and general confidence. Both people with aphasia and their partners experienced anxiety that using a computer in therapy might prove too demanding. One partner expressed fears that computer therapy would compound social isolation. All believed any improvements, however small, would be valued.

4.2.5 Experiences of Remote Based therapy

Investigation of participants' experiences of therapy was intended to provide information as to who might benefit from therapy and develop hypotheses as to the key components by which benefits might occur and the potential barriers to successful use of the software.

4.2.5.1 Patterns of use

The interviewer introduced this topic. All participants reported using the computer most days (most commonly five out of seven) and three reported sometimes carrying out two practice sessions in a single day (P1, P2, P6). This relatively high intensity of use occurred in the context of people having been invited to use the software as and when they chose. Variations in use reflected lifestyle and individual preferences. For example, some reported doing no or less practice on weekends (P1, P2) either because there was no time or because they valued the break.

Two distinct patterns of organising daily practice emerged from the group. One pattern revealed a preference for routine practice and involved doing therapy

exercises at the same time each day, most usually early morning and/or early evening (P1, P4, P5). Those who chose this option explained it in terms of being able to carry out practice when feeling most alert. The other pattern revealed a preference for opportunistic practice and involved simply doing the practice as and when it suited, and might be at a different time each day (P2, P3, P6). Those who chose this option reported it enabled therapy practice to be fitted in around other commitments:

'You can do it any time when you want to. I think the computer is a better way of doing it - you can do a bit, then do some stuff on other jobs around the house. Better because you can do it in between taking deliveries and doing other jobs.' (P6)

People likewise varied in how long they spent practising in any one session. The predominant pattern was to work for up to an hour and this pattern was followed by people who tended to practice at the same time each day. Three experimented with longer sessions, one reporting he had spent up to three hours on one session (P2). P5 tended to work for an hour and a half. P4 reported systematically working his way through the next three exercises in the order presented on screen each session, however long this took.

With the exception of P5, those who experimented with session length concluded that shorter sessions (up to an hour maximum) were optimum and had attempted to discipline themselves into working for shorter periods, recognising the importance of regular breaks. This principle of regular breaks was also applied by participants in the sense of taking occasional 'holidays' from therapy. P2 summed this up:

'the computer...is really good but sometimes I think "Oh, I can't be doing that" and I do nothing maybe a week and then I think, "I'll be alright now, I'll have another go"'

A common theme emerging from this data was that the flexibility to determine when practice was carried out was a key factor in facilitating more practice and

hence more effective practice than in previous therapy. This will be discussed further below (4.2.6.2).

4.2.5.2 Partner role

Themes described in this section arose from the interview data rather than being introduced by the topic guide. All six people participating and all five partners reported valuing the fact that people could use the software without the partner present. Partners believed this to be an advantage as it increased the autonomy of the person with aphasia and relieved some of the frustration partners felt at not being able or not wanting to spend all therapy practice time with the person with aphasia.

'It's something he can do away from me' (P2's partner)

'It gives me rope so I can get away and do things while she's on her computer' (P5's partner)

'He's at home a lot of the time by himself anyway so he was able to go and just get on with it' (P6's partner).

However, the fact that everyone was able to use the software independently to some extent did not preclude partners from being involved in the therapy process. There was wide variation in the extent and nature of partner involvement, with participants locating themselves at different points on a continuum. At one end of the continuum, one person practised totally independently from the outset as he lived alone, clearly demonstrating that remote-based therapy was possible without partner support (P4). At the other extreme, one partner believed that therapy would not have been possible without his support. The remaining four and their partners placed themselves somewhere on the continuum between these two extremes. The role of the partner was described in terms of providing reassurance, encouragement, support where needed and sharing the pleasure of success thus contributing to maintaining motivation.

For some the degree of partner involvement changed during the course of therapy. Two particular times were identified when potential support was felt to be valuable: first, at the beginning, when people were uncertain about their ability to succeed with remotely monitored computer therapy and second, at any time when exercises proved unexpectedly difficult:

'At the beginning she had trouble doing the exercise let alone manipulating the mouse at the same time...so I used to do the mouse for her and then she got confident and then I left her to it and then she was doing both. But at the beginning it was asking too much... When you say the program is a remote-based computer programme for the disabled, it's a programme for the disabled and their helper... She couldn't have done it without me.' (P5's partner).

'I think it helped him that I've gone in with him - it's not as if he's doing his homework by himself. I think encouragement really - perhaps when things have been difficult, I've given him a slight bit of help, which has probably encouraged him really and then when it's all gone right we've both been pleased' (P1's partner).

The degree of partner involvement appeared to be related both to the time that the partner had available for support and to the beliefs of the partner and/or participant as to whether independent learning or encouragement was more conducive to success. The following comments illustrate a value being placed on independence in the learning process.

'I let him take the main role, I let him think he's a lot brighter than me!'
(P2's partner)

'I tried not to interfere unless he got stuck. If I gave him the first letter it just flowed out' (P3's partner)

'I never told him what the actual letters were, he had to work it out from negative feedback from the computer' (P6's partner)

Partners who took a more active role believed their help in encouraging a shift in the focus of practice or intervening to provide cues when an exercise proved

difficult had reduced potential frustration. Partners who took a less active role believed their ability to stand back and allow the person space to make their own mistakes and control their own learning had been beneficial. In four of the five partner relationships, the participant confirmed that the level of support received from the partner was appropriate; in the remaining case (P5) it was neither confirmed nor denied.

Amongst those taking a more active supporting role there were contrasting views as to the degree of burden this represented, as illustrated by the following two quotes:

'It's not been a stressful thing that we've got to do, it's not been a pressure' (P1's partner).

'Six months is long enough and she could do with a rest now and so could I...it was a strain at one time...but it's been worthwhile and she's got benefit from it' (P5's partner)

In summary, participants varied in the extent to which partners contributed to the therapy process. One participant (P4, a very experienced computer user prior to his stroke) used the software entirely without partner support. However, others saw partner support as critical. It seems likely that for the latter, the appropriate level and timing of partner support was indeed a key factor in bringing about successful use of the software.

4.2.5.3 Speech and language therapist role

One of the key aims of the post-therapy interview investigation was to determine views on this novel mode of delivering therapy where no face-to-face contact was provided during the six-month therapy period. This theme was therefore introduced via the topic guide. All contact with the therapist was via phone and Internet unless technical problems arose, in which case a home visit was carried out. Aside from pre-scheduled assessment visits, three participants requested additional home visits during the twenty-seven week therapy period to sort

technical difficulties with the modem (P1 and P3, two home visits each) and reconfigure the hard drive (P4, two home visits and a period of four weeks without access to the therapy software).

Despite the absence of face-to-face contact, everyone perceived the role of the speech and language therapist as crucial in providing both motivation and reassurance. The fact that this support came from someone outside the family was identified as significant and the symbolic value of knowing someone was going to check progress at some point was identified as very important by several participants (P1, P2, P3, P5).

'I think if you just do everything on the computer um...probably not to do so much whereas if there's something coming out...I make sure I've done it'. (P1)

'It's to let the person know that they have got back up, that there is someone who knows what they're doing, not just me'. (P3's partner).

As with partner support, therapist support was particularly valued when exercises proved unexpectedly difficult. The extent to which participants tried to influence the course of therapy varied. One reported directly overruling the therapist's suggestion that exercises he found difficult be removed, as he wished to continue practice on them (P6). Another welcomed the speech and language therapist's suggestion that a particularly difficult exercise could be removed or modified and returned to at a later stage (P1). Another commented how encouraging it had been to return to an exercise to find it had become easier (P2). Variation was also reflected in the different ways people approached the process of requesting new exercises for practice (described further in section 4.2.5.4).

In summary, therapist support was perceived by all to be a key component in maintaining motivation to practice and may have facilitated the high intensity of practice observed in this group.

4.2.5.4 Process of requesting new exercises

This theme arose from analysis of the interview data and appeared to reflect different approaches among participants and their partners to the therapy process. These findings are included as they shed light on who may benefit from this form of therapy.

The number of remote therapy sessions per participant over the twenty-seven week period ranged from four to six. Everyone received the same instructions at the outset of therapy regarding when to initiate a therapy update (that is to request new exercises after three to four weeks or as they felt their performance reach a plateau). If no contact had been made after six weeks, the therapist initiated phone contact. People approached the process of requesting updates in a variety of ways. The manner in which they approached the update process reflected individual beliefs about the optimum time to practise one set of exercises, but could also be influenced by beliefs about professional and participant roles.

The predominant pattern was for people to work for two to four weeks on exercises before asking for an update (five participants). Three weeks were identified as optimum by P1's partner in the following terms:

'after a fortnight (he) would have most of it sussed and then just refine it perhaps for another week, and then think, well, yes I have got it, I can ring'.

Another partner expressed very similar views about the importance of taking time to consolidate performance. She believed that requesting updates after two weeks was too soon for her partner and had encouraged him to spend an extra week consolidating performance on current tasks. She also expressed embarrassment at being asked by her partner to contact the therapist after only two weeks, as she believed that the therapist intended to offer monthly updates and might be too busy to offer them more frequently.

The person who did not have a partner (P4) managed the update process totally independently from the start. The remainder all involved their partner initially, but in two cases people became completely independent in managing the update process, so that the partner was no longer aware when it took place (P1 and P6). In a further two cases the participant forwarded the results independently then enlisted partner support to phone the therapist (P2 and P3). One person and her partner never requested updates, instead waiting each time for the therapist to initiate contact (P5). Failure to do so clearly reflected perceived boundaries of participant and professional roles as indicated by this partner's comment:

'I felt the course was laid out specifically and broken up into phases and who am I to argue with the boss' (P5's partner).

Interestingly, reluctance to 'intervene' in what was perceived to be the exclusive role of the therapist prevailed despite this partner's awareness that he had insights into his partner's patterns of practice, which might have been informative to the therapist. In particular he believed that P5 had at times exceeded the optimum time to be spent on one set of exercises:

"Frustrating for me because I'd know she'd been doing an exercise almost 100% and then suddenly to be struggling with that same exercise, you know - if it could have been taken away from her in the beginning, I think it would have avoided a lot of frustration...When you'd already done the exercises and you know what it's on about, you're always doing 100%, then you're not going to go anywhere but down." (P5's partner).

Post hoc examination of exercise data results did not support this perception of deterioration with time. However, it is possible that this partner observed deterioration in performance, but that his support during tasks prevented this deterioration being reflected in results.

Examination of computer usage data for P5 (section 4.4 below, Table 4.11) showed that although P5 had used the software for a greater number of hours

than other participants, her gains were below the mean for the group. It may be that practice beyond a certain threshold brought no further gain and that by adopting a passive approach to receiving new exercises when allocated rather than requesting them according to her own progress, she learned less effectively than others in the group.

4.2.5.5 Ending therapy

This theme emerged from interview data and was included here as a separate theme because of the strength of feeling with which views were expressed. Three participants reported experiencing the end of computer therapy as abrupt (P2, P3 and P5). All five partners raised concerns that with therapy coming to an end, improvements might not maintain. The general view was that unless language skills were used and exercised regularly any gains would be lost:

'I think it's stupid because slowly but surely getting better. It (therapy) all gone and the next moment it'll be (gestures down) I need to do exercises every day or, you know, like that, I don't know how but that is the only way.'
(P2)

This experience of therapy ending abruptly was reported in the context of a finite research study where all participants had been given clear aphasia friendly spoken and written explanations of the procedures and timescales for therapy input at the outset and all were aware that therapy would be for a fixed term only.

These views reflected a belief that continued practice was a key component in the maintenance of benefits. However, P3's partner offered an alternative perspective. She argued that increased social participation and communication activity that had resulted from therapy would function to promote continued stimulation of the language mechanism and further gains to language skills (see section 4.2.3.3 above).

4.2.6 Beliefs about aphasia and aphasia therapy

These beliefs provided the context in which beliefs about benefits resulting from therapy were expressed and helped develop hypotheses as to the key components contributing to a positive outcome and who was likely to benefit.

Participants and their carers expressed strong beliefs about the nature of recovery in aphasia and what is therefore required in aphasia therapy. These emerged from the interview data prompted by comparison of remotely-monitored therapy with previous speech and language therapy received.

4.2.6.1 Process of recovery in aphasia and timing of therapy

Two partners (P3's partner, P6's partner) and one person with aphasia (P1) likened the process of regaining language in aphasia to the process of acquiring language as a child: the process required constant repetition a little and often and needed to continue for many years after stroke. All people with aphasia believed that they had the potential to make improvement many years after stroke, if given the opportunity. One person who had been told to expect little recovery after the first three months or at most after the first year, believed this information to be both incorrect and unhelpful: incorrect because, in this person's opinion, experience with remotely monitored computer therapy had proved the assumption about a limited 'window of recovery' wrong (people with aphasia were all between 19 months and 11 years post stroke); unhelpful because it took away hope and the motivation to keep aiming for improvement.

'When he first had his stroke he was told that, if he didn't regain his speech back in the first three months, the likelihood of him regaining it was poorer, so when the first three months had passed, I think he felt very frightened that he wasn't going to get it back... so it just goes to prove it's not always the case, he's slowly got better'. (P2's partner).

Views on optimum timing for remotely monitored therapy varied from person to person and were influenced by individual circumstances. All felt it would not

have been appropriate in the acute phase, as therapy required good concentration and good learning ability. One person (P2) identified one month post onset as sufficient time but his partner disagreed, believing he would not have had sufficient insight into his difficulties until six months post onset. All others regarded the period of six months to a year post onset as the optimum time to consider this mode of therapy. The only exception was someone whose personal circumstances of having to care for a sick partner meant that the person concerned would have felt unable to focus on remotely monitored therapy before three years post onset, perhaps another reflection of the substantial time commitment that people associated with this mode of therapy.

The general consensus was that this mode of therapy would be beneficial for people with aphasia from six months post onset onwards but that individual factors influencing time available for practice would also determine for whom this therapy was suitable.

4.2.6.2 Repetition in learning: implications for intensity of therapy practice

All participants expressed the belief that large amounts of repetition was crucial for learning in aphasia and that unrestricted access to practice had been crucial in bringing the substantial progress which had been perceived. The one feature of remotely monitored computer therapy that was valued above all else and contrasted favourably to previous therapy received was the fact that people with aphasia had control over the timing, duration and hence intensity of therapy practice. All believed that this had enabled far more intensive practice than had ever been possible when receiving previous speech and language therapy and four people believed that progress had therefore been greater than in previous speech and language therapy (P1, P2, P3, P6). Key factors in facilitating this intensive practice were access to the software at home and independence from both the speech and language therapist and partner in carrying out practice. Although the quality of previous speech and language therapy was, with one

exception, felt to have been good, all participants expressed frustration at the quantity, intensity and duration of therapy.

'Only really 1 session each week and that is stupid I really need or need to have not all the time but um every day you know slowly but surely better' (P2)

'It's one year (gestures 'ending') No good. 'Bye Bye'...It's one day, one hour, one hour! It's oh...bloody hell!...The computer is good...it's you to decide' (P3)

'(reflecting on previous therapy)...good but think...two years and stop. And 'bye bye'. Very naughty, no, not naughty, sad. (The SLT) very very nice but um part time and um I know it...very very busy and a tiny bit, but not good (Contrasting with remote-based computer therapy) in the morning, one hour each day...precision all the time (gestures repetition) copyng and reading and all...once a day an hour, and also again and again and again, a little bit of speech' (P4).

This evidence suggested that access to intensive repetitive practice was regarded as a key component in bringing the degree of benefit experienced.

4.3.6.3 Nature of the software: 'Listening and that, control, control' (P5)

The nature of the software and the nature of the learning environment it provided were also seen as key components in bringing about benefits. Participants identified some aspects of the software, which made it more attractive to them than conventional therapy. Two commented on the variety of tasks and the variety of material that could be presented via computer as instrumental in maintaining interest and motivation (P3, P5) and this was confirmed by computer usage data (section 4.4.2 below), which indicated that participants were assigned between 44 and 70 different exercises each over the therapy period. Another commented that presenting a large quantity of exemplars (for example having 20 target items to retrieve) in one exercise was a good idea, as it gave more opportunity for practice (P1).

All valued the facility offered by the software to record their speech and monitor their own attempts at production. This enabled multiple attempts at producing the same target item, repeat monitoring of these attempts and comparison with a model, until satisfied that progress had indeed been made: P2's partner summed up this process:

'It was good because he didn't feel a fool if he didn't get it right the first time and he'd keep trying, trying until he got it right. He could take as much time as he wanted, he didn't feel he was taking up the speech therapist's time.'

A sense of pleasure and confidence was derived from the fact that results provided evidence of progress made, and this appeared to provide motivation for further practice, creating a cycle in which success fuelled motivation (Figure 4.1). The fact that people could access a graph of their results was also felt to be important as it provided concrete visual evidence of improvements:

'The results speak for themselves' (P3's partner).

It may be that direct access to graphic feedback on results provided by the software gave participants a more tangible sense of progress than when dependent on a therapist for feedback.

4.2.6.4 Preferred model of therapy delivery

People varied in terms of their ideal model of therapy delivery. Five expressed a clear preference for computer-based therapy over face-to-face therapy, on the assumption that it was nonetheless monitored remotely as it had been to date by a speech and language therapist (P1, P2, P3, P4, P6). Another identified the ideal as being a weekly face-to-face session with a therapist, supplemented by independent computer practice (P5). All partners except one, believed that remote based therapy was the preferred option. The one exception, P5's partner, welcomed a short break from remotely monitored therapy because of the demands it had made on his time, but still expressed the desire to continue in future.

The participant who valued face-to-face therapy equally with remote based therapy was the one who had adopted the approach of awaiting updates rather than requesting them. It may be that people taking a more active role in therapy will prefer this mode of therapy to face-to-face therapy.

4.2.7 Summary of qualitative findings

Before presenting the findings of the quantitative evaluation, this section briefly summarises findings of the qualitative evaluation with reference to the questions posed in this study. Further consideration of these questions will be given once quantitative data has been presented in sections 4.3 and 4.4 below.

In what ways may people with aphasia benefit from using computers to target word-finding skills delivered remotely?

Primary effects

All perceived an improvement in ability to name pictures (to be confirmed by quantitative data, section 4.3.2 below) and produce words in conversation (not confirmed by quantitative data, section 4.3.2 below), although evidence given by some to support the latter claim was clearer than for others. Participants varied in the extent to which they perceived an improvement to computing skills and phone use and whether they perceived computer therapy as occupational. For those perceiving improvement and occupational value, this increased confidence generally.

Secondary effects

All reported improved confidence and self-esteem as a result of therapy. It was not possible to separate out to what extent this was the result of improvements to language impairment specifically and to what extent it was the result of more general therapy effects such as improved confidence as a result of learning new skills in computing or experiencing improvements in therapy tasks (Figure 4.1). All reported increased activity and participation (Table 4.3). Again it was not

possible to separate what gains resulted from improvements to word finding and what were the result of increased confidence. Improvements in activity and participation in turn had a positive impact on confidence thus continuing the positive cycle of perceived gain and increased confidence. Any perceived benefit was highly valued no matter how small it might appear.

Negative effects

All negative effects related to the time spent in therapy practice and the negative impact this had on time for other things or physical effects of sitting too long.

Who may benefit from computer therapy to target word-finding skills delivered remotely?

All six participants in this study reported benefits to all levels of communication and confidence or self-esteem and mood. Participants did not need to have previous computing experience nor be confident in their ability to use a computer in therapy at the outset to benefit. Remote based therapy was likely to be appropriate from approximately six months post onset onwards, although individual contextual factors impacting on time available for practice needed to be taken into account.

What were the key components contributing to a positive outcome?

Those aspects of the therapy process that were perceived as key in contributing to a positive outcome included the nature of the software and the learning environment it provided. The ability to record and self-monitor their own attempts at naming, limitless opportunities for repetition of a target item and unconstrained access to practice enabled an intensity of practice previously not experienced with face-to-face therapy. The graphic feedback of progress made on exercises was also valued.

An increase in confidence associated with learning new skills on the computer contributed to the perceived increase in communication activity and participation as much as the perceived improvement in word finding ability. The acquisition of these computing skills appeared to be a key component in contributing to the degree of benefit perceived from therapy. A positive cycle of increased communication activity and increased confidence was created that appeared self-perpetuating irrespective of language gains made. There was evidence that some participants believed that practice with the computer would need to continue in order to maintain improvements and this may have reflected the importance of maintaining levels of confidence. Others believed that improvements to language skills had resulted in improved communication activity and social participation and that this would ensure ongoing stimulation and benefit to language skills.

The speech and language therapist's role was seen as crucial in providing motivation to practice and responding to requests to adjust difficulty of tasks. For those with little computer experience partner support may have been critical at the outset. Active involvement to influence the rate at which new exercises were assigned may result in a more positive outcome than a more passive approach.

4.3 Evaluation of outcome II

Quantitative evaluation of language skills

4.3.1 Purpose

This evaluation set out to determine whether there was quantitative evidence of change in participants' ability to find words following therapy. The data from the

quantitative evaluation could then be compared to the findings of the in-depth interviews, in particular the finding that all participants perceived an improvement in performance in both picture naming tasks and in conversation (section 4.2.3.1 above).

The quantitative evaluation comprised evaluation of word finding skills in picture naming and evaluation of word finding in connected speech. A test of sentence comprehension provided a control task. The findings of each will be reported in turn.

4.3.2 Word finding in picture naming

This evaluation provided a quantitative evaluation of improvements in picture naming to compare with qualitative findings. All participants had reported a perceived improvement on therapy tasks or assessments (section 4.2.3.1 above). Results of assessment of object naming and action naming as measured by the Object and Action Naming Battery (Druks and Masterson 2000) are shown in Tables 4.4–4.6. Table 4.4 shows the baseline naming scores from A₁ and A₂. A test of difference between two proportions (two-tailed) showed that there was no significant difference between these two measures ($p > 0.01$), indicating that baseline performance was stable. For P2 the increase in score between A₁ and A₂ for object naming came very close to significance ($p \leq 0.01$). For this participant three consecutive baseline measures were therefore compared for Set B items (A₁, A₂ and A₃). Comparison of A₁ and A₂, A₂ and A₃ and A₁ and A₃ showed that change did not reach significance in any of these comparisons ($p = 0.02$, $p = 0.34$ and $p = 0.19$ respectively). From this it was assumed that baseline measures were essentially stable. A mean score was calculated for baseline assessments and this was used for comparison with post therapy measures.

Table 4.4 Baseline naming scores for object & action naming

	P1		P2		P3		P4		P5		P6	
Object												
N=162	<i>N</i>	%										
A ₁	42	26	58	36	84	52	72	44	64	40	51	31
A ₂	49	30	78	48	89	55	72	44	66	41	60	37
z score A ₁ -A ₂	0.87		2.27		0.56		0.00		0.23		1.06	
p-value	0.39		0.02		0.58		1.00		0.82		0.29	
Action												
N=100	<i>N</i>	%										
A ₁	22	22	17	17	20	20	30	30	33	33	25	25
A ₂	21	21	26	26	18	18	33	33	33	33	29	29
z score A ₁ -A ₂	0.17		1.56		0.36		0.46		0.00		0.64	
p-value	0.86		0.12		0.72		0.65		1.00		0.52	

Pre and post therapy results for naming are shown in Table 4.5. A test of difference between two proportions demonstrated a highly significant improvement in ability to retrieve object names for each of the six participants, ($p \leq 0.01$ in each case for both post therapy assessments). A highly significant improvement in ability to retrieve action names for four of the five participants was noted ($p \leq 0.01$ in each case).

In the case of P4, improvements only reached significance ($p \leq 0.01$) at the time of the second, maintenance assessment. For other participants, re-administration of the naming assessments six weeks following completion of therapy revealed that progress maintained to show a significant improvement over baseline scores for all six participants on both objects and actions ($p \leq 0.01$).

Table 4.5 Comparison of mean baseline scores for naming with post therapy assessment (A₄ and A₅).

Object	P1		P2		P3		P4		P5		P6	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
N=162												
Baseline	46	28	68	42	87	53	72	44	65	40	56	34
A ₄	119	73	117	72	132	81	106	65	111	69	83	51
Z Base-A ₄		9.17		5.78		5.65		3.88		5.35		3.13
p-value		0.00		0.00		0.00		0.00		0.00		0.00
A ₅	131	81	125	77	133	82	107	66	99	61	100	62
Z Base-A ₅		11.25		6.91		5.81		4.01		3.86		5.15
p-value		0.00		0.00		0.00		0.00		0.00		0.00
Action	P1		P2		P3		P4		P5		P6	
N=100	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Baseline	22	22	22	22	19	19	32	32	33	33	27	27
A ₄	61	61	50	50	67	67	43	43	54	54	46	46
Z Base-A ₄		6.09		4.40		7.84		1.69		3.06		2.85
p-value		0.00		0.00		0.00		0.09		0.00		0.00
A ₅	73	73	53	53	65	65	56	56	55	55	49	49
Z Base-A ₅		8.40		4.87		7.45		3.60		3.21		3.29
p-value		0.00		0.00		0.00		0.00		0.00		0.00

Results of the interim object naming and action naming assessments A₃ for the untreated set B are shown in Table 4.6. Although there were improvements over the mean baseline scores in object naming of untreated items this did not reach significance ($p \leq 0.01$) for any participant. Results of the interim assessment for action naming showed that no significant changes over mean baseline scores were found for any of the untreated items and gains were much smaller.

Table 4.6 Comparison of baseline and interim scores for object and action names of non-treatment items (Set B)

Object	P1		P2		P3		P4		P5		P6	
	<i>N</i>	%										
Baseline	22.5	28	31.5	39	44	54	32	40	29	36	23.5	29
A ₃	34	42	45	56	55	68	41	51	36	44	31	38
Z Base-A ₃		1.89		2.20		1.78		1.41		1.04		1.22
<i>p</i> -value		0.06		0.03		0.07		0.16		0.30		0.22
Action	P1		P2		P3		P4		P5		P6	
	<i>N</i>	%										
Baseline	10.5	13	10.5	13	9.5	11.5	16	19.5	16.5	29	17.5	29
A ₃	13	16	14	17	13	16	16	20	N/A	N/A	15	15
Z Base-A ₃		0.43		0.56		0.65		0.06		N/A		1.71
<i>p</i> -value		0.67		0.57		0.51		0.95		N/A		0.09

From this it was concluded that treatment effects were item specific. No interim assessment of action naming was carried out for P5 as verb therapy was introduced for her after the interim assessment.

4.3.3 Word finding in connected speech

This data provided a quantitative evaluation of improvements in word finding in connected speech. All participants had reported perceiving an improvement to word finding in conversation (section 4.2.3.1 above).

Missing data for one participant

One tape, the post therapy recording for P3 was lost in storage prior to transcription. For this participant, interview data speech samples were substituted for video descriptions to determine any changes between pre and post therapy spontaneous speech. This substitution of interview data resulted in a number of methodological challenges; pre and post interviews had been carried out by two different interviewers (pre and post interview samples for P3

were carried out by the lead researcher/JW respectively) and the differing interview styles were likely to result in very differing speech samples being obtained in the interview. It was possible that the contributions made by the interlocutor might influence the number of nouns and verbs produced in each interview. The procedure for counting nouns and verbs was modified accordingly. The total number of nouns and verbs from the second ten minutes of each interview (allowing for conversation to become established), one pre and one post, was counted. From this, any nouns or verbs that had been introduced by the interviewer into the conversation first were deducted. The remaining count gave an indication of the number of nouns and verbs introduced independently by P3.

Noun and verb count

The results of analyses of the connected speech samples are shown in Tables 4.7 – 4.9. Table 4.7 shows the results of the analysis of number of nouns and verbs in the pre and post therapy samples.

Table 4.7 Noun and verb count for pre and post speech samples.

	P1		P2		P3		P4		P5		P6	
	<i>Pre</i>	<i>Post</i>										
N	23	29	22	16	44	39	36	29	34	29	18	17
Range N	14	18	13	14	26	19	21	19	15	15	10	10
V	41	43	13	15	65	107	21	9	26	24	36	40
Range V	19	18	7	7	2	3	11	7	9	10	6	21
Time min	7.82	10.28	6.13	5.18	10.00	10.00	5.55	5.27	5.32	3.93	1.43	1.53
N/min	2.94	2.82	3.59	3.09	4.40	3.90	6.49	5.51	6.39	7.37	12.56	11.09
RN/min	1.79	1.75	2.12	2.70	2.60	1.90	3.78	3.61	2.82	3.81	6.98	6.52
V/min	5.25	4.18	2.12	2.89	6.50	10.70	3.78	1.71	4.89	6.10	25.12	26.09
RV/min	2.43	1.75	1.14	1.35	0.20	0.30	1.98	1.33	1.69	2.54	4.19	13.70

The first and third rows in the table compare the number of nouns and verbs produced in pre and post samples. The second and fourth rows show how many different nouns were produced once all repeat productions of one noun or verb were removed. The following five rows show the time taken to produce the sample in minutes and the rate of nouns or verbs produced per minute. There was evidence that the range of nouns increased slightly for P1 and the range of verbs increased for P6. For the remainder the number and rate of nouns produced fell or remained stable.

CIU analysis

The results of the CIU analysis (Correct Information Unit Analysis, Nicholas and Brookshire 1993) are shown in Table 4.8. Previous research (Nicholas & Brookshire 1993) suggests that the calculated measures, in particular %CIU's, yield stable baseline measures to enable effects of intervention to be measured pre and post therapy. The calculated measures were therefore taken to be the most likely parameters to reflect change reliably.

Table 4.8 Results of the CIU Analysis (Nicholas & Brookshire 1993)

	P1		P2		P3 ^a	P4		P5		P6	
	<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>		<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>	<i>Pre</i>	<i>Post</i>
N wds	258	340	131	102	-	204	140	209	166	213	202
N CIU's	108	47	40	33	-	86	75	20	23	106	117
Time (s)	469	617	368	311	-	333	316	319	236	86	92
Minutes	7.82	10.28	6.13	5.18	-	5.55	5.27	5.32	3.93	1.43	1.53
% CIU's	41.86	13.82	41.27	32.35	-	42.16	53.57	9.57	13.86	49.77	57.92
WPM	33.01	33.06	21.36	19.68	-	36.76	26.58	39.31	42.20	148.6	131.7
CIU's/m	13.82	4.57	6.52	6.37	-	15.50	14.24	3.76	5.85	73.95	76.30

^a No CIU analysis was carried out for P3 as it was not felt appropriate to transfer an analysis designed for narrative to conversational samples that had been elicited in conversation with two different interlocutors.

Comparison of raw pre and post figures indicated that an increase in %CIU was shown for P4, P5 and P6. For P1 and P2 %CIU was actually lower post therapy, indicating a decrease in the proportion of information conveyed according to this analysis. Of the other calculated measures (WPM and CIU/m) both showed positive change for P5 only. For P1 and P2 and P4 %CIU's and CIU's/min remained constant or decreased post therapy, the latter indicating a decrease in amount and efficiency of information conveyed.

POWERS Analysis

Results of the POWERS analysis are shown in Table 4.9. In interpreting the POWERS data the fact should be born in mind that, in contrast to the CIU analysis, no judgement was made on how appropriately words were used in the context of the video description. All semantic errors were included in the count of content words and nouns as it was felt that a decision as to whether something could be classed as a semantic error or a circumlocution was likely to be highly subjective and therefore difficult to apply with consistency.

Sample lengths used for this analysis varied but were all matched within case. A test of difference between two proportions (two tailed) showed there was no evidence that the number of content words as a proportion of speech units changed significantly ($p < 0.01$) for any participant, although an increase was recorded for P2, P5 and P6. The number of nouns as a proportion of speech units did not increase significantly for any participant although an increase was recorded for P1, P2 and P6. The number of filled pauses as a proportion of speech units did not reduce significantly for any participant although a decrease was recorded for P2 and P5.

Table 4.9 Results of the POWERS Analysis (Herbert et al. in progress)

	P1		P2		P3 ^b		P4		P5		P6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Time min	5m	5m	5m				5m	5m	3m		1m	1m
					-	-	16	16	55		28	28
Sp Unit	183	184	177	135	-	-	196	206	186	199	218	204
Content					-	-						
wd	34	31	32	33			63	59	48	59	66	71
Nouns	12	15	17	20	-	-	31	30	28	31	15	24
Filled					-	-						
pause	28	38	55	37			45	57	29	26	6	13
%CW	18.5	16.8	18.0	24.4	-	-	32.1	28.6	25.8	29.6	30.2	34.8
	8	5	8	4			4	4	1	5	8	0
% N				14.8	-	-	15.8	14.5	15.0	15.5		11.7
	6.56	8.15	9.60	1			2	6	5	8	6.88	6
% FP	15.3	20.6	31.0	27.4	-	-	22.9	27.6	15.5	13.0		
	0	5	7	1			6	7	9	7	2.75	6.37
<i>Comparison Pre-Post CW/SU</i>												
z score		0.43		1.36	-	-		0.76		0.84		0.99
p-value		0.66		0.18	-	-		0.45		0.40		0.32
<i>Comparison Pre-Post N/SU</i>												
z score		0.59		1.38	-	-		0.35		0.14		1.72
p-value		0.56		0.17	-	-		0.73		0.89		0.08
<i>Comparison Pre-Post %FP/SU</i>												
		1.34		0.71	-	-		1.09		0.71		1.78
p-value		0.18		0.48	-	-		0.28		0.48		0.08

^b No POWERS analysis was carried out for P3 as the pre and post sample were elicited in interview with two different interlocutors making comparison of the two inappropriate.

Reliability of language analyses

To determine the reliability levels of the above procedures for language analysis, a proportion of the data was re-analysed and the level of agreement between the original analysis and the repeat analysis was calculated. Reanalysis was conducted blind and carried out at least one month after the original analysis. All pre therapy data was included in the noun and verb reanalysis and the POWERS reanalysis. For the CIU reanalysis a minimum of 100 words were reanalysed from each pre therapy sample, representing at least 50% of each pre therapy sample and in cases where it was small, the entire sample. The level of agreement between the original analysis and the repeat analysis is shown in Appendix 7. This data shows that there was a high correlation, with a small difference in mean value between the two analyses, indicating good reliability with all three procedures.

Summary of analyses of connected speech

In summary, there was no conclusive evidence from any of the above analyses of significant change to the amount of information conveyed, the quality of information conveyed or the efficiency with which information was conveyed in connected speech. This failure to find conclusive quantitative evidence of change contradicts the findings of the qualitative evaluation in which all participants had reported perceiving improvements to word finding in conversation (section 4.2.3.1 above).

4.3.4 Sentence comprehension

Results of the sentence comprehension assessment (control measure) are shown in Table 4.10. This assessment was used as a control assessment as sentence comprehension was not expected to show significant change as a result of therapy specifically targeting people's ability to retrieve names of objects or actions. Comparison between the two baseline measures using a test

Table 4.10 Results of control assessment of sentence comprehension*

RSCT	P1	%	P2	%	P3	%	P4	%	P5	%	P6	%
Pre 1	22	55	16	40	22	55	28	70	19	47.5	17	42.5
Pre 2	24	60	20	50	24	60	32	80	18	45	16	40
Mean Pre	23	57.5	18	45	23	58	30	75	18.5	46.3	17	41.3
<i>Z Pre1&2</i>		0.45		0.90		0.45		1.04		0.22		0.23
<i>p-value</i>		0.65		0.37		0.65		0.30		0.82		0.82
Post	22	55	17	42.5	20	50	33	83	21	52.5	15	37.5
<i>Z Pre- Post</i>		0.23		0.23		0.67		0.82		0.56		0.34
<i>p-value</i>		0.82		0.82		0.50		0.41		0.58		0.73

*Significance is taken at $p \leq 0.01$

of difference between two proportions (two-tailed) showed no significant change between the two baseline measures taken before therapy ($p \leq 0.01$). Mean pre therapy scores were therefore calculated for comparison with post therapy scores. Comparison between the mean pre therapy score and the post therapy score using the same test of difference between two proportions (two-tailed) showed no significant change between the pre and post therapy measures. The stability of measures before and during therapy was taken as evidence to support the case that spontaneous improvement had not been taking place during therapy.

4.3.5 Summary of findings

This evaluation set out to determine whether there was quantitative evidence of change in participant's ability to find words following therapy, as measured in picture naming tasks and in connected speech. Findings showed a highly significant improvement in ability to name object and action pictures after therapy as compared to before therapy for all participants and this improvement was maintained at six weeks post therapy. Although non-treatment items

showed a trend to improved naming this did not reach significance. From this it was concluded that therapy had a highly significant item-specific effect. There was no evidence of significant change on the control assessment of sentence comprehension. These findings confirmed the qualitative findings regarding benefit to picture naming.

There was no evidence from analyses of connected speech of significant change to the amount of information conveyed, the quality of information conveyed or the efficiency with which information was conveyed. These findings contradicted the findings of the qualitative evaluation, which reported improved ability to find words in conversation for all participants (section 4.2.3.1).

4.4 Evaluation of outcome III

Quantitative evaluation of computer usage

4.4.1 Purpose

The purpose of this evaluation was to provide quantitative data on how individuals used the software and how much it was used. The aim was to capture individual variations in the amount of time spent using the software and individual variation in patterns of practice relating to individual exercises. This quantitative data could then be compared to qualitative data regarding patterns of practice (section 4.2.5.1 above) and quantitative data regarding benefit to word finding (section 4.3.2 above).

4.4.2 Findings

The usage data for the six participants is shown in Table 4.11. For each parameter values are presented in rank order for this group with the aim of highlighting differing patterns of practice carried out by each participant.

Included in this data is the percentage gain made by each participant on object naming for comparison with patterns of practice. In examining this data the hypothesised level of impairment underlying the word finding difficulty for each participant should be borne in mind: P1 and P2 were hypothesised to have difficulty with phonological processing. P3 and P5 were hypothesised to have difficulty with both phonology and semantics and P4 and P6 were hypothesised to have difficulty with phonology and subsequent phonological encoding.

This data reveals variation in how individuals used the software and this data will be compared to participant reports from in-depth interviews (section 4.2.5.1 *Patterns of use*) and findings of language assessments (section 4.3 *Quantitative effects on languages skills*). Average session duration ranged from 37 to 52 minutes for five participants with P2 recording a substantially longer average session duration of 1 hour 11 minutes. These values were lower than the estimates of average session length given in the interviews (approximately one hour, section 4.2.5.1). The discrepancy between the two may be explained by the fact that session duration as captured by the software did not include the time taken to start up the computer and access the appropriate exercise, time taken switching between exercises nor time taken to shut down the software or computer. P2 had reported working up to 3 hours on occasions and this is supported by the longer average session duration in his case.

Intensity of practice

Findings from the qualitative investigation indicated that participants believed intensive practice had been crucial in bringing about the gains made. The question therefore arose as to whether there was a correlation between the amount of practice and levels of benefit demonstrated.

Table 4.11 Computer usage data for 6 participants

Rank order	1	2	3	4	5	6
%↑Obj naming	49 P1	32.5 P2	28.5 P3	25 P5	22.5 P6	21.5 P4
Time hrs						
Total	92:43 P5	88:48 P2	88:09 P1	73:38 P6	57:21 P3	46:48 P4
Mean /mnt	15:27 P5	14:48 P2	14:41 P1	12:16 P6	9:30 P3	7:48 P4
Mean/wk	3:26 P5	-	3:17 P2 P6	3:15 P1	2:07 P3	1:43 P4
Sessions						
Mean N week	5.67 P5	5.25 P4	4.33 P1	3.66 P6	3.33 P3	3.00 P2
Mean length (hrs)	1:11 P2	0:52 P1	0:47 P3	0:46 P6	0:38 P4	0:37 P5
Activity						
% wks active Max= 27	93 P5	89 P2		81 P1 P6	-	52 P3 P4
% active days Max = 184	80 P5	55 P1	48 P6	43 P2	38 P4	37 P3
Exercises						
N assigned	70 P1	55 P6	54 P4	53 P2	50 P5	44 P3
Mean attempts	18 P5	13 P2	11 P6	-	9 P1 P3	6 P4
Mean N/ week	34 P5	27 P2	26 P1	22 P6	21 P4	20 P3
MeanN/ session	9 P2	-	-	-	6 P1 P3 P5 P6	4 P4
N updates			6 P1 P2 P6	5 P5		4 P3 P4

There was considerable variation in the group in terms of amount of use. P3 and P4 fall at the bottom end of the range on many of the parameters reflecting usage (total cumulative time using the software, mean time per month and per week, number of active weeks and number of active days, mean number of attempts per exercise, mean number of exercises per week and mean number of exercises per session). Only on the parameters of mean duration of session (P3) and total number of exercises assigned (P4) do either of these participants rank more highly within this group. As might be anticipated with relatively less

usage, P4 ranked sixth in the group in terms of percentage gains demonstrated on picture naming tasks. However, P3 ranked third in the group in terms of percentage gains, despite less intensive use.

By contrast, P5 ranked at the top end of the range for computer usage in terms of total hours spent, mean time per week and per month, total number of active days and weeks, mean number of attempts per exercise and mean number of exercises per week yet ranked only fourth in the group in terms of percentage gains made. She was at the lower end of the group range in terms of total number of exercises assigned and average session duration (37 minutes). The latter figure was a substantially shorter period than her estimate of 1 hour 30 minutes per session as expressed in the post therapy interview. It was not clear whether this discrepancy reflected a genuine perception of much longer practice sessions or whether she was influenced by other factors (for example knowing the interviewer was a speech and language therapist) to claim longer practice time than she actually carried out. The longer session duration she reported may have included playing computer games in addition to carrying out exercises, as she reported an increase in the time spent on computer games as a result of therapy. As P5 was assigned fewer exercises in total compared with the group median (50 compared with 53.5) she clearly engaged in more intensive practice on each exercise (mean number of attempts per exercise=18). She also had fewer breaks in terms of days or weeks without practice (N of active weeks = 25 over a period of 27 possible active weeks, N of active days = 147 over a period of 184 possible active days). This contrasted with others who took between five and 13 weeks off during the therapy period (P1, P3, P4, P6) or used it less than half the number of days it was available (P2, P3, P4, P6). Her partner had reported deterioration in performance after a certain time spent on an exercise. It may be that there is an optimum period of practice beyond which gain is minimal and boredom can be counterproductive. The importance of

taking regular breaks (in terms of days or weeks off) were reported by P2 (Section 4.2.5.1 *Patterns of use*).

Given the polarisation in usage patterns between P3 and P4 at one end of the scale and P5 at the other, the question arises of whether evidence of benefits showed any correspondence to intensity of software use. Contrasting with both these extremes, data for P1 indicated that he made most gains and was assigned considerably more exercises than anyone else in the group but attempted each on average fewer times than some others. The variation in gains made relative to time in practice suggests more rapid learning by some participants than others. These issues will be taken up further in the discussion (section 7.3.4.2).

4.5 Summary of findings of study one

This section will draw together the qualitative and the quantitative evaluations and relate findings as a whole to the study objectives. Further discussion of these issues with reference to the literature is reserved for Chapter Seven.

This study investigated the outcomes and process of computer therapy, which targeted word-finding skills (impairment) for people with aphasia, taking as its primary focus the perspective of people with aphasia. Specifically the study investigated in what ways people may benefit from such therapy; developed hypotheses as to who may benefit from therapy for word retrieval, which is delivered and monitored remotely; and developed hypotheses as to the key components bringing about a positive outcome in the intervention. The hypothesis was that computer therapy targeting the impairment of word finding in this way would bring benefits beyond benefits to word finding alone.

4.5.1 Benefits of therapy

A very broad range of perceived benefits were reported not only to impairment but also to communication activity, social participation, confidence and self-esteem. This was in the context of therapy targeting impairment alone. Table 4.12 summarises these effects, bringing together findings of both the qualitative and quantitative evaluations.

Primary effects

All participants perceived an improvement in impairment as represented by ability to name pictures targeted in therapy. This was confirmed by quantitative data indicating an item specific treatment effect for word finding therapy with no indication of change to a control measure. Findings regarding word finding in conversation (activity) were less clear. All participants perceived an improvement in ability to produce words in conversation, although evidence given by some to support the latter claim was clearer than for others. However, this was not confirmed by any of the quantitative analyses of connected speech data. Participants varied in the extent to which they perceived additional benefits such as an improvement in their computing skills and phone use and whether they perceived computer therapy as occupational. For those who did perceive an improvement and an occupational value, these factors had increased their confidence generally.

Secondary effects

All participants reported improved confidence and self-esteem generally as a result of therapy. It was not possible to separate out to what extent this was the result of improvements to language impairment specifically and to what extent it was the result of learning new skills in computer use and experiencing improvements on therapy tasks (Figure 4.1). Likewise all reported increased activity and participation (Table 4.3). Again it was not possible to separate out what gains resulted directly from improvements to word finding and what were the result of increased confidence. Improvements in activity and participation in

Table 4.12 Summary of reported and measured therapy effects incorporating qualitative and quantitative data

	Primary							Secondary			Negative	
	WF: Picture naming		WF: Connected speech		Spelling	Comp skills	Phone use	Occup. Act.	Confidence	Sense of self	Activity	
	<i>Quali</i>	<i>Quanti</i>	<i>Quali</i>	<i>Quanti</i>	<i>Quali</i>	<i>Quali</i>	<i>Quali</i>	<i>Quali</i>	<i>Quali</i>	<i>Quali</i>	<i>Quali</i>	
P1	✓	✓	✓ e.g. ^a	✗	✓	✓	✓	✗	✓	✓	✓	✓
P2	✓	✓	✓ e.g.	✗	✗	✓	✓	✓	✓	✓	✓	✓
P3	✓	✓	✓	✗	✗	✓	✗	✓	✓	✓	✓	✗
P4	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✗
P5	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✓
P6	✓	✓	✓ e.g.	✗	✓	✓	✓	✗	✓	✓	✓	✗

^a E.g. denotes able to give specific examples

turn had a positive impact on confidence thus continuing the positive cycle of perceived gain and increased confidence. The strength of emphasis placed by participants on the cyclical nature and complexity of the multi-directional relationships found amongst therapy effects had not been anticipated at the outset, but fitted well with the multi-directional model of the ICF (WHO, 2001) and its recognition of the influence of environmental factors on functioning. Dramatic changes in levels of activity and performance reported neatly illustrated the distinction between capacity and performance, which is highlighted by the ICF model (section 2.4.3) and illustrated how changes in personal context (for example, levels of confidence) could have a dramatic effect on performance.

Negative effects

All negative effects related to the time spent in therapy practice, and the negative impact this had on time for other activities, or the physical effects of sitting too long.

The qualitative data therefore provided very strong evidence that benefits impacted well beyond the level of impairment for all participants. Benefits to impairment were perceived to carry over to impact on levels of activity and participation as well as to confidence and self-esteem, creating a positive cycle and involving a complex cumulative interaction between various therapy effects. Quantitative data indicated a clear therapy effect to benefit impairment but did not confirm whether this benefit carried over to impact on word finding in connected speech.

4.5.2 Who may benefit?

Influence of underlying language impairment

All six participants in this study perceived a benefit at the level of impairment from therapy and all six participants demonstrated an item specific treatment effect in picture naming with no change on a control task. This group included participants who were hypothesised to have impaired semantic and phonological processing (P3 and P5), participants who were hypothesised to

have difficulties accessing the phonological word form (P1 and P2) and participants who were hypothesised to have both difficulty accessing the phonological word form and possible phonological encoding difficulties (P4 and P6) (section 4.1). Examination of percentage gains on word finding in picture naming (Table 4.11) shows that the participants who benefited most at the level of impairment (the target of therapy) were those who were assumed to have impaired access to the phonological word form (P1 and P2). Next in terms of percentage gain were participants demonstrating a mix of semantic and phonological processing difficulties (P3 and P5). The participants who showed the least gains were those who had difficulties with phonological encoding in addition to other difficulties (P4 and P6). These findings will be discussed in relation to the literature on how response to therapy may differ according to the nature of underlying language-processing difficulties in Chapter Seven below.

Time post onset

Participants in this study were all between 1 year 7 months and 11 years post onset of stroke. All demonstrated measurable benefits to impairment and reported broader benefits to confidence and self-esteem, activity and participation irrespective of time post stroke. Participants in this study believed that this form of therapy would be appropriate from six months post stroke.

Other factors

Participants all emphasised the significant demands that therapy practice made on time and that this needed to be taken into account in determining who might benefit. Participants did not need to have had previous computer therapy or previous computer experience to benefit.

All participants in this study were highly motivated and self-selecting in that they had chosen to take part in a research study that offered them the opportunity to try computer therapy. All participants also came from middle to upper social classes. It is not clear therefore what impact these factors may have had on their ability to benefit.

4.5.3 Key components in bringing about benefits

The influence of factors such as the underlying language impairment and time post onset have already been highlighted above. Other factors emerged from the qualitative data that appeared to be key in facilitating the benefits experienced and quantitative data on computer usage provided some confirmation of these findings. The nature of the therapy task, total therapy time, intensity of practice, autonomy in practice, speech and language therapy supervision, partner support and previous computer experience all appeared relevant. The cyclical nature of benefits appeared to impact on the degree and range of benefits reported.

Nature of therapy task

Comments on the nature of the therapy tasks indicated that participants valued being able to make multiple attempts at production and to self-monitor production themselves. They valued the graphic presentation of results on screen, which provided concrete evidence of progress, the large number of exemplars available in each exercise to practice to prevent boredom and the variety in type of therapy task. Computer usage confirmed a broad range of tasks assigned to each participant (from 44 to 70 in total). People with aphasia and their partners regarded the software as easy to use.

Total therapy practice time

Participants believed that the total therapy practice time facilitated by computer therapy carried out at home in this way was considerably greater than could be obtained via conventional therapy and that this had contributed to the degree of benefit experienced. Quantitative data showed that cumulative practice time was considerable (between 42 and 96 hours) and this was achieved with the input of between four and six remote update sessions per participant taking on average two hours each. The ratio of therapist time to practice time varied therefore between 1:10.5 hours and 1:16 hours, representing a relatively efficient means of facilitating increased practice relative to therapist time.

However, variations in cumulative practice time within the group did not correlate with relative progress made. Clearly other factors in addition to cumulative practice time may have influenced relative gains made.

Frequency of practice

Participants also believed that this mode of therapy gave them access to increased frequency of practice and this was confirmed by computer usage data confirming between 3 and 5 sessions per week. This compares very favourably with what is offered in conventional therapy.

Independence and autonomy

Independence and control in carrying out therapy tasks brought various benefits. Firstly, it enabled participants to determine the number of repetitions or attempts at naming before moving onto the next target item. Second, participants were able to determine the timing and duration of therapy practice and therefore practice when feeling most alert. Finally, participants valued the increased independence resulting from being able to practice independently of both the speech and language therapist and the partner.

Speech and language therapist support

Therapist supervision was regarded as critical in providing external motivation to maintain practice and modifying the difficulty of tasks in response to participant progress. Where the monitoring role appeared to work best it enabled a partnership to develop between the participant and the therapist, whereby progress through therapy was jointly planned and negotiated.

Partner support and previous computer experience

Findings also suggested that partner support may be critical for participants who are inexperienced or anxious about their ability to use computers. Although one participant demonstrated that partner support was not required, this participant had considerable pre-stroke computer experience. Even those with previous computing experience reported their partner support had been crucial at the outset.

Cyclical nature of benefits

Finally, the cyclical nature of therapy benefits, whereby participants experienced a general increase in confidence as a result of acquiring computer skills and seeing progress on task appeared to be as significant in bringing benefits to levels of confidence, activity and participation as the measured benefits to impairment.

Chapter Five

Background and Methods: Study Two

An investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid.

This chapter will outline the background, purpose and methods used in study two, an investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid.

Key background issues pertinent to the use of voice recognition software by people with aphasia will be summarised first (5.1). A section outlining study aims, theoretical stance and rationale for methodology (section 5.2) will follow. The next section will describe study methods and design (5.3) and a detailed section will follow, which describes procedures for training in use of voice recognition (5.4). The following three sections will outline the methods used for evaluating outcome. Section 5.5 describes the qualitative evaluation of views of participants on the process and outcome of therapy. Section 5.6 describes a quantitative evaluation of language skills. Section 5.7 describes the quantitative evaluation of computer use. Findings of this study will be presented separately in Chapter Six.

5.1 Background

Written language expression pervades everyday life, not only because it is critical for successful employment, but also because of its role in a myriad of daily activities such as

writing checks, making shopping lists, taking phone messages, writing Christmas cards, postcards, and address-book entries, and more recently, it has become indispensable in the use of computers, the internet and email.'

Rapp and Beeson 2003:531

Thus Rapp and Beeson (2003) summarise the all-pervasive nature of written language communication and go on to describe the crucial role literacy skills can have in realising the economic and personal potential of the individual. Despite this the treatment of written language difficulties is largely neglected in the training of speech and language therapists. The increasing dominance of the Internet and the World Wide Web as a means of communication and commerce has threatened to reinforce the marginalization of people with literacy difficulties (Elman, Parr and Moss 2004, Egan, Worrall and Oxenham 2004, Rapp and Beeson 2003, Elman 2001). VR offers the user with aphasia the prospect of being able to dictate text into the computer thus bypassing the need to spell and the physical need to write or type. It may also offer a route to access email and the Internet for people who may otherwise be excluded.

5.1.1 Theory & practice of writing therapy in aphasia

Parr's investigations of literacy practices in aphasia (1996a, 1996b, 1995) draw attention to the fact that the organisation of pre-morbid literacy practices will be very diverse and will be influenced by social, work and leisure roles. Likewise the adaptation of these roles and, therefore, literacy practices after the onset of aphasia will be equally diverse. On these grounds, Parr champions the role of qualitative methodologies in assessing what pre and post morbid roles and literacy practices are, and the need to establish the attitude of the person with aphasia to their impairment and its treatment. This theoretical perspective provided the framework for this study for investigating what additional factors might influence the successful use of VR by people with aphasia.

5.1.2 Introduction to voice recognition software

In order to understand the potential benefits and challenges of VR to people with aphasia, it is important to understand how VR software has developed.

Early versions of VR software all used 'discrete' speech recognition, that is, dictation had to be 'word...by...word' with a short pause between each word dictated. *DragonDictate*® is a discrete VR software, which was last updated in 1999. In 2002 a decision was made to discontinue its production and as a result it is no longer easily available. Versions of VR software produced since 1997 have used continuous speech recognition, which is able to recognise the continuous speech associated with conventional dictation style. *DragonNaturally Speaking*® is an example of continuous VR, with the most recent version at the time of writing being version 7.

Controversy continues within the literature as to whether discrete or continuous dictation is easier for people with non-standard speech (AbilityNet 2004, CALLCentre 2000, Follansbee 2003) and research on the relative merits of different forms of VR is complicated by the fact that older software packages are rapidly superseded or increasingly restricted in their availability. Discrete VR (for example, *DragonDictate*®) has the advantage of forcing the user to pace their speech, which may aid clarity for some users. Continuous VR requires a normal dictation style (for example, *Dragon Naturally Speaking*®). Newer versions of the continuous recognition software are reportedly increasingly able to transcribe dictated speech, which is not fluent, as is often the case for people with speech and language difficulties (Follansbee 2003).

5.1.3 Using VR software

After installing the software an enrolment procedure is required for anyone wanting to use the system. This involves creating a speech file, which is unique to the user and then training the software to maximize the recognition accuracy of the system. Earlier versions of the continuous VR software required the reading aloud of 20 pages of text into the system in order to train the software. In more recent versions of the software, enrolment can be completed in as little as five minutes as the amount of text that must be read aloud is reduced. Moreover, people who have difficulty reading can be assisted in this process by being provided with a model of the text for repetition whenever reading difficulties arise (Bruce, Edmundson and

Coleman 2003, Donegan 2000). Once software training has been completed, dictation can begin and at this stage the user needs to acquire an understanding of how to navigate the system, control the microphone, dictate in an appropriate style and learn how to recognize and correct recognition errors (AbilityNet 2004, CALLCentre 2000, Donegan 2000). There is also evidence that some users require help in learning to structure the content of their dictation (Bruce et al. 2003, Noyes 2001).

5.1.4 Challenges posed by VR to people with aphasia

The only study published to date evaluating the use of VR software by a person with aphasia is that published by Bruce et al. 2003. A further study by Manasse, Hux and Rankin-Erickson (2000) describes a participant who had dysarthric speech and reading and writing difficulties secondary to a head injury. As such both of these studies will be referred to frequently as providing important background context to study two. However, many of the challenges posed by VR for people with aphasia are similar to those posed to dysarthric speakers and students with learning difficulties and the most important of these will be listed here. Firstly, speech sound production may be affected in aphasia and intelligibility of speech reduced. The recognition accuracy for any user will depend on the creation of a good set of speech files during software training. This in turn depends on the intelligibility of the user's speech. Poor intelligibility in production may reduce recognition accuracy (Thomas-Stonell, Kotler, Leeper and Doyle 1998). Secondly, language-processing impairments in aphasia can result in difficulties with reading aloud and users may need assistance to complete enrolment (section 5.1.3). Thirdly, learning to use the software independently requires the ability to identify errors and learn routines for correcting them, activities that involve adequate reading skills and ability to learn new procedures. Both may be negatively affected in aphasia. Next, the patterns of spoken language impairment associated with aphasia such as syntactic errors, semantic errors and word-finding difficulties will be reproduced in written language produced via dictation and these may negatively affect the quality of writing. Finally, the skill of composing text via dictation is one that needs practice and in some cases structured teaching (Bruce et al. 2003, Noyes 2001).

5.1.5 What makes VR a functionally attractive tool to the user?

Fine (2000) suggests that up to 80% of all users who try VR never get it working properly. This may be for a combination of reasons, for example, disappointment at low levels of accuracy recognition due to unreasonably high expectations or lack of awareness of strategies to overcome initial difficulties. The figures are likely to be considerably higher for people with speech or language difficulties. Debate continues as to what circumstances make VR a functionally attractive tool for the user with special needs. In the past, much attention has been paid to the level of recognition accuracy achieved by users. Reports vary considerably as to the levels of recognition accuracy reported in studies describing people with dysarthria. The only study to describe a user with aphasia reports accuracy levels of 84-92% (Bruce et al. 2003). One of the disadvantages of a high error rate is that a disproportionately high percentage of time is spent correcting errors (Koester 2001). For a user with 95% accuracy this will translate into five errors per 100 words dictated or 125 errors per page of A4 (approximately 2,500 words). This amount of text can be dictated in 25 minutes at a rate of 100 wpm but error correction will take an estimated additional hour (Halverson, Horn, Karat and Karat 1999). Although users with aphasia may not be dictating at this level of accuracy or speed the proportion of time spent on error correction is likely to be similar or possibly greater, particularly so if the user has spelling difficulties. Maximising recognition accuracy will minimise time lost on error correction.

However, tolerance of recognition errors will depend on other factors as well. Recent studies have argued it is not just recognition accuracy, but also the ability to correct errors and to access alternative modes for writing, which will influence a user's perception of the value of VR and hence longer term use (Kotler and Tam 2002, Hawley 2002). Rosen and Yampolsky (2000) argue that a low recognition rate may be tolerated if errors are easily corrected or if VR enables a task to be completed that they would be impossible otherwise. Findings reported by Manasse et al. (2000) showed that the brain injured user in their study expressed a preference for VR, despite text produced using VR

taking longer than that produced by typing, that is, quality was more important to this user than speed of production.

De la Paz (1999) argued that use of VR allows students with learning difficulties to focus on higher-order concerns such as planning and content generation. The mechanics of writing may interfere with such higher order skills. Having to switch attention to mechanical demands may lead the writers to lose the flow of their narrative. Writers may forget their ideas because they cannot write their thoughts fast enough. Similar findings were reported by Bruce et al. 2003 in their single case study of a man with aphasia. Text produced using VR showed an increase in speed, use of more sophisticated vocabulary and use of longer and more complex sentences. In line with De la Paz, Bruce et al. argued these improvements were the result of no longer having to switch attention to spelling, combined with the benefit to memory of seeing text already generated appear on screen.

Bruce and colleagues suggest that for someone to succeed with VR, ideally, they will need residual spelling ability to correct errors, ability to dictate in continuous phrases and to be consistent in production. They will also need training that is individualised to their needs but they need not have had previous computer experience.

5.2 Purpose of the study

5.2.1 Study Aims

This study was an investigation into the process and outcome of computer therapy, which involved training people with aphasia to use voice recognition software as a writing aid. This study differed from study one in that therapy did not target writing impairment. Instead it aimed to facilitate writing activity by using VR as an assistive technology, simply by-passing the language impairment. In common with study one, however, the primary aim of the investigation was to evaluate the outcome of therapy from the perspective of people with aphasia as a means to determine the extent of the impact of

therapy and illuminate the processes by which impact occurred. The key question was whether therapy targeting writing activity was perceived to have had any impact not only on writing activity, but whether impact was broader than this. As in study one the aim was also to determine whether objective measures confirmed or contradicted the perceptions of participants. Perceived and measured benefits found for the two studies could then be compared and contrasted to determine similarities and differences in outcome. Specifically the study:

- Investigated what evidence there was that computer therapy targeting writing activity (use of VR software as a writing aid) had any impact on writing activity and whether there was evidence of impact extending beyond the level of writing activity
- Developed hypotheses about which people with aphasia may benefit from such therapy
- Developed hypotheses as to the key components bringing about a positive outcome in the intervention and the potential barriers to success

The following hypothesis was tested:

- Computer therapy targeting the activity of writing will result in broader benefits than simply to the activity of writing itself

Whereas in study one there was particular interest in whether improvements demonstrated at the level of impairment impacted on levels of communication activity and social participation, for this study there was particular interest in whether improvements demonstrated at the level of activity impacted on levels of impairment and whether the benefits to confidence and self-esteem reported in study one were likewise demonstrated in study two.

5.2.2 Theoretical stance and rationale for methodology

Like study one, study two is situated at Phase 1 or the modelling stage of the Medical Research Council framework for development of Randomised Controlled Trial's for complex interventions to improve health (MRC 2000, section 2.5.3.2). The aim of this stage is to delineate the intervention's components and how they inter-relate and how active components of the intervention may relate to outcomes. Given the exploratory nature of the study, a strong qualitative component was particularly appropriate. This enabled hypotheses to be formed regarding key components in the intervention and potential facilitators and barriers to change identified (Campbell, Fitzpatrick, Haines, Kinmouth, Sandercock, Spiegelhalter and Tyrer 2000).

The aim was to assess the outcome of therapy from the perspective of people with aphasia in a way, which captured all dimensions of communication of relevance to them. Traditional assessment of functional language use (for example, the Functional Communication Profile, Sarno 1969, Communicative Activities of Daily Living, Holland 1980) in aphasia have been criticised for failing to recognise the specific needs of the individual at the centre of assessment (Worrall 2000, Parr and Byng 2000)

'What is important is that an assessment reflects the individual everyday communicative needs of clients'.

Worrall 2000:10.

These approaches to assessment involve rating a performance on parameters generated by others and may fail to take account of issues that are critical to the individual. Flexibility cannot be gained through standard assessments and functional needs must be assessed collaboratively with the client. Parr and Byng (2000) instead suggest the use of in-depth interviews as an appropriate methodology for establishing the client's needs and concerns for therapy and as a means of evaluating outcome.

The study was therefore based around a qualitative investigation of the views of participants on both the processes and outcome of using VR as a writing aid. The aim in applying a qualitative evaluation in this way was to capture the perspective of participants on the intervention rather than superimposing the professional framework of the author (JW) with all the presuppositions this might carry with it. Themes emerging from the qualitative investigation were then analysed using the theoretical framework of the ICF (WHO 2001). This framework was used because it attempts to incorporate the social model perspective and because it also acknowledges the importance of context (environmental and personal) in response to the intervention.

The qualitative investigation was supplemented by quantitative evaluations of data that were either hypothesised at the outset as being significant in intervention or outcome or emerged from qualitative findings as being significant. The aim was to apply a multi-method approach as outlined by Mason (2002) whereby the research question could be approached from a number of angles and a multi faceted exploration would result.

Findings from study one had indicated that the impact of computer therapy targeting impairment was indeed considerably broader than simply benefit to impairment itself. It had also indicated that people with no previous experience of using computers were able to learn to use purposively designed software independently. This study was to use software that was not adapted to people with aphasia so the question arose as to whether people with no previous computer experience would succeed in learning to use the software. Findings from study one had also shown an overwhelmingly positive response to therapy amongst a relatively small group (six participants). The question therefore arose as to whether such effects could be found if recruitment was broadened to include larger numbers and people that it was hypothesised would not succeed with the software.

5.3 Methods

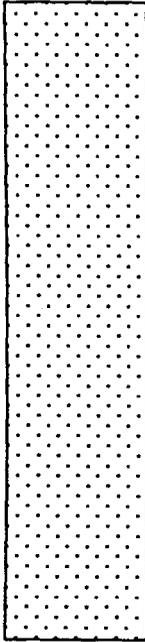
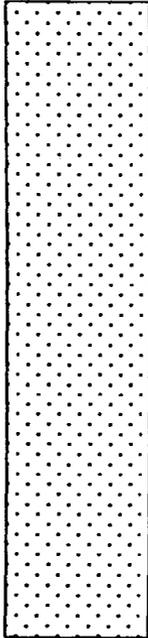
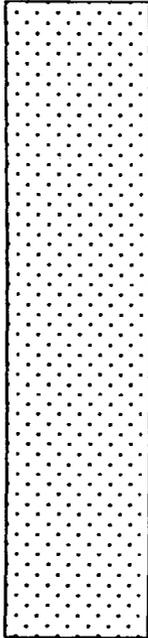
5.3.1 Study Design

The study was a case series study involving a total of 14 people who were recruited iteratively in three separate phases: a pilot study involving two people (participants T1 and T2) was followed by the main study consisting of two consecutive phases each of which involved six people (phase 1 and 2, participants P1-12). The study used an $A_1BA_2CA_3$ design with A_1 representing a period of baseline assessment, B representing training in how to use the computer, A_2 representing re-assessment following completion of training, C representing a period of unsupervised use, and A_3 representing reassessment following the period of unsupervised use. Figure 5.1 illustrates the timing of assessment and intervention.

5.3.2 Aims of pilot study compared to main study

The design of the entire study was iterative, that is, findings from the pilot phase (T1 and T2) fed into the first phase of the main study (P1-5) and findings from this phase led to minor amendments to procedures for the final phase (P6-10). In the context of the relative paucity of published literature on use of VR by people with aphasia (Manasse et al. 2000, Wade, Petheram and Cain 2001) the pilot study was set up to evaluate whether the proposed training procedures were feasible and practical with people with aphasia. In particular it sought to evaluate the training protocol (including which software was used) and the precise nature and timing of outcome measures used, including the content of the proposed in-depth interviews. Findings from the pilot resulted in modification to training procedures and added depth to the fields of inquiry of the in-depth interviews and some adjustment of recruitment criteria and assessments used. In the account of methodology, differences between pilot procedures and main study procedures will be highlighted where necessary. Results for all participants will be presented together, however, where appropriate, differences in procedures will be highlighted in comparing findings.

Figure 5.1 Study two: timing of assessment and intervention

	Assessment _{1 & 2}	B Training	Assessment ₂	C Independent Practice	Assessment ₃
	2 baselines separated by 4 wks	20 sessions		1 month	
In-depth interviews	X				X
WAB (Kertesz 1982)	X				
RSCT (Byng and Black 1999)	X X				X
Spon speech samples	X				
Written samples					
Hand/typing <i>FVT</i>	X X		X		X
<i>Spon Sample</i>	X X		X		X
VR <i>FVT</i>	N/A N/A		X		X
<i>Spon Sample</i>	N/A N/A		X		X

5.3.3 Ethical issues

Ethical approval was granted by North Bristol NHS Trust Ethics Committee in April 2001 and extended to include Royal United Hospital Bath NHS Trust (May 2001) and United Bristol Healthcare NHS Trust (July 2002). All information and consent forms for the study was provided in aphasia friendly format (key word writing supported by pictures) and information was also discussed with participants to clarify any questions. Following completion of the study, study findings were fed back to participants by means of two aphasia-friendly presentations one following phase one and one following phase two. All study participants were invited to attend; three of the 12 did not attend the final presentation. One had moved away from the area. Two others decided that they were not interested in findings and declined an offer by the author to visit them at home to give feedback. The remaining participants valued this presentation as a means of exchanging experiences and tips with others.

5.3.4 Recruitment criteria

5.3.4.1 Influence of study one findings on the recruitment criteria

One of the limiting factors constraining interpretation of findings from study one was the small number of participants (six). Moreover all six participants in study one had proved successful users of the *StepbyStep*® software and the response to therapy from all participants had been overwhelmingly positive. For this study therefore, it was decided to aim to recruit a larger number of participants (14 in total) but to recruit them in successive phases (2-6-6) in order to accommodate the intensity of training proposed (two times a week). Recruitment criteria were deliberately broad so as to enable the recruitment of people who might not succeed, as well as recruiting those who it was assumed had a good chance of success. It was felt that failure to succeed might be as informative in meeting study objectives, particularly in identifying barriers to

success. This issue was discussed openly with all study recruits during the recruitment process. Finally, every attempt was made in recruiting to this study to achieve a wider age-range amongst participants, a broader range of socio-economic backgrounds and to include some with no previous computer experience.

5.3.4.2 Recruitment criteria

Fourteen people with moderate or mild aphasia were recruited via local therapists or voluntary groups and met the following recruitment criteria:

- 6 months post CVA
- 16 years or older
- Premorbid literacy skills
- no severe hearing loss
- no severe visual impairment
- Able to perform at 50% or greater accuracy on a formal test of comprehension (Test for Reception of Grammar Bishop 1983 – pilot phase, Reversible Sentence Comprehension Test Byng & Black, 1999 – main study)
- spoken language equal or superior to written language
- (able to identify specific goals for writing – criterion dropped in phase 2)

A minimum of six months post stroke had been identified as the earliest time that people felt they would benefit from work with a computer in findings from study one. Previous literacy skills were seen as a pre-requisite as this study concerned rehabilitation. Reasonable hearing was required for people to benefit from text to speech feedback. Reasonable vision was required for navigating around the screen. Severe visual loss would necessitate additional screen reader software to enable on screen text to be read aloud. Some degree of hearing loss or impaired vision was however regarded as acceptable as both are relatively common among people with aphasia following stroke.

Reasonable comprehension skills were required to understand the training instructions. It was also assumed that for people to benefit from VR, spoken skills would need to be equal or superior to writing skills, otherwise writing 'with voice' would produce poorer written text than other modes of writing. Finally, it was felt that having a clear necessity or objective for writing was likely to be an important factor in achieving success and this was made a recruitment criterion at the outset. As data from phase 1 of the main study indicated that people might become clearer in their goals as a result of working with the computer and software, this criterion was dropped for phase 2.

Within the parameters imposed by these criteria, participants were recruited purposively to include both those likely to succeed with VR, but also to include some people who it was hypothesised might not succeed. For the pilot, T1 and T2 were recruited because of their motivation to use the software, their previous computing experience and their contrasting likelihood of succeeding with VR. At the time of recruitment to the pilot phase, it was assumed and discussed with T1 that he might not succeed in becoming an independent user of VR, on the basis of his profile of speech and language abilities. He had a significant expressive language difficulty resulting in a pattern of dictation, which reflected the non-fluent character of his speech, with significant difficulties with word retrieval. He also had a significant reading difficulty, which was likely to affect his ability to correct errors on screen. However, outcomes for T1 indicated that there was evidence of benefit to him using VR when measures of his written language, progress in achieving his chosen goals and his views on the process and outcome of training were taken into account. T1 himself perceived this functional benefit with software accuracy levels as low as 60%. This confirmed the hypothesis of Kotler and Tam (2002) and Hux, Rankin-Erickson, Manasse and Lauritzen (2000), who argued that acceptability of accuracy rates is likely to vary with the extent to which the user has access to alternative modes of writing. If no alternatives are available, tolerance of errors is likely to be higher.

Motivation for success using the software provided by T1's strong desire to be able to write and concrete goals for writing appeared to have been a factor in enabling him to meet the challenges posed by his language difficulties and relatively low software recognition accuracy. The hypothesis was generated that other factors such as motivation might in some cases override significant language difficulties and low software accuracy. To test this hypothesis further in the main study, it was decided purposively to sample some people who had significant expressive language impairment and who therefore might be considered unlikely to succeed with VR.

P2 showed greater impairment of spoken than written language as measured on the WAB (Kertesz 1982) but was included, as he was perceived to be particularly motivated to improve writing skills. Following his success with using the software in phase 1, recruitment in phase 2 was widened to include people whose spoken language was more impaired than written.

5.3.5 Hardware and software

Controversy continues within the literature as to whether discrete ('word...by...word' dictation required) or continuous dictation (connected phrase level dictation required, see section 5.1.2) is easier for people with non-standard speech (Follansbee 2003, AbilityNet 2004, CALL Centre 2000). Discrete VR has the advantage of forcing the user to pace their speech, which may aid clarity for some users. However, discrete recognition software is no longer produced and is not easily obtainable, whereas continuous recognition software continues to improve in its recognition accuracy with each version produced.

At the outset of the main study, *Dragon NaturallySpeaking*® version 6 had been released and evidence from experts in the field indicated that recognition accuracy had improved to such an extent as to warrant trial of the software with

people with communication difficulties (CALLCentre 2000, Donegan, personal communication). During the pilot study, T2 had used *VoiceXpress*® but technical difficulties arose with the text to speech facility on the software, which proved a recognised fault with this software. Evidence in the literature indicates that the performance of *Dragon*® software was significantly better and more consistent than *Microsoft Dictation*® or *VoicePad Platinum*® in trials with speech disordered participants (Hux et al. 2000, Donegan 2000). Prior to the main study the protocol was therefore amended to introduce everyone to the most recently published version of *Dragon*® continuous dictation software (*Dragon NaturallySpeaking*® version 6) in the first instance and if no progress was made with this then to trial them with discrete dictation software (*DragonDictate*® *Classic*).

Each person had access at home to a minimum specification Pentium 11/400 MHz processor, with at least 128 MB Ram and 30 MB free hard disc space. All PC's were equipped with appropriate sound cards for use with VR (*Creative Labs SoundBlaster 16*®), speakers and a *Plantronics*® SR1 headset microphone. PC's in the main phase used Windows 98®, Windows 2000® or Millenium®.

Pilot phase

T1 was provided with *DragonDictateClassic*® (discrete voice recognition software) and *Keystone*® (text to speech or screen reader software). The decision for T1 to use discrete speech recognition was made on the basis of his ability to repeat single words relatively accurately as compared to his considerably poorer attempts at phrase level production. It was assumed that he would benefit from using discrete voice recognition given the difficulties, which the continuous recognition software available at the time of the pilot study (*Dragon NaturallySpeaking*® version 4) showed in recognising single word dictation. T1 was also loaned a suitable computer. T2 already had invested in *VoiceXpress*® (a continuous voice recognition software of the same generation

as *Dragon Naturally Speaking*® version 4) and begun to teach himself how to use the system on his own PC. His PC and this software were used in his case, as a switch to different software was likely to confuse.

Main phase

Dragon NaturallySpeaking® Preferred Version 6 (DNSV6, P1-5) or *Dragon Naturally Speaking*® Version 7 (DNSV7, P6-10) was supplied for the main study. P2, 4, 5 and 9 used their own computers. P1, 3, 6, 7, 8 and 10 were loaned computers, either because they had no home computer or because the specification and soundcard on their computer made it unsuitable for VR. *Dragon Dictate*® was also loaded onto the machine for P3 once it became clear she was not making progress with DNSV6. P4 also had access to *Keystone*® text to speech software on her PC.

5.4 Procedures for training use of VR

This section will describe procedures used for training use of VR. The aims of training will be described first (section 5.4.1) followed by a description of the location and timing of training (section 5.4.2). Training for the software to achieve maximum recognition accuracy (software training, section 5.4.3) will be described first. This will be followed by a description of procedures to train participants in the computer skills required to achieve the desired degree of independence in using the software (general computer skills training, 5.4.4). Findings from the pilot phase fed into the development of procedures in the main study and this developmental process will be described in section 5.4.5.

5.4.1 Aims and method of training

Training was carried out with two distinct but complementary aims in mind: first, to train the software to recognize the user's speech with maximum accuracy (section 5.4.3); second, to train people in the computer skills required to achieve the desired degree of independence to be able to use the software

without the author present (section 5.4.4). Not all participants had the help of a supportive partner during the training process so it was assumed that independence was the goal for everyone. However, some participants did have very supportive partners and made use of this support particularly during the learning phase.

The protocol for training incorporated the findings of previous studies on training people with aphasia to use VR (Bruce et al. 2003, Wade et al. 2001) and training people with physical difficulties, developmental dyslexia and/or speech and language difficulties to use VR (Donegan 2000). Recommendations for adaptive training techniques and practical advice on appropriate hardware and software, available on the websites of AbilityNet and CALL Centre (AbilityNet 2004, CALL Centre 2000), also informed procedures.

5.4.2 Location and timing of training

People received up to 20 sessions of individual training in use of VR by the author (JW). The first 10 sessions for T1 took place in the Speech and Language Therapy Research Unit at his request, as he believed this would improve his concentration. Following this, the software was made available to him at home on a PC loaned specifically for the trial and all training sessions continued at home. All training sessions for all other people took place at home, where the software was available on a home PC. Training took place twice a week during home visits with approximately an hour spent training each session and visits lasting up to 1 hour 30 minutes in total. P5 was the exception, having training once a week, at his request, due to other commitments. Participants were encouraged to practice between sessions and taught to save all dictation done without the author present.

5.4.3 Software training

5.4.3.1 Standard enrolment

One of the challenges of using voice recognition software for people with speech and language difficulties is that the standard enrolment procedure may be difficult or indeed impossible for some people to complete. Standard enrolment requires the user to read aloud a prescribed story comprising some 15 paragraphs of text into the software (*Dragon NaturallySpeaking® V7*) or a prescribed list of words and short phrases (*DragonDictate®*). The speech patterns of the user are then stored in the form of speech files, unique to that person. The software uses these speech files to decode all subsequent dictation by that user. Difficulties with repetition or reading can render the task of reading or even repeating these words or phrases impossible to people with aphasia.

5.4.3.2 Training via live dictation

An alternative procedure to standard enrolment was therefore developed based on findings of a previous study (Wade et al. 2001). It involved first having someone of the same sex, age and local accent as the participant carry out the standard enrolment to create a set of speech files ready for dictation. The participant was then introduced to live dictation using these surrogate speech files. Any recognition errors were corrected as they occurred during live dictation. As corrections were made, the author led the participant through a live training process so as to improve recognition of misrecognised words in future. This method had two advantages over standard enrolment training. First it enabled people who had difficulty with repetition and/or reading to dictate spontaneously rather than struggling to reproduce a prescribed text. Second it enabled the user to target personally relevant vocabulary and to train these words specifically. The potential disadvantage of the method was that training the software proceeded word by word only when errors arose and was

therefore likely to take longer than standard enrolment, which used information from the dictation of whole paragraphs of text to create individual speech files.

5.4.4 General computer skills training

Anyone wishing to use VR software independently must have the basic skills to switch on the computer, navigate into, around and out of the software, and print or save any material dictated for subsequent retrieval. These are general computing skills that people with previous computer experience may already have. However, for those new to computing these skills would take time to acquire.

Additional skills, specific to using VR must also be acquired. In using VR, the user has the option to correct recognition errors as they occur and even to train recognition of specific words, which are repeatedly misrecognised (using the same procedures as were used to train the software during live dictation) and by doing so to improve recognition accuracy levels. However, if errors are left uncorrected and speech files are saved as the software is closed, this leads to perpetuation of the uncorrected errors and gradual 'corruption' of the user speech files over time, with a resulting deterioration of recognition accuracy levels. To prevent this occurring, it is possible to configure the software so that speech files are saved manually rather than automatically. Users are then prompted with an option to save as they close the software and can be taught not to save.

This approach to using the software is essential for users who fail to correct the majority of recognition errors as even a small number of uncorrected errors will lead to a gradual deterioration in recognition accuracy over time (Koester 2001). However, it has the disadvantage of preventing any corrections that have been made from improving future recognition accuracy. There is clearly a trade off between maintaining and improving accuracy levels. Only if

recognition accuracy obtained via initial software training is satisfactory to the user's needs, it is possible to use the software in this way. In summary, the minimum required for long-term functional use of VR software is adequate recognition accuracy (for the user) achieved through initial training combined with the ability to maintain this level of recognition accuracy with use, by consistently rejecting the option to save speech files after use. The preferred option, however, whenever the user is able, will be for the user to be able to improve recognition accuracy obtained during enrolment training, by correcting misrecognised words and saving speech files after these corrections are made. The options for training procedures are summarised in Figure 5.2.

Some people were likely to need help in learning to structure dictation (Bruce et al. 2003). Basic writing frames and prompts were provided, to guide people to think about the narrative sequence of events (for example, '*What happened first?*' '*What happened next?*' '*How did it finish?*' '*Who, what, where, when, how, why?*').

5.4.5 Amendments to main study procedures in response to pilot findings

5.4.5.1 Standard enrolment versus live training

Both standard enrolment training and live training were used in parallel in the pilot study with T2, with the aim of providing a comparison between the two methods to determine which resulted in the best recognition accuracy. For each training procedure a separate set of speech files was created and levels of software recognition accuracy obtained were monitored from baseline throughout training. Accuracy levels were taken at the outset then at regular intervals during training to enable the effectiveness of these two training procedures in maximising recognition accuracy to be compared. Comparison of recognition accuracy showed clearly that standard enrolment training

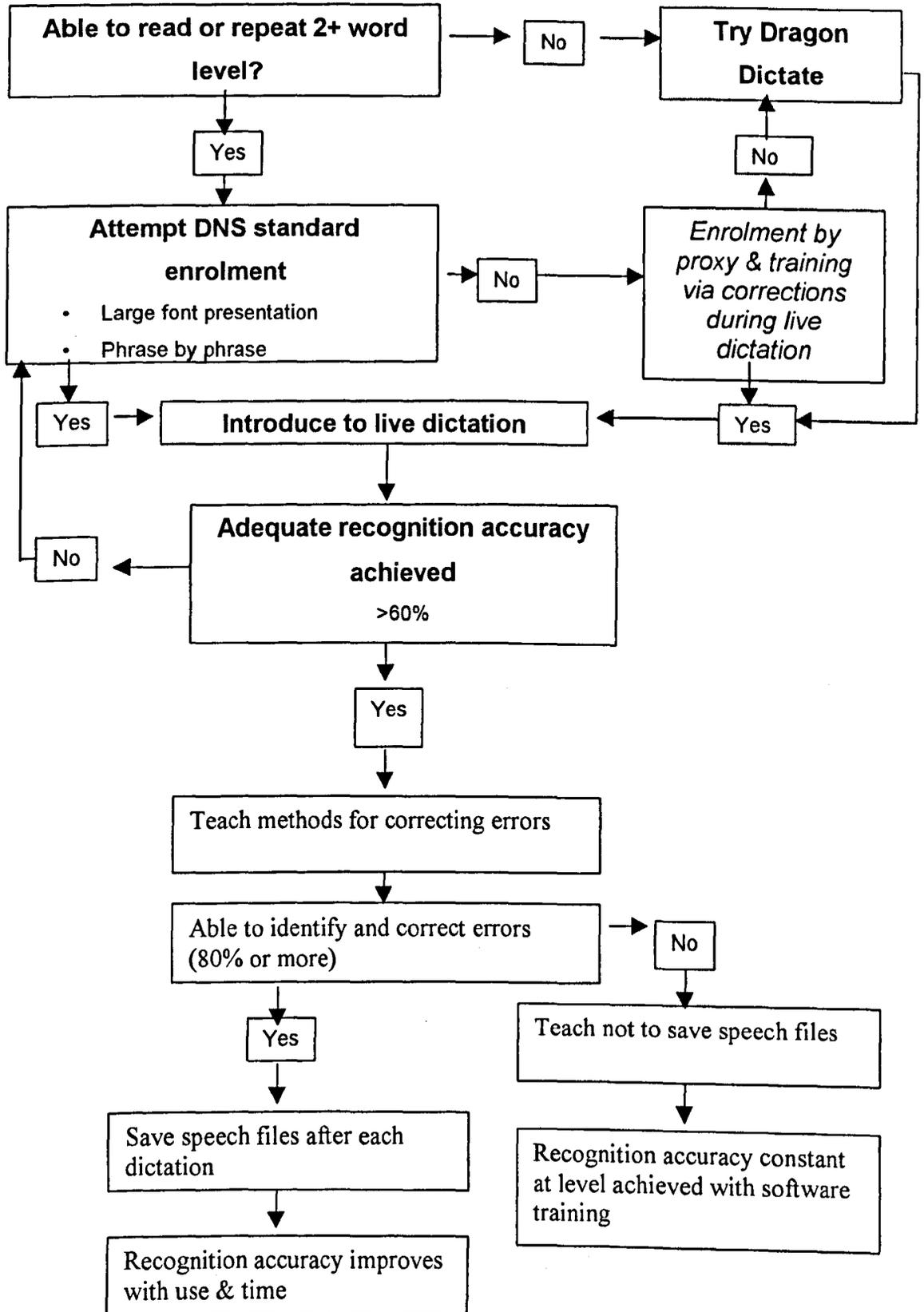
resulted in higher accuracy (see Appendix 8). The use of standard enrolment training wherever possible was therefore established for the protocol of the main study (see Figure 5.2). Only if the standard enrolment process proved impossible was live training of DNS to be considered. People were supported through this process by being provided with an enlarged print version, presented phrase by phrase and/or a spoken model for repetition, phrase by phrase. The author (JW) also controlled the microphone at this stage to enable people to focus exclusively on their speech. One (P3) was unable to complete this process with the above assistance. She was therefore supported through the process of training the software using live dictation.

Difficulties with accurate repetition prevented T1 from completing the standard enrolment training for *DragonDictate*® so the process of live dictation was used in his case. T1 achieved what he perceived to be a functional level of accuracy using the live training. The option of using live training was therefore not ruled out of the protocol for the main study (see Figure 5.2).

5.4.5.2 Division of training time between software training and general training

The pilot study protocol divided software training into two phases (A and B) comprising a maximum of eight and ten sessions respectively, following the protocol proposed by Manasse et al. 2000. Phase A aimed to maximise software recognition accuracy and demonstrate routines for error correction. Phase B aimed to teach software navigation and error correction while maintaining the level of software accuracy achieved in phase A, if not enhancing it further. Observation of T1's progress during the pilot indicated

Figure 5.2 Protocol for training in VR for people with aphasia



that he was motivated and able to start acquiring the necessary software navigation and correction skills during phase A. Acquisition of these skills required repeat practice over a considerable period of time, such that the sooner practice was introduced the better. It was therefore proposed to adopt a much more flexible approach to training in the main study, with skills being acquired and practised in parallel rather than strictly sequentially. A hierarchy of skills was drawn up to include computing skills that those unfamiliar with computing would need to acquire (for example, switching the computer on and shutting down, Windows management, mouse skills, basic keyboard skills).

Computing skills	VR skills
<p><i>Computer</i></p> <ul style="list-style-type: none"> computer on/off software opened/closed <p><i>Keyboard</i></p> <ul style="list-style-type: none"> microphone control key backspace space bar return/enter arrow keys <p><i>Mouse</i></p> <ul style="list-style-type: none"> move cursor select text <p><i>File management</i></p>	<p><i>Dictation skills</i></p> <ul style="list-style-type: none"> audio set up to check mike function microphone control using keyboard rehearse dictation aloud phrase by phrase dictation coordinate mike with dictation <p><i>Error correction</i></p> <ul style="list-style-type: none"> identify 80% +errors delete & repeat dictation use correction box <ul style="list-style-type: none"> select target from choice of 5 <p><i>Maintain software accuracy</i></p> <ul style="list-style-type: none"> initially taught not to save user files

Figure 5.3 Hierarchy of computer skills and specific VR skills required

These were organised to start with the most essential or simplest tasks and move on to the more complex tasks. In this way training became self-paced rather than fixed pace but was still very much organised around learning procedures in a stepwise progression. All these principles for structuring learning have been identified as beneficial to older adults when learning to use computers (Czaja and Lee 2001).

Figure 5.3 illustrates user-training procedures. Each person brought different levels of computer experience and word processing ability to the project. A hierarchy of learning objectives was established, both to ensure users had the

general computing skills required and to train users in specific skills relevant to VR (see Figure 5.3).

Guidelines, designed to be easily followed by someone with aphasia, were developed for the main phase and adapted to the needs of each person, to provide a reference guide for the individual steps needed to carry out various tasks learnt for example, '*Switching the computer on and off*'; '*Opening the software*'; '*Correcting an error*'. These guides were intended as a reminder and reference should the person fail to remember a routine. They were not intended as a self-teaching tool. An example is given in Appendix 9.

5.5 Evaluation of outcome I

Qualitative investigation of participant views

Outcome was evaluated using both qualitative and quantitative methods. The qualitative methodology (in-depth interviews) provided the primary focus of the evaluation in keeping with the objective of investigating outcome from the perspective of study participants. However, it was supplemented by additional quantitative analyses of language skills and computer use, the results of which could be compared and contrasted with qualitative findings. These findings could then be compared and contrasted to the findings of study one in which the focus of therapy had been impairment and the software used specifically designed for people with aphasia.

This section will describe the qualitative evaluation of outcome from the perspective of participants. Sections 5.6 and 5.7 will describe the quantitative evaluation of language skills and computer use respectively.

5.5.1 Purpose of evaluation

The objective of the qualitative evaluation (in-depth interviews) was to investigate the views of participants on receiving training in use of VR software as a writing aid in order to:

- Explore participant views on what ways people with aphasia may benefit from using VR as a writing aid in therapy;
- Explore participant views on which people with aphasia may benefit from using VR as a writing aid;
- Develop hypotheses as to the key components contributing to a positive outcome in this novel mode of therapy delivery;
- Identify barriers to success;
- Identify parameters for supplemental quantitative evaluation of outcome.

The following hypothesis was tested:

- Computer therapy for people with aphasia will bring benefits that impact more broadly than simply on impairment.

Outcome was to be evaluated in its broadest sense, from the perspective of the participants. Findings could then be compared to quantitative data regarding benefit to language impairment and activity (section 5.6) and quantitative data regarding computer use (section 5.6). Data were obtained by carrying out in-depth interview investigations with people participating.

5.5.2 Rationale for methodology: in-depth interviews

The in-depth interview methodology was reapplied in this study for the reasons outlined in section 3.4.2 above; it enabled participants to raise issues of individual relevance to them and likewise enabled the interviewer to adapt the interview to accommodate the individual communication difficulties of each participant. It was appropriate for a study, where the objective was to investigate the impact of computer therapy as perceived by the people receiving therapy and for a study that was highly exploratory, involving the use of a new technology by people with aphasia (Marshall and Rossman 1995). It was felt that this methodology had been highly effective in revealing unexpected insights into how people with aphasia might experience aphasia therapy delivered via computer in study one. Further discussion of how the

previous study influenced the development of procedures in this one is given below (section 5.5.5).

5.5.3 Interview procedures

Pre-training interviews set out to explore views of participants about their communication difficulties in general and writing in particular, previous experience of computer use, current motivation for wanting to use the computer and benefits people were hoping to gain. Post-training interviews set out to investigate experiences of using the computer and voice recognition software, how this differed from expectations, perceived benefits and negative effects of computer/VR use, views on the training process with suggested improvements and views on progress towards goals. Topic guides were used in carrying out the interviews (see Appendix 10 – pilot phases and Appendix 11 – main study).

Interviews lasted between 45 and 90 minutes. All participants were encouraged to end the interview at any time; in the event, two participants requested breaks (T1 and P6) and were then happy to complete the interviews. All interviews were videotaped (or audiotaped if participants preferred), with the written consent of those involved, for subsequent verbatim transcription. Videotape rather than audiotape was used wherever participants consented, so as to capture non-verbal communication. Drawing and writing were used by both interviewer and interviewee whenever helpful. Pre training interviews were carried out in the person's home or at the Speech and Language Therapy Research Unit, according to individual preference. Post training interviews were all carried out in participants' homes in front of the computer with the voice recognition software available on screen for reference. The author (JW) developed the topic guides, conducted interviews and carried out the analysis.

5.5.4 Data analysis

Analysis was conducted using the five stages of 'Framework', (Ritchie, Spencer and O'Connor 2003, Pope, Ziebland and Mays, 2000) as detailed in

section 3.4.4 above. As in the previous study, although the five stages of analysis (familiarisation, identification of a thematic framework, indexing, charting and mapping/interpretation of data) are separated conceptually, in practice analysis was not linear but iterative, involving constant movement between stages of analysis. The final stage of analysis involved reviewing themes and establishing the range of experiences and views amongst the group in order to identify commonalities and contradictions.

5.5.5 Impact of previous study and pilot findings on the qualitative investigation

Procedures were modified both in response to findings of the in-depth interview investigation in study one and in response to findings from the first two pilot interviews in this study. Modifications were made to procedures for data collection and to a lesser extent to data analysis and quality control. These modifications will be described here.

Following study one and the pilot interviews to study two, interview procedures were modified so that all interviews took place in front of the software so that direct references could be made to software and explanations backed by demonstrations. All transcripts were transcribed in full by the author (JW). Although data from transcripts were transferred to charts and these charts were used to identify higher-level themes, the original transcripts were also checked in the process of establishing these higher order themes. This ensured, as far as possible, that the original meaning of the data as interpreted in the context of the interview, was kept in the final interpretation.

The method for controlling quality of analysis was also developed from that used in study one. A speech and language therapy researcher familiar with qualitative research methodology, but unfamiliar with the data read all transcripts for P1-5, and created a thematic framework for the data, then summarised key themes. All of this was done independently of the author (JW). Thematic frameworks and key themes were then compared to check for undue weighting or misinterpretation in analysis.

5.5.6 Exclusion of partner data from study two in-depth interview investigation

In-depth interview data from partners had played a valuable role in study one, adding an extra dimension to the data collected. Partner accounts had provided additional corroborating evidence for benefits claimed (section 4.2.3.2). The level of agreement between participants and their partners regarding the appropriate role for the partner to take in practice (section 4.2.5.2) appeared generally high with only one person failing to confirm that the level of support given was appropriate (P5). Conversely, the failure to acquire partner data for one participant in study one (P4) had resulted in more cautious interpretation of reported benefits. These findings clearly indicated the value of partner data.

The original aim for study two was therefore to include partner data in the investigation and partner views were collected where possible. In practice, however, a partner interview proved possible for only five of the twelve participants. In most cases this was because the participant had no partner. In one case neither the partner nor the participant wanted the partner to be involved. As a result of experience analysing data in study one, where failure to acquire partner data for one participant had necessitated a more cautious interpretation, a decision was made to limit analysis to participant data only in study two, in order to facilitate an even handed analysis of the data and avoid according more status to the views of those for whom corroborating partner data might be available. Further comments on the role of the partner in therapy will be included in the discussion (section 7.5.2.2).

5.6 Evaluation of outcome II

Quantitative evaluation of language skills

5.6.1 Purpose of evaluation

Two quantitative evaluations supplemented the qualitative evaluation, a quantitative evaluation of language skills and a quantitative evaluation of computer use. The quantitative evaluation of language skills is described in this section.

Quantitative evaluation of language skills was carried out with two objectives in mind. The first objective was to investigate using quantitative measures the key effects of the intervention reported by participants (benefit to quality and quantity of writing produced, benefit to writing activity) to establish whether quantitative data confirmed the perception of participants regarding outcomes.

The second objective was to profile the language skills of each participant in order to examine how participants' language skills related to their success using the software and generate hypotheses as to what profile of language skills is likely to facilitate successful use.

5.6.2 Rationale for methodology

With these two objectives in mind, a range of methods was chosen to evaluate language skills. These methods had their roots in a modality approach to classifying language impairment (Western Aphasia Battery, WAB, Kertesz 1982) and linguistic approaches to evaluating language impairment (description of spontaneous speech samples, quantitative evaluation of written language samples). However, in recognition of the fact that such methods have been criticised as 'asocial' (Parr 1996a) and mindful of the need to evaluate activity in a way that was relevant to each individual, an attempt was made to individualise the assessment of writing as an activity. Methods of evaluation will be outlined in turn under the following headings:

- formal assessment of language impairment
- spontaneous speech samples – linguistic analysis and description
- written language samples – linguistic analysis and ranking judgement

5.6.3 Formal assessment of language impairment

The aim of this assessment was to provide a baseline profile of speech and language abilities in order to determine how language abilities corresponded to functional use of the software. The Western Aphasia Battery (WAB) (Kertesz 1982) provided a baseline profile of speech and language abilities across all language modalities (comprehension, speech, repetition, reading and writing). This assessment was introduced following pilot study findings. These indicated that it would be useful to carry out a screening assessment to profile each person's speech and language abilities across all four language modalities (comprehension of speech, speech, reading and writing) if meaningful hypotheses were to be generated regarding what profile of aphasia was indicative of likely success in using VR. The WAB is a valid and reliable assessment tool (Shewan and Kertesz 1984) which provides an indication of the severity of aphasia in the form of an Aphasia Quotient (AQ) calculated from the scores on comprehension and speech. The WAB also assigns people to one of the diagnostic categories identified in the Boston classification of aphasia (Goodglass and Kaplan 1972) outlined in Chapter Two (section 2.3.1).

5.6.4 Linguistic analysis of speech samples

The aim of this evaluation was to provide a detailed linguistic profile of the expressive language abilities of each participant in order that this information could be compared to the degree of success in using VR. The spontaneous speech subtest of the WAB did not give sufficient detail on parameters of speech that were likely to have a considerable impact on ability to train and use VR, in particular intelligibility (section 5.1.4).

A sample of speech was obtained for subsequent linguistic analysis, by asking participants to provide a spoken description of the same video as was used to elicit spontaneous speech samples in the study of word retrieval therapy described in Chapter 3, section 3.5.2.2, the Functional Video Tool (FVT: Mortley 1998). The same process of eliciting the sample was used. Participants were able to familiarise themselves with the content by watching the short video a couple of times. Having watched the video, they were then asked to describe the content from memory and their description was audio taped for subsequent transcription and analysis.

The parameters chosen for linguistic analysis were based on hypotheses regarding what type of linguistic difficulty was likely to prevent participants from training the VR software or being able to dictate using the software. It was hypothesised that word finding difficulties per se would not necessarily prevent dictation, particularly if the predominant error pattern was delay in retrieving or failure to retrieve items or substitution of a semantically related word. In dictation, sentences could be rephrased to accommodate this type of word finding difficulty. However, extensive use of fillers (for example, 'um', 'uh') would necessitate careful microphone control to ensure the microphone was off when such fillers were used. Difficulties with speech sound production or word finding difficulties characterised by speech production errors, were likely to impact on software recognition and might prevent functional use of VR. Patterns of impaired morphology and syntax in spontaneous speech would be reflected in any writing produced via dictation and could impact on how well a message was conveyed. Patterns of word retrieval, speech sound errors, morphology, (grammatical agreement) and sentence structure (syntax) were therefore analysed descriptively for each participant.

5.6.5 Linguistic analysis and ranking judgement of writing samples

The aim of this assessment was to provide a quantitative evaluation of the quantity and quality of writing produced before and after therapy. A range of language samples was elicited (see Figure 5.1) so as to compare the quantity

and quality of written language produced before training (using whatever mode was preferred at that time for example, handwriting or typing) compared to dictation using VR after training. It also allowed comparison of writing produced after training using VR and writing produced after training by hand/typing to investigate generalisation of benefits from using VR to other modes of writing used. It examined aspects of language identified by participants as having benefited from use of VR, namely efficiency of writing (number of words and number of word errors), length of sentence used (mean length of utterance), and complexity of vocabulary used (number of words used greater than seven letters). In addition to these parameters, the grammatical complexity was also investigated by examining use of verb phrases and use of embedded phrases. Grammatical complexity had been identified as a relevant parameter for measuring benefit to language in previous studies (Bruce et al. 2003, Manasse et al. 2000).

Two sets of written language samples were obtained, one where the content was constrained and one where the content was completely unconstrained (see Figure 5.1). For the first set (content constrained) people were asked to provide a written description of the video (FVT: Mortley 1998) described above. A time limit of 10 minutes per sample was imposed. Figure 5.1 illustrates the timing and type of samples taken at baseline (to establish stability) and samples taken after training (to establish maintenance). Following findings of the pilot study, in an attempt to adapt assessments to be more relevant to each individual, a second set of samples (content unconstrained - spontaneous samples) was collected at the same time points as the first. For these, people wrote for 10 minutes on a topic of their choice. These samples were then subjected to two contrasting forms of analysis: a linguistic analysis and a ranking process carried out by independent judges, blind to the mode and timing of each sample produced. Each of these will be described in turn.

5.6.5.1 Linguistic analysis of written language samples

The aim was to provide a simple quantitative analysis of written language data, by counting the number of words, number of word errors, number of

utterances, number of verb phrases and embedded clauses as gross indicators of the quantity, quality and complexity of written language produced. This method was based on the approach to analysing the quality and quantity of text produced using VR applied by Bruce et al. (2003) and was based on linguistic theory. This analysis had the advantage of being applicable across text produced by hand, typing or VR and was feasible given the large amount of data generated by twelve people. The system of rules devised for applying the analysis is given in Appendix 12.

5.6.5.2 Ranking judgement of written language samples

The aim of this analysis was to obtain independent judgements on the quality of written language produced by participants before and after therapy. Three judges, blind to the mode of writing (VR versus hand/typing) and timing of when a written sample had been produced, ranked writing samples from each person for how well each sample communicated its message. The aim in obtaining this judgement was to establish whether judges perceived a qualitative difference between handwritten/typed samples produced before training and samples produced by VR and by hand/typing after training

Three naïve judges, unconnected and unfamiliar with the project, were asked to rank up to 12 written language samples for each of the 12 participants. One judge was a speech and language therapist, one a professional with no experience of speech and language therapy and one the partner of one of the study participants. Judges were directed not to pay too much attention to grammatical correctness but simply 'how well the message was conveyed'. Judges were presented with up to six samples at a time, all from one person with content either constrained (video descriptions) or unconstrained (spontaneous samples) and asked to rank them relative to the others in the sample. Judges were aware which samples described the video and which samples were spontaneous, but all clues as to which were produced by hand, by typing or by voice recognition were removed (all samples were presented as typed text) and judges were blind to the time when samples were produced with order of presentation being randomised. Judges were also aware that people had been given 10 minutes for every sample (samples varied

considerably in length so this was not intuitively obvious). Details of the instructions presented to judges are given in Appendix 13.

No ranking task was carried out for P3 due to her having declined to carry out post training reassessment of written language. For others (T1, T2, P4, P5, P6) some samples were missing, for example, T1 and T2 no spontaneous samples were ranked, some people produced only one pre training handwritten sample (T1, P5) or some produced only one post training sample for either VR or hand writing (T1, T2, P6, P7). For these people four or five samples were available for rank ordering. P4 produced only lists before training in her spontaneous samples whereas after training she produced sentences, both using VR and handwriting. As lists were felt to be qualitatively so different from the paragraphs, judges were asked to rank post-training samples only for her spontaneous samples (VR versus handwriting). Judges were thus required to rank a total of 107 samples presented in bundles of between four and six at a time.

The three judges were asked to make this judgement on two occasions, separated by one week. Intra-rater and inter-rater reliability on the judgement task was calculated using Spearman's rank correlation (r_s). Analysis (again using Spearman's r_s) determined inter-rater reliability for ranking samples produced after intervention compared to samples produced prior to intervention. This was done by first calculating the mean rank position assigned to pre training samples, post training VR samples and post training handwritten/ typed samples for each judge. According to the value of this mean score, a rank position was then assigned from 1-3 for each type of sample (pre, post VR, post hand/type) and a Spearman's rank correlation was calculated as a means of evaluating inter-rater agreement.

5.7 Evaluation of outcome III

Quantitative investigation of computer use

5.7.1 Purpose of evaluation

This evaluation was the second quantitative evaluation to supplement the qualitative evaluation. The aim was to provide quantitative data of participants' use of VR and the computer for comparison with other outcome measures (qualitative investigation into the process and outcome of therapy, section 5.5, and quantitative investigation of language skills, section 5.6). The data collected included measures of software recognition accuracy, a profile of competencies and performance in using VR software and the number of independent dictations completed by participants.

5.7.2 Software accuracy measures

These measures were taken in order to determine the range of recognition accuracy recorded by successful users of VR. The aim was to generate hypotheses regarding what level of software accuracy might be required in order to use the software functionally. Software accuracy measures were taken to determine the level of software accuracy immediately following initial enrolment training and then to monitor software accuracy at regular intervals (that is, maximum 14 days apart) during user training as time constraints allowed. The percentage accuracy of a sample was calculated using the method proposed by Hux et al. (2000), according to the formula:

N of words recognised x 100 = % accuracy.

N of words dictated

Appendix 14 gives details regarding what was counted as a 'word'. Software accuracy levels could then be compared to findings provided by other outcome measures.

5.7.3 Profile of performance using the software

The aim of this evaluation was to create a profile of performance for each participant against the checklist of skills required for using VR developed for the main study. It was predicted that progress towards key learning objectives, in particular ability to identify and correct at least 80% of errors and ability to maintain or preferably enhance recognition accuracy with use, might impact on functional use of the software. It was also noted that although some skills had been taught and reinforced during therapy sessions, participants did not always use all of these during independent dictation. Some of the reasons for the discrepancy between competence and performance were explored during in-depth interviews. A summary of performance for each participant at the time of the final assessment provided the framework for this exploration.

5.7.4 Number of independent dictations

The number of dictations carried out independently by people during the training and re-assessment period was recorded as a gross measure of the amount of independent practice carried out by participants. This was in the absence of any facility within the software to capture time spent using it (as had been possible in study one). This data was collected by participants saving all attempts at dictation or writing on the computer as a new document.

Chapter Six

Study Two: Results

An investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid

This chapter will outline the results of study two, an investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid, the background and methodology of which were described in Chapter Five. The first section will describe study participants (6.1). This will be followed by three sections detailing the results of the study: section 6.2 will present findings of the qualitative evaluation of views of participants on the process and outcome of therapy; section 6.3 presents the findings of the quantitative evaluation of language skills; section 6.4 describes the quantitative evaluation of use of voice recognition software. A final summary will draw qualitative and quantitative findings together (6.5).

6.1 Study participants

Table 6.1 summarises biographical information for the people recruited to the study (T1-T2 from the pilot study and P1-P12 from the main study). T1 and T2 had independently acquired VR software and attempted to teach themselves how to use it prior to the study. T1 had failed to achieve a functional level of accuracy but T2 had already demonstrated some success in using the software independently. No other participants had previous experience of VR. P11 (phase one) and P12 (phase 2) withdrew during assessment, one because he felt unable to complete assessment and the other due to his partner's suddenly deteriorating health. P3 withdrew from training after 10 sessions.

Table 6.1 Background information on study two participants

	Age	Sex	TPO y;m	Living arrangements	Computing experience	Pre stroke computing	SLT in 12 mnths pre study
T1	58	M	14;3	Alone	Yes	Yes	No
T2	41	M	2;0	Alone	Yes	Yes	Yes
P1	82	M	1;4	With partner	Yes	Yes	Yes
P2	62	M	7;6	With partner	Yes	Yes	No
P3	75	F	3;3	Alone	No	No	Yes
P4	44	F	1. 3;2 2. 2;1	With partner	Yes	No	No
P5	61	M	13;10	With partner	Yes	Yes	No
P6*	49	M	2;10	With partner, daughter, son.	Yes	N	Yes
P7	69	M	5;8	With partner	No	No	Yes
P8	78	F	0;7	Alone	Yes	Yes	Yes
P9	57	M	1. 2;6 2. 1;3	With partner	Yes	Yes	Yes
P10	76	M	5;8	With partner	Yes	Yes	Yes
P11	73	M	2;5	With partner	No	No	Yes
P12	79	M	2;2	With partner	No	No	Yes

*All participants had English as their first language except participant 6. His first language was Punjabi and he had moved to the UK at the age of 10 years.

Table 6.2 gives details of aphasia, stroke lesion, associated loss of consciousness (LOC) and associated deficits for the study participants (T1-T2, pilot study and P1-P10, main study).

Table 6.2 Details of aphasia, stroke and associated deficits for study participants

	Aphasia type	Lesion	LOC	Dominant hand use	Visual impairment
T1	Anomia	L MCA embolic	Yes	None	None
T2	Anomia	Not known	Yes	None	None
P1	Conduction	L internal capsule	Yes	Impaired	None
P2	Anomia	L MCA infarct	Yes	None	L peripheral
P3	Anomia	L parietal infarct	Not known	Normal	None
P4	Anomia	1x R CVA 1x L CVA	No	Normal	Peripheral vision L & R
P5	Conduction	L CVA	No	None	N
P6*	Anomia	L frontal lobe embolism	No	Normal	Peripheral vision L& R
P7	Conduction	L embolism	Yes	None	None
P8	Anomia	L embolism	Yes	Impaired	Peripheral vision L & R
P9	Anomia	L parietal embolism	Yes	Normal	None
P10	Anomia	Not available	No	Normal	None

6.2 Evaluation of outcome I

Findings of qualitative investigation of participant views

6.2.1 Purpose of investigation

The objective of the qualitative evaluation was to investigate the views of participants on receiving training in use of VR software as a writing aid in order to:

- Explore participant views on what ways people with aphasia may benefit from using VR as a writing aid in therapy;
- Explore participant views on which people with aphasia may benefit from using VR as a writing aid;
- Develop hypotheses as to the key components contributing to a positive outcome in this novel mode of therapy delivery;
- Identify barriers to success;
- Identify parameters for supplemental quantitative evaluation of outcome.

Data were obtained by carrying out in-depth interview investigations with people participating. Findings could then be compared to quantitative data regarding benefit to language impairment and activity (section 6.3 below) and quantitative data regarding computer use (section 6.4 below).

6.2.2 Impact of pilot findings on qualitative investigation

The pilot in-depth interviews provided invaluable insight into procedures for training and led to amendments to the protocol regarding recruitment (5.3.4), software used (section 5.3.5) and training procedures (section 5.4.5), to procedures for in-depth interviews (section 5.5) and other outcome evaluations (5.6). The interviews also resulted in the identification of a number of potential themes for investigation in the main study, the relevance of which would only be demonstrated by the collection of further data. Issues raised by participants in the trial study included individual preferences regarding the learning environment, reported difficulties with new learning after stroke, the importance of writing in re-constructing a sense of self, the value of letter writing and email in

maintaining social contact and the great value placed on being able to write independently by people who had otherwise been dependent on others to complete writing tasks. As a result of these findings, the original topic guides used for the pilot interviews (Appendix 10) were developed to ensure the themes identified above were adequately explored in the main study (Appendix 11).

6.2.3 Analysis and presentation of data from in-depth interviews

Although the interview process was iterative, with analysis of data obtained from pilot interviews feeding into subsequent interviews, the final thematic analysis incorporated all data. A range of themes is presented therefore which arose from all interviews both pre and post training. The final analysis will draw out the broader themes of particular relevance to the current study. As in the previous study some quantification of data has been presented to accompany qualitative findings. Findings here will be reported thematically. Concession is made to integrating findings with case-by-case reporting of other findings by indicating in brackets participants to which each theme applied.

One of the key aims in the qualitative investigation was to capture people's views on the effects of this intervention on their communication skills for subsequent comparison with quantitative findings. The perceived effects of the intervention will therefore be reported first (6.2.4) and will be followed by sections providing background information on expectations (6.2.5) experiences (6.2.6) and contextual issues (6.2.7) and how these influenced the outcome.

6.2.4 Effects of training

This section will present views of participants on the effects of therapy. To determine the perceived effects of therapy was one of the key objectives of the qualitative investigation and these findings were of central importance in that they enabled comparison to be made with quantitative data regarding measured effects. This theme was therefore introduced via the topic guide.

Benefits will be described under two headings, primary benefits that resulted directly from training in use of VR and secondary benefits that appeared to result

indirectly from some of the primary gains. Primary benefits will be described first (section 6.2.4.1) followed by secondary benefits (section 6.2.4.2). Figure 6.1 represents the relationship between the two.

6.2.4.1 Primary benefits

Progress with VR: 'Early days' T1

Nine of the twelve participants (T1, T2, P1, P2, P4, P5, P6, P7, P9) perceived themselves to be successful users of VR at the time of the post-training interview. The degree of success varied: some (T1, T2, P1, P4, P6 and P7) believed they were still consolidating skills and expected to become more fluent. One noticed considerable improvement during the one-month independent practice post training. P6 left for an extended holiday immediately post training, so did not have the opportunity for a month's independent practice and consolidation prior to the post-training interview, this being held immediately after completion of training.

Two people (P3 and P8) were disappointed with the lack of progress they had made. P3 was unable to explain this lack of progress, other than indicating the software had simply not understood her speech. P8 ascribed the lack of progress to a general loss of confidence associated with the stroke, resulting in her feeling unable to practise alone and as she lived alone she had no-one to support her through practice. It was unclear from interview data whether P10 felt he had been successful or not, although observation of his use of the software showed that he was not using the most basic procedures for dictation, error identification or correction. Failure of these three participants to report successful use of VR was confirmed by quantitative data on computer skills gained (section 6.4.3 below).

Benefits to writing (writing impairment and writing activity)

There was little evidence that participants perceived their actual writing skills (impairment) to have improved as a result of using VR. Instead, the software as a tool improved performance by decreasing demands on the language system, with no change to underlying impairment. Use of VR was perceived to facilitate writing by removing some of the competing demands inherent in writing (section

2.9.3). Participants were able to focus on content rather than spelling. This increased writing efficiency: whole sentences could be dictated then checked for errors rather than deliberating over the spelling of each word (P2, P5). The perceived result was longer sentences, longer text and more sophisticated vocabulary (T2, P2, P4). Using text-to-speech to hear read aloud by the software what was written on screen was perceived to aid composition (P4). Some reported that VR brought the simple benefit of enabling them to write independently whereas this had been totally impossible before (T1, P1, P4, P6, P7):

'Emails and letters finally only me so almost any time not only one or two hours and me and friend but anytime'. T1

One person (P6) reported his handwriting had worsened as a result of use of VR simply due to reduced handwriting practice affecting ability to form letters physically. However, his typing skills had improved with increased familiarity with the keyboard. Two participants, (P9, P10), were unable to describe any way in which writing with VR was superior to typing or handwriting. This was despite P9 reporting the belief that he was a successful user of VR.

Benefits to other language skills (impairment).

Many (T1, P1, P5, P4, P6, P9, P10) believed that the language processes involved in using VR software (the need to speak clearly, the need to read words on screen to make corrections, the facility to hear what was written on screen spoken aloud) had a positive effect on other language skills such as reading comprehension and spoken language comprehension. However, no specific examples were given to demonstrate that these aspects of language processing had in fact improved. These views were based on beliefs about potential favourable effects, which were evident prior to training, rather than concrete evidence to indicate benefit.

'Reading, well it's bound to help isn't it?' P10

'It's helped me a hell of a lot...making me voice work and making me mind work and talking about things' P1

Acquisition of computing skills

Training in use of VR also gave access to basic computer skills (for example skills with the mouse, knowledge of the keyboard, familiarity with screen layout P2, P3, P4, P6, P7) and for one participant this was the most important single benefit in its own right:

'I'm getting more familiar with the computer...that's probably the main gain' P2

Specific skills such as use of email (T1, P2, P4, P6) or access to the Internet (P2) were also valued. Such skills and access were perceived as the norm for the general population and exclusion from them caused frustration (T1, P3, P4, P6, P7). Acquisition of these skills improved confidence and self-esteem:

'You can learn so much from this. And you think, oh my God, the life a lovely life for people that can do all these things now you know'. P3

'I just wanted to know I can do as well as anybody else'. P6

Four participants had considered enrolling for basic computer training offered via adult education (T1, T2, P3, P6). One (P3) rejected this as an option due to fears that trainers would have insufficient understanding of the difficulties associated with aphasia, a fear summed up by another:

'I mean you know what I am, so if you were somebody and only met me once you'd be thinking 'Well what's wrong with him?'
P7

Another (P6) had tried then abandoned a basic computing course, when he found he needed more support than the teacher was able to give him within this group setting.

Access to a meaningful leisure occupation

Several people had stopped work (paid or voluntary) as a result of the stroke (T1, T2, P2, P3, P4, P6, P7, P8, P9). P1 and P10 had already retired and P5 was able to return to work for some time post stroke before retiring. For some whose working life had been disrupted, previous work was closely related to sense of self (T2, P2, P8) and loss of work was associated with a threat to pre morbid identity (T2, P8) and the creation of much free time. Several reported the

challenge of how to fill this time meaningfully (T1, P3, P4, P6, P8, P9) and a sense of feeling 'stuck' or 'stale':

'If you don't have the interest of doing things, you're just like a cabbage or something. You have to do something in order to appreciate life' P6

'Actually sorry but stale' T1

'I sit around and feel fed up with myself, because I don't know where to start or anything. I don't know what's going to happen - why am I here and I'm not doing anything? My life is stuck, well I've told you...I need to do something stronger, better.' P3

Some valued using the computer as occupational activity (T1, P3, P4, P8, P10), that could be carried out independently of help from a partner (P7) and which functioned as a positive distraction, even when success with VR did not result:

'Because it's getting me out of myself and getting me back into the world. It's this inward looking that's the trouble. You know you think you are the worst person in the world, you don't think about anybody else'. P8

Several described the computer as a positive alternative to watching day-time TV (T1, P4, P9). Others (P2, P5) found that life was already very busy and fitting time for practice between sessions was a challenge.

6.2.4.2 Secondary benefits

Benefits to writing activity (activity and participation)

People reported a broad range of new writing activities that were taken up as a result of training in use of VR. Specific activities included corresponding via letter or email to friends, relatives or professionals involved in their care (T1, T2, P2, P4, P6, P7); writing letters to thank friends, relatives or professionals for the help received since the stroke (P4, P6, P7); writing letters of complaint (T2, P4); keeping a daily journal (P6, P7); recording significant life events (T2, P1, P6, P7); creating an account of the experience of their stroke (T2, P4); making contact with others who had had similar experiences (T2, P4). T1 had also been able to write down notes on which to base an advert for a new business he planned to set up.

Physical restrictions on movement for many (T1, T2, P3, P4, P7, P8 and P10) had led to a sense of social as well as physical isolation (P4, P8, P10) and this isolation fuelled the desire to communicate with others via writing, particularly via email (T2, P4 & P8) as a means of social contact:

'I don't speak enough people' P10

Achievements which, outside of the context of living with aphasia might appear modest, were highly valued:

'Well it's changed my life really because before...I couldn't really ...well you saw ...I couldn't with the spelling. And now it's fantastic, I mean it's revolutionised my life really.' T2

'The end of the day, the success I have with the computer is having something in my hands that is already printed...and it's good...in reality of life, it okay it might be a piece of paper, but that piece of paper it gives me the satisfaction... of having something in my hand and saying, this is what I did' P6

'What I can do now is beautiful...I wouldn't have been able to do it at all...I can't write ordinary but I can do it on a computer' P7

Those who failed to acquire basic VR skills (6.2.5.1) were unable to report any new activities relating to writing (P3, P8, P10). Two participants, who were successful in acquiring these skills, were nonetheless unable to identify new writing activities undertaken as a result of training (P5 and P9).

Impact on self-esteem

Many participants reported an increase of self-esteem associated with the training in use of VR. There appeared to be a link between successfully learning new skills (either writing skills or new computer skills) and increased confidence (P2, P3, P6, P7, P8, P10).

'I think it's a matter of proving that I can do it' P2.

Interestingly, those reporting this positive effect included those not perceiving themselves to be successful using VR (P3, P8, P10).

Motivation to learn new skills (for example, computing) or regain old ones (for example, writing) stemmed in part from a desire to regain a sense of the former

'competent' self. Three people reflected explicitly on how the stroke had affected their sense of self. One (T1) reported the stroke had made him 'like a baby again', far less sure of himself and more timid. Another described the experience of no longer having a sense of who he was (T2). Another (P8) reflected how having had the stroke had reduced her confidence by suddenly confronting her with the fact she was unable to do things that had been easy before:

'It's not me, I don't make a mess of things' P8

Use of writing to reconstruct sense of self

Several participants used the writing made possible by use of VR to help re-establish a sense of self. They did so by creating a narrative of events surrounding the stroke and their reaction to it (T2, P6) or by creating a written account of significant life events (P1, P6, P7), which predated the stroke in an attempt to reconnect with pre-stroke identity. Finally, by creating a written daily journal of everyday events, participants recreated a sense of continuity in their lives, continuity that had been disrupted with the onset of language or memory problems that left them unable to recall the names of people or places visited (P4, P6, P7).

'Every day I write things down just for the memory sake and what I'd done yesterday or the day before or the day before or whatever. And in order to keep up my memory'. P6

6.2.4.3 Summary of effects

Figure 6.1 summarises reported therapy effects. Benefits to impairment have not been included as no evidence was provided that they took place. Primary effects not only concerned benefits to writing but also included acquisition of VR and computer skills and access to a meaningful leisure pursuit. Secondary effects included increased writing activity to fulfil a range of functions and increased self-esteem as a result of benefits to writing, increased writing activity and increased computer skills.

6.2.5 Expectations and aspirations for VR and computer training

This topic was introduced via the topic guide to provide a context within which perceived benefits could be interpreted. Responses indicated that people

Figure 6.1 Reported benefits from using VR

<p>Primary benefits</p> <ul style="list-style-type: none">• Acquisition of VR skills• Benefit to writing from using VR<ul style="list-style-type: none">-Improved quality/quantity-Increased autonomy• Acquired computer skills• Access to meaningful leisure pursuit <p>Secondary benefits</p> <ul style="list-style-type: none">• Benefits to writing serving a range of functions<ul style="list-style-type: none">-Social-Leisure-Business-Health related-Memory aid-Reconstruction of identity• Increase in self-esteem as a result of<ul style="list-style-type: none">-Benefits to writing and writing activity-Improved computer skills
--

generally started therapy with rather vague hopes for improvement in communication skills of any kind rather than concrete aspirations for writing.

6.2.5.1 Writing impairment: nature, impact and aspirations

Surprisingly, given that therapy was specifically targeting the activity of writing, only two participants (T2 and P8) identified the loss of writing ability as their sole

concern for communication (reflected in the WAB scores for P8, see Table 6.3 below). Writing difficulties were attributed to physical difficulty writing with the non-dominant hand (T2, P1, P5, P7, P10), spelling difficulties (reported by all), difficulties forming letters (P7, P8) or difficulties reading back what had been written (P4).

Despite writing difficulties being only one of several areas of concern in communication, writing was identified with a broad range of functions and the loss of writing ability curtailed these functions. One (P10) had enjoyed calligraphy as a pre stroke leisure pursuit. Where writing had been an integral part of work practices before the stroke (T2, P2, P5, P7, P8, P9), being a fluent writer was closely associated with pre-stroke identity (T2, P2, P7 and P8):

'Well I was an English teacher at Middleton School and before I was well, very good, but certainly above average. But now I'm just well, I'm not sure really, but I think that I'm below average really.' T2

For some, writing had become *more* important following the stroke. Even where writing was less essential to work pre-stroke, it was regarded as essential for a return to work (T1, T2, P6). It served a therapeutic purpose: writing to improve writing skills or language skills generally (P6, P7, P8). It served a social purpose especially maintaining contact with friends and family via letter or email. It functioned as a potential memory aid (T1, P2, P4, P6, P9) by use of lists, recording important information such as phone messages or appointment dates (T1, P2, P4, P9) or by creating an account of important events (P5, P6).

Where specific aspirations for writing were reported, these followed naturally from the functions for writing identified above. By far the most common objective was to use VR to communicate with friends or family via email or letter or both (T1, T2, P2, P3, P4, P5, P6, P7, P8, P9). For some, email held an almost magical appeal in that it was so quick and could be accompanied by pictures: *'With a touch of the button it'll be there'* P6. Others still valued letter writing:

'Email I think mainly me and anyway, but short hand right, but letters much more not, not close, just much more, just friends'

instead, because even recently and mainly email, but I actually I think both' T1

Other functions included writing a life story (P1), writing accounts of significant life events (P6, P7) including the stroke in particular (T2, P4) and acknowledging in writing support from friends, family or professionals since the stroke (P4, P6, P7). One wanted to write a letter of complaint about health care services received (P4) and one wanted to write down ideas for advertising his business (T1). Finally, one wanted to write fiction (P5). One (P6) was already keeping a daily journal as a memory aid and to practice writing, and wanted to continue this more independently.

6.2.5.2 Reading impairment: nature, impact and aspirations

Reading difficulties were described in terms of difficulties reading function words (P4) or difficulties reading at text level, because it was hard to read and retain information (T1, P2, P3, P4, P5, P6, P7). For many, difficulties with reading had resulted in the loss of a valued leisure pursuit (T1, T2, P3, P4, P7). Only one had started reading for pleasure again (T2). Others had abandoned this pastime completely (P3, P4, P7) or could only partly enjoy it (T1, P6). Memory demands of retaining plot information prevented people from reading novels (P3, P6, P7). One identified reading difficulties as a barrier to returning to work (P6). One (P4) identified reading as the key issue, with writing secondary to reading.

6.2.5.3 Communication impairment: nature, impact and aspirations

There was considerable variation in participants' perception of how communication impairments generally impacted on daily life and in aspirations for how communication abilities might improve. The most common pattern was equal concern about speech, reading and writing (T1, P1, P2, P3, P7, P9, P10). Most identified specific difficulties finding words (T1, T2, P1, P2, P3, P4, P5, P7). Three participants (P5, P7 and P9) identified comprehension difficulties as an issue but only in the context of group conversations.

6.2.5.4 Range of expectations of VR

Expectations of VR ranged from the very specific (*'life story out of it'* P1) to the more general (*'find out more about this puter'* P1) and one person might express this broad range of expectations. Many, including someone with previous

unsuccessful experience of using the software (T1), reported not knowing what to expect from VR and having doubts about their ability to succeed (T1, P1, P2, P3, P4, P6, P7):

'Well I didn't really know what it was going to be, so I just sort of turned up and see what happens' P2

'Well I don't really know, no I don't. I'm sort of stuck. It's completely different to me, and I've no idea how to start, you know...so I just hope it's going to work to something for me' P3

Previous computing experience did not necessarily make expectations more specific. P10, who had some previous computing experience, was very vague in his goals whereas P4, who had almost no previous experience, was relatively specific in hers. After training some (T2, P1, P5) reported their expectations had been unrealistic. All perceived themselves to be successful with the software and all had previous computer experience. Unrealistic expectations included expecting the software to restore their normal speech or help them express their ideas more fluently:

'I thought I could talk in it and it would come out normal. To be quite honest with you, I thought I could get my speak, whereas I got to do it myself, I got to put down as much as I can, I got to get my voice pattern right and then it starts going' P1

'I was more looking for something that would help me express myself, rather than actually write' P5

Unrealistic expectations were reported particularly in the pilot and first phase of the main study (T2, P1, P5) and these findings were fed back into the recruitment process for subsequent recruits (P6-10). VR software was demonstrated live to these people and all were given a chance to try the software themselves in all subsequent recruitment. This may account for a reduction in unrealistic aspirations in the second phase of the main study (P6-10).

6.2.5.5 Aspirations after training

Aspirations for use after training were similar to aspirations pre training in that they ranged from the specific to the general and related to projects involving writing or projects involving computers more generally. The former included writing accounts of significant life episodes (T2, P1, P6, P7), writing letters to

thank people (P4, P6, P7), creative writing (P5), and creating calligraphy scripts using the computer (P10) and using VR to generate further advertising materials about a proposed business (T1). Projects for computing included specific courses to enhance computer skills in web design (T1, T2), learning to use the Internet or email (P1, P7) or simply learning more about what a computer can do (P3, P4, P6, P10). T2 saw the computer as a means to access work:

'Obviously I want to get a job, but I think that my possibilities are not really practical at the moment. But in time it might be possible. So I'm not sure what I want to do as far as courses are concerned really. But I would be interested in doing work with PowerPoint' T2.

Some aspired to voluntary or paid work (T1, T2, P4, P6, P9). They believed they had experiences and skills of use to others, either because of their experience of aphasia or of computing or of the two combined. One felt his skills would be of use to fellow teachers less skilled with computers (T2). Another believed her experience of having had a stroke would be useful experience in voluntary work supporting people who had been through similar experiences (P4). All those aspiring to work were under 60 years. Those with no aspirations to work were over 60.

6.2.5.5 Summary of expectations for VR

Although for most participants writing was just one of several concerns for communication, writing was identified with a broad range of functions (leisure, business, social, work related and therapeutic) and loss of writing had impacted on ability to carry out such functions. For some writing had become more important since the stroke. Impaired reading ability was associated with the loss of a valued leisure pursuit. It was common for people not to know what to expect of the training in using VR and to be unsure as to whether they would succeed. Previous computing experience did not necessarily make expectations more specific nor realistic. Following training people had more concrete goals for writing and for improving computer skills.

6.2.6 Experiences of training in VR

Investigation of participants' experiences of training in use of VR was intended to provide information as to who might benefit from therapy and develop

hypotheses as to the key components by which benefits might occur and the potential barriers to successful use of the software.

6.2.6.1 Frequency and duration of training sessions

Training sessions were held twice weekly with exceptions due to illness, holiday or other commitments (P5 requested once weekly sessions to accommodate other commitments). Two factors influenced participants' perception of how frequently training sessions should be held. First the need to maintain motivation to practice between sessions; second the need to fit training around other commitments.

P5 (once weekly sessions) P4 and P8 believed they would have managed more practice between sessions had sessions been more frequent, as this would have aided motivation, and in turn resulted in more rapid learning. All other participants found two sessions a week just right (T1, T2, P1, P3, P6, P7, P9, P10). For many, sessions needed to be fitted around other commitments (T1, P1, P2, P5, P6, P7, P9) and thus could not be more than twice a week. Twice weekly sessions enabled them to recall what they were doing for practice and motivated them to maintain practice. If problems arose, the wait to sort them was never too long.

'If you didn't come once a week, I'd be thinking 'What have I got to do?' Whereas you used to come twice a week and it was alright. It was helpful to me'. P7

For most session length was about right (up to 1hour 30 minutes total with a maximum of 1 hour spent on computer training and the remainder spent discussing progress). Participants valued having a break mid-session if required (T1 and P6) to aid concentration.

6.2.6.2 Location of training sessions

There were two views on preferred location for training. Most preferred it to take place at home (P1, P2, P3, P5, P6, P7, P8, P9 and P10) for a range of reasons: practical (parking difficulties or time taken for travel in the context of other commitments, P1, P6); physical (discomfort associated with transport elsewhere, P1, P5, P6, P8); negative emotions associated with the hospital setting (P7,

P10); value of having the computer at home for practice between sessions (T1, T2, P1, P3, P5 P6, P7, P10). Two people (T1 and P4) valued training away from home to aid concentration. For T1 training away from home was organised during the first 10 sessions. For P4 this could not be arranged due to travel constraints.

6.2.6.3 Patterns of use of VR: Frequency, duration, timing and methods

People varied in terms of how long they were likely to spend on dictation, from 20-30 minutes minimum (T1, T2, P5) to two hours (T1, T2, P2) or even three hours maximum (P4). One commented specifically that it was not worth trying to use VR if he had less than 30 minutes in which to complete his writing task, because of the time taken to correct errors. Others tended to use the computer for a maximum time (approximately 30 minutes to an hour) then take a break (P1, P6, P7). Some reported using it up to 2-3 times a day (T1, T2, P1), whereas others were more likely to use it once a day, two to three times a week (P2, P3, P6, P7, P9, P10).

Levels of fatigue and ability to concentrate, general motivation and the nature, timing and extent of other commitments influenced patterns of practice. Those who had large amounts of spare time tended to use the computer more than once a day and this use might be at any time during the day (P3, P4, P10). Those who reported having regular commitments tended to practise in a structured way, often at a similar time each day, for example, when their partner was out or when concentration was best (T2, P1, P5, P6). The exceptions to this were T1 and P2, both of whom had many different commitments, but were nonetheless relatively unstructured in the timing of practice. Some people identified mornings as optimum for levels of concentration and practice (P1, P2, P6). Most people reported having learnt to stop and take breaks if dictation was not progressing well (T1, T2, P1, P2, P3, P4, P5, P6, P7):

'If I maybe get up, I get on the computer and it starts breaking down, I'll shut it off, as simple as that'. P1

Printed guidelines for computer use were used as a backup resource for reference only when stuck (made available to P1-10 but not available during pilot phase). No-one followed the guidelines routinely.

6.2.6.4 Role of the speech and language therapist

Participants perceived the author (JW) to have supported learning in a number of ways: providing motivation, keeping participants focussed and facilitating learning via a series of manageable stages that could be adjusted to individual needs. The latter was particularly valued by someone (P6), who had abandoned computer training at a local college, feeling he needed one to one tuition:

'It's having someone coming in, having the relationship between you and me. And helping to focus. And the focus bit is the hardest a person can do. You have to keep on and keep on and keep on. And this is what you are doing to me. You are telling me to do, do this, do that.' P6

'I thought it was a lot of things to do, but you were doing it quietly and so many bits – we were doing it right. Starting at the beginning and gradually working, you know what I mean?' P7

Not all participants experienced the author (JW) as a facilitator. Some found it harder to dictate in her presence, due to anticipation of interruption (P1, P5).

6.2.6.5 Autonomy versus independence

Some people wanted independence in using the software whereas others aimed for autonomy, facilitated by either a partner or friend. The desire to achieve independence was motivated by the fact the person lived alone (T1, T2, P3, P8) or because they felt their partner's assistance was not helpful (P1, P2, P4, P10). Autonomy was favoured if people valued their partner or friend's help. This help might be offering prompts for what to write during dictation or giving assistance if stuck (P6, P7) or editing text that had been produced independently (T1, P5, P9).

'It's better if she's here because – although she don't come in, I can shout out if I go anything wrong' P7

For times when accuracy was particularly important, participants acknowledged that they would always depend on some degree of support in editing (T1, P7). For some who had previously been dependent on friends or relatives, writing independently was the key perceived benefit (see section 6.2.4.2 above T1, P1, P4, P6, P7).

'But she do go and I do keep – so I don't have to be with my Vicky you know, she's gone so and I still do it' P7

6.2.6.7 Summary of experiences of using VR

These experiences were valuable in casting light on the key components in training that might contribute to a positive outcome, and showed how individual preferences might demand a different approach to learning for each one. Two training sessions per week provided the right intensity for training for most participants, although some found it hard to practice between sessions due to difficulties with motivation or lack of time. Participants valued the flexibility of session length to accommodate ability to concentrate. Although most valued receiving training at home, two preferred to travel elsewhere for training. Participants developed patterns of practice according to what other commitments they had and at what time of day they were able to concentrate best. The author (JW) supported learning by keeping the person focussed on task, providing motivation and being flexible in the pace of learning but some found it easier to dictate without her present. Dependent on support available, people might aspire to write independently or with the help of a partner, particularly for editing.

6.2.7 Contextual factors influencing success

One of the objectives for this evaluation was to identify key components of therapy that had contributed to a positive outcome and potential barriers to success. Participants identified a number of contextual factors that influenced outcome. Other influencing factors arose from data analysis. Factors might be environmental or might be linked to personal attitudes or experience. Barriers will be considered first before examining facilitative factors.

6.2.7.1 Personal Barriers to success

Difficulty with learning

The most common reason for failure to acquire skills was difficulty with new learning since the stroke. Difficulties were described in terms of a need to take longer over learning (T1, P2, P9) and, for one participant, constituted the greatest source of frustration during training:

'My head is slow these days' P9

Difficulties with learning were also described in terms of the need for constant repetition (T1, P2, P4, P6) and the need to focus learning on one thing at a time (T1, P4, P7).

'I think over and over and over and over and over and finally sink in basically you know' T1

'I only get with it after a while. That's life, not immediately, then after two or three goes, then I sort of get it suddenly'. P2

Anxiety associated with using computer

This was reported by people with little or no previous computer experience (P4, P7, P8) and for P4 and P7 had largely resolved by the time of the post-training interview.

'Well because you're there and I do things... but if I'm on my own, I might not do them the right way.' P8

'It's a computer, you don't touch it, you don't mess about with it because you don't know' P4

6.2.7.2 External barriers to success

Complexity of procedures

VR software was not designed for people with aphasia and associated deficits. Although all adaptations to increase accessibility within existing software parameters were used, routines could not always be simplified. Some multi-step procedures were experienced as highly complex. One person (P10) summed up his whole experience of the training process generally as simply too complicated: *'It's a job to understand it' P10*. People responded to difficulties in two ways: intensive practice or spontaneous simplification of procedures (for example, in correcting recognition errors).

Procedures for sending email were identified as particularly challenging (T1, P2, P4, P6). Procedures for correcting recognition errors were also difficult to learn (P1, P4, P5, P7, P8, P9, P10, see section 5.4.4). One person (P1) reported failing to understand the purpose behind using the correction dialogue box (namely to improve recognition accuracy). Others chose not to adopt this

procedure for error correction (P1, P2, P5, P7, P9) even where it had been taught. This did not compromise future recognition accuracy provided speech files were not saved. However, this approach to error correction meant that recognition accuracy for these users would not improve over time (quantitative data on these skills is presented in section 6.4.3 below)

Technical difficulties

Frustration at technical difficulties (for example, participants in phase one found the software frequently froze) compounded difficulty mastering procedures:

'When the computer doesn't work. Very frustrating especially when you don't know what to do. You don't know when you can't get out of something and it freeze... freezes quite a lot.' P4

Participants developed coping strategies to counter frustrations, for example, leaving the computer and returning after a break.

6.2.7.3 Facilitating factors

Perception of benefit to writing

Clear perception of benefit to writing by using VR facilitated regular use of the software. Where no clear benefit was perceived, (P2, P5, P9, P10) regular use did not occur, despite good software accuracy levels and competency navigating the software and correcting errors in some cases:

'By the time I'd corrected errors it can take some time. And if you can get two or three mistakes in a short piece of work which it would have been just as easy to type, type it.' P5

'When all said and done I can write pretty good' P2

This contrasted with others who had a clear perception of difference between writing with and without the software:

'I can't write ordinary but I can do it on a computer' P7

This issue is discussed further when presenting quantitative data on benefits to writing in section 6.3.3 below.

Clear goals for writing

Having specific goals to achieve using VR made successful use more likely. A general but vague desire for progress was not enough (P3, P9, P10), nor was

the desire to return to the pre-morbid level of functioning (P8). However, goals were not necessarily clearly identified before training (T1) or the same following training as they had been at the outset (T1, T2, P4, P6, P7). Only one person (P1) had a single, immutable goal, to write his life story.

Specific VR techniques

One participant with previous experience using VR (T2) identified a number of specific techniques for dictation that had helped improve software accuracy rates. These included using a keyboard control key to switch on the microphone and switching off the microphone during pauses in dictation; dividing dictation into short phrases; and the approach of planning and rehearsing dictation aloud before switching on the microphone to dictate each phrase.

P6 reported that he particularly valued the facility in the software for training recognition of specialist vocabulary as this had enabled software recognition of key Punjabi names (for example, family or religious festival names) to be improved. He found the adaptability of the software to his language and cultural needs particularly motivating.

Previous computing experience.

Previous computing experience was seen as an advantage in terms of not needing to learn the layout of the keyboard or screen (P4, P5, P6). Experience also provided valuable insight that it was 'normal' to be able to do something with the computer one moment then suddenly forget a procedure, which had seemed familiar (P2) and reduced anxiety (section 6.2.7.1 above). Some reported this insight after training (P3, P4, P7). However, some participants (P4, P7) were able to acquire all necessary skills from a baseline of no experience within the twenty sessions and were given no extra training time in order to acquire them. Hence inexperience in itself was not necessarily a barrier to success provided learning ability was good and there was time, motivation and support for practice.

Support for practice

Ability to engage in concentrated independent practice appeared to enable people to overcome some of their learning difficulties.

'When you're not there, I'm always on the computer. So I can dictate, do whatever needs to be done. And after a while it becomes natural for me to speak into it' P6

P4 and P7 both had support during independent practice, one from a volunteer and the other from his partner. This initial support may be crucial for some in becoming familiar enough with the technology to feel confident to explore it alone, and following on from this, to engage in sufficient practice to acquire the necessary skills. P8 never overcame her anxiety about using computers alone. She failed to carry out more than two attempts at independent practice and failed to acquire basic skills for independent use (section 6.2.4.1 above and section 6.4.3 below). She attributed this to lack of support during practice. This view is further supported by comments from P6 that previous computer training had not enabled him to make progress, because he needed more individual support.

Desire for progress

Two themes regarding recovery from stroke emerged: acceptance and a desire for a 'return to normal' or more generally for 'progress'. In most accounts, the theme of progress dominated but the theme of acceptance was interspersed within it, particularly for those who had experienced a stroke more recently (P1, P8, P9). P8 alone expressed only a desire to return to normal (seven months post stroke).

'Well, I think, my previous life - I want to be able to get back to it. That's the biggest thing.' P8

For those two or more years post stroke (T1, P2, P6, P7, P10) there was acceptance that return to pre-morbid levels was not possible, juxtaposed with optimism that improvement could and would continue nonetheless (acceptance and progress in tandem).

'I don't think it will ever be the same but it is interesting, each year it is going to get better very slowly' P2

The desire for progress led to certain beliefs and behaviours: people believed it was worth leaving no stone unturned in the process of striving for progress (P6, P7, P9); people believed that any task requiring language processing would have a positive effect on language impairment, however small (T1, P4, P6, P7, P9,

P10); finally any improvements were valued as confirmatory evidence of progress (T1, P6):

'Because also inside brain and even one area now used to be dead, now maybe now almost alive again, because not dead really, but just asleep and I think 20 years ago and even doctors: 'Sorry altogether that area dead altogether'. 'No!' actually, and sooner or later and even stroke and more and more alive and wow.' T1

'I go forward. I know, maybe four weeks go forward, I know that, but time. That's why. It's a lot of work. Maybe, maybe Easter it's not bad. I goes forward now, yeah, it's not bad.' P9

'Well it's something to learn about' P10

For some (P2, P3, P6, P7, P9, P10) the theme of progress reflected a more general philosophical approach to life, which predated the stroke. Life was viewed as a journey towards a series of goals, against which progress could be measured. Participants voiced their frustration at a general feeling of being 'stuck' and feeling thwarted in their desire to experience a sense of progress and purpose:

'Either we go ahead or we die, as simple as that' P2

'You have to learn in order to progress in life.' P6

6.2.7.5 Summary of contextual factors

Various contextual factors were identified as influencing success. Personal barriers included difficulty learning and anxiety associated with computer use. Contextual barriers included the complexity of software procedures and technical difficulties. These were countered by perceptions of benefit to writing, clear goals for writing, specific techniques using VR, previous computing experience, support during practice and a general desire for progress.

6.2.8 Summary of findings of qualitative evaluation

This section briefly summarises findings of the in-depth interviews with reference to study questions. Further consideration of these questions will be given once quantitative data has been presented (section 6.3 and 6.4 below).

How may people with aphasia benefit from using computers to aid writing by use of VR software?

Benefits were reported that had impacted on a broad range of communication skills, both directly and indirectly. Primary benefits included gaining skills in the use of VR software so as to be able to perceive a benefit to writing with the software (in quality, quantity or autonomy). There was no evidence that use of VR had benefited writing impairment, although participants believed that there was potential for benefit at this level. Other primary benefits included the acquisition of basic computer skills and access to a meaningful leisure occupation.

Secondary benefits included being able to engage in a range of new writing activities serving a range of functions that included social, leisure, business, health related, memory and reconstruction of identity. Primary benefits and the increase in writing activity impacted on social participation, self-esteem and a sense of self. Benefits to confidence were reported in the absence of successful use of VR or perceived benefit to writing and were attributed to having gained computer skills generally and/or access to a new leisure occupation. All emphasised that any perceived benefit was highly valued no matter how small it might appear.

Who may benefit from computer therapy to target use of VR software to aid writing?

Nine of the twelve participants identified themselves as successful users of VR a month post completion of training. All but one of these perceived benefits to writing using VR. Of these nine successful users, seven were able to give examples of increased writing activity. Irrespective of success with VR, all participants perceived general benefits including improved computer skills, access to meaningful occupation and increased self-esteem. Participants did not need to have previous computer therapy experience nor be confident in their ability at the outset to benefit. However, where this was the case, participants benefited from help from a friend or relative to help practice between sessions.

One participant attributed her failure to acquire basic skills with VR to the fact she had no-one to support her in practice between sessions. All participants who failed to become successful users had no partner support for practice between sessions.

What were the key components contributing to a positive outcome?

Contextual factors influencing success included personal and environmental factors. Personal barriers to success included difficulties with new learning (reported by all) and anxiety associated with using computers (reported by the less experienced). Environmental barriers included the complexity of software procedures and technical difficulties. Factors that had a facilitative effect were the perception of clear benefits to written language through use of VR, clear goals for writing, specific techniques to maximise recognition accuracy during dictation, previous computing experience and opportunities for practice with support if required. Finally, participants varied in their approach to learning, indicating that flexibility was required regarding the timing and location of training.

What factors were identified for supplemental quantitative evaluation?

These findings highlighted the relevance of VR/computer skills acquisition in successful use of VR and it was decided to incorporate a means of quantifying acquisition of these skills in the quantitative evaluation. Time spent using the software also appeared relevant and an attempt to measure this was also incorporated. Other quantitative evaluations, which were planned at the outset, were confirmed by these findings (for example, reports of improvements to quality and quantity of writing produced using VR).

6.3 Evaluation of outcome III

Findings of quantitative investigation of language skills

6.3.1 Purpose of investigation

Quantitative evaluation of language skills was carried out with two objectives in mind: to profile the language skills of each participant in order to examine how participants' language skills related to their success using the software so as to generate hypotheses as to what profile of language skills was likely to facilitate successful use; to establish whether there was quantitative evidence of change in parameters of language identified from the qualitative investigation as benefiting from use of VR (6.2.4.1).

6.3.2 Profile of language skills

6.3.2.1 Standard assessment

Results of the WAB (Kertesz 1982) are presented in Table 6.3. Rank ordering of participants alongside the raw score for each modality is shown for ease of comparison across the group. No WAB scores were taken during the pilot phase (T1 and T2). It was hypothesised that participants who had the highest scores for spontaneous speech and repetition would achieve the highest software recognition accuracy rates with VR as these modalities were crucial for the processes of dictation and standard software enrolment (section 5.4.3.1). Software accuracy rates achieved might in turn influence successful functional use of the software. Participants with severe writing impairment, however, might be more motivated to succeed with VR than those whose writing was less significantly impaired.

P1-10 all had relatively high-level aphasia with a WAB Aphasia Quotient (AQ) range of 70-97 (>90 for P1, P4, P5 and P8). All were categorised anomic or conduction aphasia representing the highest and second highest ability ranges measured by the WAB. Subsections of the WAB showed a range of strengths and weakness across language modalities. Spontaneous speech measures,

Table 6.3 WAB scores showing Aphasia Quotient, aphasia type and sub scores for spontaneous speech, comprehension, repetition, naming, reading and writing.

Rank order	AQ		Speech		Comp		Rep		Naming		Reading		Writing	
	N=100*		N=20		N=200		N=100		N=100		N= 100		N=100	
1	P5	97	P4	20	P8	199	P2	98	P1	93	P5	100	P2	97
	<i>Anomia</i>		P5						P5					
2	P4	95	-	-	P4	196	P5	96	-	-	P1	96	P5	96
	<i>Anomia</i>				P5 196						P10			
3	P8	94	P1	19	-	-	P8	94	P4	87	-	-	P10	91
	<i>Anomia</i>		P8											
4	P1	91	-	-	P10	193	P4	90	P8	84	P2	91	P4	86
	<i>Anomia</i>						P10				P8			
5	P10	87	P3	17	P1	184	-	-	P6	79	-	-	P9	77
	<i>Anomia</i>		P6						P9					
			P10						P10					
6	P2	82	-	-	P7	176	P1	80	-	-	P3	83	P6	66
	<i>Anomia</i>				P9									
7	P6	79	-	-	-	-	P6	74	-	-	P7	75	P1	48
	<i>Anomia</i>													
8	P3	74	P7	16	P2	175	P7	68	P2	76	P6	71	P3	47
	<i>Conduct</i>													
9	P7	73	P2	15	P3	171	P3	58	P3	55	P9	55	P7	41
	<i>Conduct</i>													
10	P9	70	P9	13	P6	148	P9	52	P7	51	P4	36	P8	25
	<i>Conduct</i>													

*Non-aphasic range =93.8-100

were normal or close to normal for four participants (>18/20, P1, P4, P5 and P8). Repetition skills were highest (>90%) for P2, P4, P5, P8 and P10. Writing skills were poorest for P1, P3, P6, P7 and P8 (<70%). P8 scored relatively highly on all but writing, which was severely impaired (25%) thus appearing to be an ideal candidate for use of VR. P4 had relatively intact language skills in all but reading (36%). The extent to which these findings measures predicted software accuracy rates will be discussed below (section 6.4.2).

6.3.2.2 Spontaneous speech samples

The analysis of spontaneous speech samples provided a descriptive profile of those characteristics of spontaneous speech that were most likely to impact on use of VR. Table 6.4 summarises these characteristics for each participant. A sample of the spontaneous speech of each participant is given in Appendix 15.

It was hypothesised that word finding difficulties per se would not necessarily prevent someone being able to dictate using VR, but that difficulties with speech sound production, were likely to impact on software recognition of a word and if software accuracy levels were too low might prevent functional use of VR. It was also hypothesised that dysfluency (prolonged sounds or repetition of syllables in word production) might impact negatively on software accuracy levels. Patterns of impaired morphology and syntax in spontaneous speech would be reflected in any writing produced via dictation and could impact on adequate communication of the message. Thus patterns of word retrieval, speech sound errors, morphology and sentence structure were summarised for each participant.

People showed a range of word retrieval difficulties. These included extensive use of fillers such as 'um', 'what is it called' (T1, P2, P3 and P4); failure to retrieve the target (T1, P2, P7, P10 and notably more frequently for P3); semantic substitutions (T2, P1, P5, P7, P9). Whole word dysfluencies (T2, P6, P8) and initial sound prolongations (T2, P8) were noted for some participants. Although sound substitution errors were common, only two participants were unable to self-correct these errors (P3, P9 for longer words only). This was revealed during the repetition section of the WAB assessment, but was less clear from the spontaneous speech sample, possibly because P9 was aware of the problem (he informed the author of it during assessment) and may have avoided multi-syllabic words in his spontaneous speech.

Table 6.4 Summary of the characteristics of spontaneous speech

	Word finding	Speech sounds	Morphology	Sentence construction
T1	Uses fillers fails to retrieve target <i>what the word</i>	Few sound substitutions Plants → <i>plaits</i>	Severely restricted omits 3s endings & uses base form of verb	Agrammatic — severely limited sentence & phrase level structure
T2	Semantic substitutions Cat → <i>dog</i>	Few sound substitutions Dysfluency: whole word & initial sounds		
P1	Semantic substitutions Dug → <i>drawed</i>	Speech sound substitutions Door → <i>gore</i> Not all self-corrected		
P2	Uses fillers ++ Fails to retrieve target <i>um, what's it called</i> Most items retrieved	Very few sound substitutions	Omits 3s endings & uses base form of verb	Agrammatic at times but also able to produce full sentence structure reflecting simplification strategy
P3	Uses fillers ++ Fails to retrieve target <i>um, I can't say it'</i> Difficulty retrieving target	Speech sound errors multiple attempts not self corrected: Gardening → <i>guh gardering guarding,</i> <i>no</i>		
P4	Use of fillers but retrieves target			
P5	Semantic substitutions Bag → <i>basket</i> Good retrieval of target	Few speech sound substitutions Knitting → <i>mi knitting</i> All self-corrected		

	Word finding	Speech sounds	Morphology	Sentence construction
P6	Target usually retrieved	Occasional whole word dysfluency <i>'the..the..the...cat'</i> Few sound errors		
P7	Semantic substitutions Cat → dog Lack of specificity and failure to retrieve target <i>'Got a small thing out of the...'</i>	Few sound substitution errors & most self corrected Water → <i>war wuh water</i>		
P8	Frequent dysfluency with prolongation of initial sound or whole word repetition. Always retrieves target	Dysfluent: Initial sound prolongation/repetition & whole word repetition		
P9	Semantic substitutions Plants → seeds Retrieves most targets	Sound substitution errors self corrected, Gloves → <i>glow gloves</i> But difficulty self-correcting longer words.	Omission of e.g. 3s marker	Agrammatic speech & very limited sentence structure
P10	Failure to retrieve target She put the <i>/f/</i> no...	Sound substitutions sometimes able to self correct Cot → <i>cot, no, cot, cat.</i>		Sentence structure within normal limits

Analysis of sentence structure shows that T1, P2 and P9 stood out in the group as using agrammatic sentence structures. In the case of P2, this appeared to be a simplification strategy used sometimes to reduce processing demands as elsewhere in the sample he used a broader range of sentence structures. For T1 and P9 the use of agrammatic sentences appeared to be the result of a significant impairment to sentence processing affecting both spoken and written output. All three omitted morphological markers at times. All others presented as having no major difficulties with sentence processing.

6.3.2.3 Summary of language characteristics and implications for use of VR

Table 6.5 summarizes information from the WAB assessment and spontaneous speech descriptions. On the basis of performance on the WAB, it was predicted that P4, P5 and P8 were the most likely to obtain good recognition accuracy with VR on the basis of their superior score on the Aphasia Quotient (AQ) and on measures of spontaneous speech and repetition. On the basis of impaired writing ability P1, P3, P6, P7 and P8 were likely to feel the greatest motivation to succeed with VR.

Table 6.5 Summary of hypothesised positive indicators for VR

WAB	Hypothesised most likely to succeed +VR	Spontaneous speech	Hypothesised high recognition accuracy
AQ	P1 P4 P5 P8	No/few speech sound errors and no dysfluency	T1 P2 P4 P5 P7
Spontaneous speech	P1 P4 P5 P8		
Repetition	P2 P4 P5 P8 P10		
Writing poor	P1 P3 P6 P7 P8		

It was hypothesised that those with few or no speech sound errors or dysfluency would achieve the highest recognition accuracy and thus be more likely to succeed. Finally, although sentence structure impairments would lead to difficulty producing sentence level text via dictation, this would not necessarily preclude the ability to communicate information meaningfully and was therefore not seen as a potential barrier to success.

6.3.3 Findings of written language sample analyses

6.3.3.1 Linguistic analysis

The linguistic analysis of writing samples was carried out to determine if there was evidence of change to written language skills as a result of training in the use of VR. Baseline measurement of writing using the preferred or available mode pre training was taken. This could then be compared to writing with VR post training but also to the pre training mode of writing after training. This enabled any improvement in writing aided by dictation compared to writing pre training to be detected. It also enabled any improvement to writing ability per se to be monitored.

Results of the written language analysis are presented in full in Appendix 16. The parameters for analysis were determined having been identified by participants as having benefited from use of VR namely efficiency of writing (number of words and word errors in sample), length of sentence used (mean length of utterance), and complexity of vocabulary used (number of words used greater than seven letters). In addition to these parameters, the grammatical complexity was also investigated by examining use of verb phrases and use of embedded phrases. Procedures for determining what to include and exclude in the analysis are given in Appendix 12.

Reliability of written language analysis

To determine the reliability levels of the above procedures for language analysis, a proportion of the data was re-analysed and the level of agreement between the original analysis and the repeat analysis was calculated. Reanalysis was conducted blind and carried out at least one month after the original analysis. For the re-

analysis all data for P1, P6 and P10 were reanalysed. The level of agreement between the original analysis and the repeat analysis is found in Appendix 17. These data show that there was high correlation between the two analyses for number of words, number of utterances and number of verb phrases. However, agreement was poor for number of words over 7 letters, number of errors and number of embedded phrases, reflecting some of the difficulties inherent in assigning error counts to such a diverse range of written texts produced by hand, typing and VR and the difficulties with deciphering some of the texts for analysis. As a result of this, only parameters for which high agreement was found have been summarised in Table 6.6 below.

Even on parameters where measures were found to be reliable, considerable within case variation in scores at baseline and at post training re-assessment was found for all participants (see Appendix 16). This rendered inappropriate the calculation of a mean score for either baseline or re-assessment measures. The data from the language analysis therefore comprises a large amount of data not readily reduced or summarised (Appendix 16). An attempt to summarise trends in the data has been made for each of the three parameters for which some degree of reliability in measurement had been demonstrated. Table 6.6 indicates for each parameter whether there was a trend upwards (↑) or downwards (↓) or no change (=). Where there was a trend from a parameter not having been marked to attempts to mark this parameter this is indicated '*Marked*'.

Benefit in using VR

Examination of FVT data in Table 6.6 shows a trend to benefit in using VR for T1, T2, P1, P7 and P8 across at least three of the four parameters. By contrast P2, P4, P5, P6, P9 or P10 show trend to benefit on one or less parameters. Analysis of spontaneous samples shows evidence of benefit to P1, P2, P4, P6, P7 and P8 on at least three of the four parameters. P5, P9 and P10 show evidence of benefit on one or less.

Table 6.6 Summary of direction of trend when comparing baseline writing samples with post training VR samples for FVT and spontaneous samples.

FVT	N words	N utterance	MLU	N Verb Phrase
T1	↑	Marked	Marked	↑
T2	↑	↑	=	↑
P1	↑	↑	↓	↑
P2	↓	↓	↑	↓
P4	↓	↑	↓	↓
P5	↑	=	=	=
P6	=	=	=	=
P7	↑	=	↑	↑
P8	↑	↑	↑	↑
P9	=	↑	=	↑
P10	↓	↓	↓	↓
Spon	N words	N utterance	MLU	N Verb Phrase
T1	-	-	-	-
T2	-	-	-	-
P1	↑	=	↑	↑
P2	↑	↑	↑	↑
P4	↑	Marked	Marked	Marked
P5	↓	=	↓	=
P6	↑	↑	=	↑
P7	↑	=	↑	↑
P8	=	Marked	Marked	Marked
P9	↓	=	=	=
P10	↓	=	↑	=

The strongest case for benefit to writing by using VR can therefore be made for T1, T2, P1, P7 and P8 across the two conditions of video description and spontaneous

sample. The evidence for benefit is weakest for P5, P9 and P10. For the remainder, evidence is more equivocal (P2, P4, P6).

Benefit to writing impairment

Examination of the data comparing baseline writing measures with post training measures (see Appendix 16, comparing baseline handwriting or typing with post training handwriting or typing) showed little evidence of change except on the parameter of number of words produced. This is likely to reflect the fact that participants were simply more willing to attempt the writing task than previously, but that the writing that they produced was in fact no better in quality.

There was therefore little quantitative evidence of benefit to actual writing impairment as a result of training in use of VR and this confirmed the findings of the qualitative evaluation that provided no evidence of specific change to writing impairment (section 6.2.4.1).

6.3.3.2 Ranking judgement

Results of the naïve ranking judgements as to how samples from each person were ranked relative to each other are shown in Appendix 18.

Table I shows the Spearman's r_s scores for intra-rater reliability. Satisfactory intra-rater reliability was judged to be an r_s above 0.7. Judges 1 and 2 achieved test-retest reliability on 75% and judge 3 achieved test-retest reliability on 60% of occasions.

Table II shows the Spearman's r_s scores for inter-rater reliability. Satisfactory inter-rater reliability was judged to be an r_s above 0.7. Inter-rater reliability between J1 and J2, between J2 and J3 and between J3 and J1 all showed agreement on 75% of occasions.

Finally Table III shows the mean aggregated score for all pre training measures, all post training VR samples and all post training handwritten samples and a rank

position assigned as a result of the aggregate score to determine inter rater agreement on the order of rank which results.

Intra-rater agreement was highest for T1, T2, P1, P2, P7 and P8 (>0.7 on at least 5/6 measures or 2/3 for T2). Inter-rater agreement was highest for T1, T2, P1, P4, P7, P8 (>0.7 on 5/6 correlation measures). These data suggest that the differentiation between samples for the process of ranking judgement was clearest for T1, T2, P1, P2, P4, P7 and P8. Data for P5, P6, P9 and P10 were less clearly differentiated and thus resulted in more variation in ranking. There was no clear difference between levels of agreement for video samples as compared to spontaneous samples. From this it was concluded that T1, T2, P1, P2, P4, P7 and P8 produced written samples, which showed clearest evidence of change.

6.3.3.3 Summary of linguistic analyses

Table 6.7 summarises the findings of the analyses of written language samples to determine benefit to writing using VR. This table shows that there was some degree of convergence between the findings of the linguistic analysis and the findings of the ranking judgement.

Table 6.7 Summary of evidence for benefit to writing using VR

Language analysis		Rank judgement		Combined analyses	
<i>Level of evidence</i>		<i>Level of agreement</i>		<i>Level of evidence</i>	
<i>Strong</i>	T1 T2 P1 P7 P8	High	T1 T2 P1 P2 P4 P7 P8	Benefit	T1 T2 P1 P7 P8
<i>Equivocal</i>	P2 P4 P6			<i>Possible benefit</i>	P2 P4 P6
<i>Weak</i>	P5 P9 P10	Low	P5 P6 P9 P10	<i>No Benefit</i>	P5 P9 P10

When these data are combined the evidence for benefit to written language is strongest for T1, T2, P1, P7 and P8. A relatively clear picture of no benefit to written language produced with VR emerges for P5, P9 and P10. Evidence of benefit to P2, P4 and P6 is equivocal.

6.4 Evaluation of outcome III

Findings of quantitative evaluation of computer usage

6.4.1 Purpose of investigation

The aim of this evaluation was to provide quantitative data of participants' use of VR and the computer for comparison with other outcome measures (qualitative investigation into the process and outcome of therapy, section 6.2 and quantitative investigation of language skills, section 6.3). The data collected included measures of software recognition accuracy, a profile of computer and VR skills before and after training and the number of independent dictations completed by participants.

6.4.2 Software accuracy measures

The results of the software accuracy measures are shown in Figures 6.2, 6.3 and 6.4 below. The percentage accuracy is shown for each person over the period of training as represented by a series of consecutive measures, each measure containing a minimum 75 words.

On the basis of WAB data (section 6.3.2), it was predicted that P4, P5 and P8 were likely to obtain the highest accuracy levels with VR given their superior ability on tests of spontaneous speech and repetition and overall aphasia Aphasia Quotient (AQ). On the basis of descriptive analysis of spontaneous speech (section 6.3.2.2) it was predicted that those with few or no speech sound errors or dysfluency (T1, P2, P4, P5, P7) would achieve the highest recognition accuracy.

Figure 6.2 Software recognition accuracy for T1 & T2

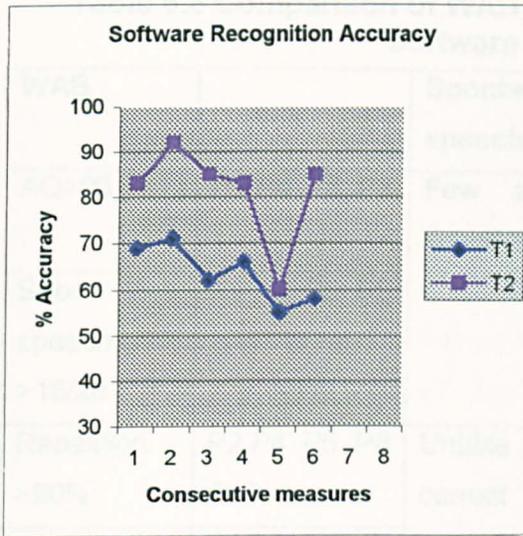


Figure 6.3 Software recognition accuracy for P1-P5

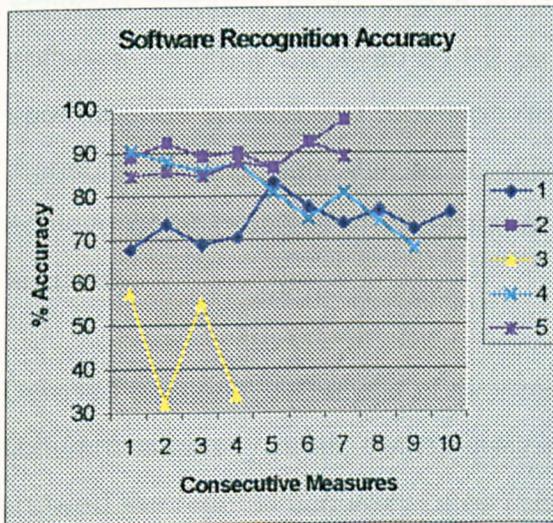


Figure 6.4 Software recognition accuracy for P6-P10

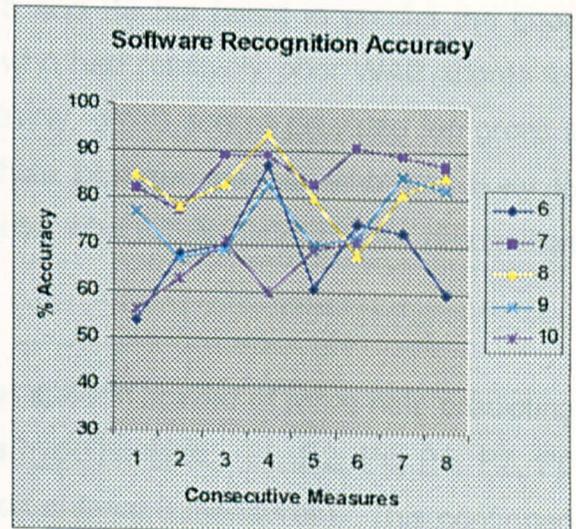


Table 6.8 summarises those participants for whom mean software accuracy rates were greater or less than 80% and compares these findings to the predictions for accuracy rates made from the WAB scores and spontaneous speech samples. Highest accuracy rates were found for T2, P2, P4, P5, P7 and P8. Lower rates were found for T1, P1, P3, P6, P9, P10.

Table 6.8 Comparison of WAB profile, spontaneous speech profile and software accuracy achieved

WAB		Spontaneous speech		Software accuracy	
AQ>90	P1 P4 P5 P8	Few speech sound errors	T1 T2 P2	>80%	T2 P2 P4
Spon speech >18/20	P1 P4 P5 P8		P4 P5 P6 P7 P8		P5 P7 P7 P8
Repetition >90%	P2 P4 P5 P8 P10	Unable to correct speech sound errors	P1 P3 P9 P10	Low<80%	T1 P1 P3 P6 P9 P10
Writing poor<70%	P1 P3 P6 P7 P8				

WAB AQ and WAB scores for spontaneous speech or repetition predicted the good software accuracy levels shown by P4, P5 and P8 but failed to predict the good software accuracy achieved by P2 or P7, who had relatively poor WAB scores for spontaneous speech and repetition respectively. WAB scores provided too gross a measure of language abilities to differentiate between people who are likely to achieve good recognition accuracy and those who will achieve poorer recognition accuracy.

Detailed descriptive analysis of spontaneous speech proved of more help predicting software accuracy rates, but not entirely as hypothesised. T1, P2, P4, P5, P7, P8 showed the highest accuracy rates (>80% on at least 6 measures). This confirmed predictions that those with few or no speech sound errors in production were more likely to achieve good recognition accuracy. Recognition accuracy for the participant who had the greatest difficulty with speech sound production (P3) was particularly poor (<50%). Those who had difficulty self-correcting speech sound errors (P1, P3, P9 and P10) showed lower recognition accuracy. However, the theory that those with dysfluent speech would also show poorer software accuracy

levels was not confirmed. Recognition accuracy for two dysfluent participants (T2, P8) was amongst the highest in the group.

All participants were taught first to rehearse aloud each phrase for dictation, before switching on the microphone and qualitative findings had identified these techniques as helpful in improving recognition accuracy (section 6.2.7.3). Apparently, those that were able to self-monitor and eliminate dysfluencies or speech sound errors before dictating achieved higher software recognition accuracy rates. Interestingly, all three dysfluent participants (T2, P6 and P8) were rarely dysfluent when speaking into the software.

If the presence of uncorrected speech sound errors is taken as a predictor of lower software accuracy levels therefore, the only exceptions to this pattern were T1 and P6, neither of whom showed uncorrected speech sound errors but both of whom had lower software accuracy. Poorer software accuracy levels for T1 (<80%) were explained by the fact he was using *DragonDictate*® software and lower levels of software accuracy are expected with this older version. Software accuracy levels were in the lower range for P6 (<80%) and it was assumed that this was because he was a non-native speaker of English and his pronunciation and prosody may have been sufficiently different to the parameters set for the software to lower software accuracy rates. However, accuracy rates for him were not substantially lower than for others for whom English was their first language.

6.4.3 Profile of computer and voice recognition skills

Qualitative findings indicated that difficulties with learning and the complexity of procedures were potential barriers to success with VR. On the basis of this a profile of each participant's skills before and after training for both general computing and specific VR skills was developed (Table 6.9). This profile allows comparison of baseline skills with skills available at final assessment. It also indicates the number of learning objectives that each participant achieved within the twenty sessions. The total number of new skills obtained post training is totalled at the bottom of each

Table 6.9 Evaluation of progress made to acquire general computer skills and VR skills

Computer skills	T1		T2		P1		P2		P3		P4		P5		P6		P7		P8		P9		P10	
Basic	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P
On/off	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Open/close VR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Keyboard																								
Backspace	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Space bar	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Return key	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Arrow keys	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mouse																								
Click to select	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Click into text	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
File Management																								
Print file	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Save file	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Retrieve file	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Email	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
open/close	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
open mail	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
reply	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Pre/Post	10	14	14	14	8	11	4	14	0	8	4	14	14	14	6	14	0	11	2	6	14	14	4	8
Gain		4		0		3		10		8		10		0		8		11		4		0		4

Table 6.9 continued

VR skills	T1		T2		P1		P2		P3		P4		P5		P6		P7		P8		P9		P10	
Dictation	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P	B	P
Rehearsal	■	■		■		■		■			■		■		■		■			■		■		■
Mike key									■											■				■
Audio set up																								
Mike timing																								
Phrase dictation																					■		■	
Maintains accuracy of speech files																								
Corrects errors	80%			■								■	■											
Delete & repeat		■		■		■		■							■		■					■		■
✓ Saving of SF				■		■		■				■	■		■		■					■		■
Enhances accuracy																								
Repeat enrolment				■								■	■											
✓ Saving of SF				■								■	■											
Use correction box				■								■	■										■	
Correct errors via correction				■								■	■										■	
Personal vocab				■								■	■										■	
Pre/post Gain	0	7	3	13	0	7	0	9	0	1	0	13	5	13	0	7	0	8	0	3	0	10	0	3
Total Gain		11		10		10		19		9		23		8		15		19		7		10		7

table. It was predicted that progress towards key learning objectives, in particular ability to identify and correct at least 80% of errors and ability to maintain or preferably enhance recognition accuracy with use, might impact on functional use of the software.

P3, P8 and P10 failed to acquire either general computing skills or specific VR skills. Although P10 acquired some skills necessary to maintain accuracy levels, the benefit of these gains was negated by failure to achieve more basic skills. These findings directly confirmed the findings of the qualitative investigation in which P3, P8 and P10 did not report successful use of VR (section 6.2.41). All other participants had or successfully acquired general computing skills, although they varied in the extent to which they acquired specific VR skills.

The final level of skills achieved was likely to influence the functional benefit of using VR. It would determine whether software errors were corrected or not and whether accuracy levels were simply maintained or enhanced with use (section 5.4.4). T1, P1, P2, P6, P7 and P9 acquired only basic skills required for maintaining the level of software accuracy achieved during standard enrolment. None were correcting more than 80% of errors so all were taught to delete errors and repeat attempts at dictation but not save speech files on closure, thus maintaining but not improving recognition accuracy over time. For P2 some of the drawbacks of this approach were mitigated by ability to repeat the standard enrolment independently as desired, to increase accuracy. P9 taught himself how to correct errors using the correction dialogue box and preferred this method. However, as he was able to correct less than 80% of errors, these skills were of no benefit to him as he was encouraged not to save any changes to speech files. Only T2, P4 and P5 mastered both the ability to repeat standard enrolment independently and ability to correct 80% or more errors thus enhancing recognition accuracy with time and ensuring gradual improvement of recognition accuracy with each dictation. For P4 this process could only be carried out with help.

When new skills acquired are totalled, P2, P4, P6 and P7 showed the most rapid learning, having started with a relatively low baseline and shown good skills

acquisition. A low number of skills gained indicated either that more skills were in place at the outset (T1, T2, P1, P5 and P9) or that few skills had been gained (P3, P8 and P10). Although qualitative findings had indicated that most participants reported difficulties learning new skills (section 6.2.7.1), these findings indicated that participants varied in the rate at which they acquired skills.

6.4.4 Number of independent dictations

Table 6.10 presents figures on the number of independent dictations carried out by each participant without the author (JW) present during the training period (4 months). In the final column, use at 12 months post completion of training is also shown, as an indication of whether use was sustained^a. The number of independent dictations carried out functioned as a gross measure of the amount of independent practice between sessions carried out by participants. This information is presented alongside a summary of other qualitative and quantitative findings used to evaluate use of VR to allow comparison of data presented thus far.

The amount of independent practice carried out by participants did not correspond to whether participants were successful in acquiring basic skills to use the software nor whether they went on to use the software 12 months later. P10 showed relatively intensive use yet did not acquire basic skills. P4 showed less use but went onto acquire basic skills and was still using the software 12 months later. Clearly factors other than levels of independent practice influenced successful acquisition of skills and continued use. It is only when all the factors influencing use of VR are considered together that the patterns start to emerge from the data.

One participant failed at the first hurdle: P3 failed to achieve more than 50% accuracy rates and chose to stop the training and did not go on to acquire basic VR skills despite showing good computer skills acquisition generally. Difficulties

^a Use at 12 months post completion of training was determined during a group session for all participants at which the findings of the study were fed back to study participants.

with speech sound production prevented her gaining prerequisite accuracy levels and made acquisition of basic VR skills impossible.

One participant failed at the second hurdle (acquisition of basic VR skills, P8). This was despite achieving good recognition accuracy (>80%) and demonstrating evidence of benefit to written language produced using VR. However, she did very little independent dictation, perhaps explaining why basic skills were not acquired. P10 by contrast, engaged in considerable independent dictation, yet also failed to acquire basic VR skills, suggesting slower learning. His difficulties acquiring skills were compounded by relatively low accuracy rates which resulted in no benefits to writing being identified or measured. P9 failed to achieve more than 80% software accuracy but did acquire the basic skills for use of VR. However, he showed no evidence of benefits to writing with VR and this perhaps explained why there was no evidence of his using the software at 12 months post training. Interestingly he did report spontaneous use six months later, when he contacted the author for help reloading the software having upgraded his PC.

Of the remaining eight participants, the most successful user was T2, who achieved high accuracy levels, showed advanced skills in using VR (increasing accuracy levels with time), demonstrated clear benefits to writing and continued to use VR well after training was finished. P4 and P7 were close behind in terms of functional success: although the latter only achieved the basic skills required for dictation, both continued to use the software 12 months post training. Some of the success experienced by P4 was attributed to the regular support provided by a volunteer assistant who came in to help her with practice once a week. P7 also had good support from his wife. All three of these most successful participants were able to write independently for the first time using the software.

Table 6.10 Number of independent dictations and evidence for continued use of the software juxtaposed with other key data

	Speech	↑ writing qualitative		↑ writing quantitative	Software accuracy	Computer skills		Level of practice	Use at 12 mths
	<i>Few errors</i>	<i>↑ quality / quantity</i>	<i>Independent In writing</i>	<i>Combined analyses</i>	<i>>80%</i>	<i>Basic VR</i>	<i>Advanced VR</i>	<i>>15 (Number)</i>	
T1	✓	✗	✓	✓	✗	✓	✗	N/A	✗
T2	✓	✓	✓	✓	✓	✓	✓	N/A	✓
P1	✗	✗	✓	✓	✗	✓	✗	✓ (42)	✗
P2	✓	✓	✗	Unclear	✓	✓	✗	✓ (15)	✗
P3	✗	✗	✗	✗	✗	✗	✗	✗ (4)	✗
P4	✓	✓	✓	Unclear	✓	✓	✓	✗ (11)	✓
P5	✓	✓	✗	✗	✓	✓	✓	✓ (23)	✗
P6	✓	✗	✓	Unclear	✗	✓	✗	✓ (20)	✗
P7	✓	✗	✓	✓	✓	✓	✗	✓ (21)	✓
P8	✓	✗	✗	✓	✓	✗	✗	✗ (2)	✗
P9	✗	✗	✗	✗	✗	✓	(✓)	✗ (12)	✗
P10	✗	✗	✗	✗	✗	✗	✗	✓ (25)	✗

T1, P1 and P6 were similar in that they all achieved only the most basic skills in use of VR, and likewise achieved relatively low software accuracy levels. These three clearly struggled to acquire the basic skills and were liable to forget these if not used regularly and were unable to improve on software accuracy levels. The net gain in terms of benefit to writing fluctuated according to the number of software errors produced in each dictation. All reported no longer using the software at 12 months post training either because of poor accuracy recognition or because of difficulty retaining basic skills.

P2 and P5 were similar to one another in their patterns of use. Both achieved high levels of accuracy, and P5 acquired more than the basic skills. However, the benefit to writing skills for both was questionable as both had relatively high baseline writing scores on the WAB. Motivation to use VR for these two participants was clearly considerably reduced by high level baseline skills using alternative modes for writing. This may explain why use was not sustained over time. It was noted that the main gain reported by P2 was the acquisition of computing skills (section 6.2.4.1).

6.5 Summary of findings of study two

This section draws together the qualitative and the quantitative evaluations and relates findings as a whole to the study objectives. Further discussion of these issues with reference to the literature is reserved for Chapter Seven.

This study investigated the outcomes and process of computer therapy, which targeted the facilitation of writing (activity) for people with aphasia, taking as its primary focus the perspective of people with aphasia themselves. Therapy targeted the facilitation of writing (activity) for people with aphasia through teaching the use of VR software as a writing aid. Specifically the study investigated in what ways people may benefit from such therapy; investigated

who may benefit from training in use of voice recognition software as a writing aid; developed hypotheses as to the key components bringing about a positive outcome in the intervention and the potential barriers to success. The hypothesis at the outset of the study was that training someone to use VR as a writing aid would result in broader benefits than simply to writing activity itself. Although the primary focus of the investigation was a qualitative evaluation of participant views, this evaluation was supplemented by quantitative investigation of key outcomes. The following summary will draw together qualitative and quantitative findings.

6.5.1 Benefits of therapy

A broad range of benefits were found not only in terms of facilitating writing but also in terms of increased writing activity, and more general benefits such as improved computer skills, increased autonomy over writing, improved confidence and the benefits of a meaningful occupation. This was in the context of therapy that only targeted writing through the use of VR software as a writing aid.

Nine of the twelve participants acquired skills to be able to use VR (qualitative data and quantitative data). Eight of these reported benefits to writing, either in terms of improved quality or quantity or improved autonomy in writing. Comparison of qualitative and quantitative data (Table 6.10) showed no clear convergence between participants perceiving improvements to quality or quantity of writing and those for whom quantitative measures demonstrated improvement. However, the type of improvement reported agreed with parameters identified as having improved. The change perceived by some may have been too small to capture quantitatively. Some of the challenges in measuring the change to written language produced will be discussed further in Chapter Seven.

Various participants reported a belief that use of the software would have a positive impact on language impairment. No evidence was supplied via qualitative data or quantitative data to support this belief.

Participants reported a range of benefits to writing activity. These activities served social, business, leisure, health or memory aid purposes or addressed issues surrounding identity. All participants reported benefit in terms of improved computing skills, even if they failed to gain basic skills to use VR and this was confirmed by quantitative measures of computing skills. Some participants identified the main gain as being an increase in autonomy over writing. Some also reported that use of the computer had offered them a valued occupational activity. Even those who did not succeed with VR software reported benefits to confidence. Improvements to confidence therefore resulted equally from improved computer skills or the benefits of accessing an occupational activity as from direct facilitation of writing.

6.5.2 Who may benefit from therapy?

A number of factors emerged from findings as to who may benefit from using VR as a writing aid. These included characteristics of spontaneous speech, baseline writing abilities and time post onset.

All participants scored achieved an Aphasia Quotient of 70 or higher on the WAB, representing collectively a relatively high level of aphasia but including some in the group who had significant language impairment who went on to succeed with VR (P7, AQ:73). Patterns of speech production therefore proved a better predictor of success with the software than overall Aphasia Quotient as measured by the WAB or subscores for speech on the WAB. Those who produced few or no speech sound errors were more likely to achieve higher software accuracy rates. Recognition accuracy for the participant who had the greatest difficulty with speech sound production was particularly poor. Those who had difficulty self-correcting speech sound errors also showed lower recognition accuracy. The hypothesis that those with

dysfluent speech would also show poorer software accuracy levels was not confirmed. Recognition accuracy rates for dysfluent participants were amongst the highest in the group. In part, this was because people with dysfluency were less dysfluent when dictating. In addition, participants were taught first to rehearse each phrase for dictation, before switching on the microphone. Those able to self-correct dysfluencies were able to do so before starting dictation. Software accuracy levels were not noticeably lower for P6 who was a non-native speaker of English. However, they were at the lower end of the range for the group.

Those with relatively high level writing skills at baseline were less likely to demonstrate a quantitative benefit to written language produced with VR and were less likely to go on to use the software functionally. This was despite the fact that some of these participants reported *perceiving* a benefit to written language when using VR.

Time post onset of aphasia for participants in this study ranged from between six months to seven months to over 14 years. The people who went on to demonstrate continued use of the software at 6 months post training ranged from 2;0 to 5;8 years post stroke. People who achieved the basic skills to use VR software ranged from 1;4 to 14 years post stroke. Participants who failed to gain the basic skills ranged from 0;7 to 3;3 years post stroke. Provided participants were at least one year post stroke, outcome did not appear to be linked to time post onset.

6.5.3 What were the key components in bringing about these benefits?

Four key factors emerged as crucial in ability to benefit from using VR. Figure 6.11 summarises key factors and the contextual factors that impact on them. Ideally, software accuracy should exceed 80%. It will be influenced by spontaneous speech (discussed above) coordination of the microphone, training of specific vocabulary and the software used. Ideally advanced VR

Table 6.11 Key factors and contextual influences on outcome

Key factors	Contextual influences
<p>Spontaneous speech production</p> <p><i>Criterion</i></p> <p>Can they self-correct speech sound production errors?</p>	<p>Dysfluency not a bar</p> <p>Speech sound errors not a bar</p>
<p>Software accuracy</p> <p><i>Criterion</i></p> <p>>80%</p>	<p>Spontaneous speech production</p> <p>Microphone coordination</p> <p>Training specific vocabulary</p>
<p>VR skills acquired</p> <p><i>Criteria</i></p> <p>Minimal: basic skills</p> <p>Ideally: advanced skills</p> <p>Able to identify & correct 80%+ errors</p> <p>Able to acquire advanced VR skills to improve accuracy with dictation</p>	<p>Software accuracy achieved</p> <p>Learning ability</p> <p>Anxiety levels</p> <p>Complexity of procedures</p> <p>Technical difficulties</p> <p>Previous computer skills level</p> <p>Support during practice</p> <p>Flexibility in training</p>
<p>Benefits to writing</p> <p><i>Note</i></p> <p>Increased autonomy may count for more than increased quality/quantity</p>	<p>VR skills acquired</p> <p>Software accuracy achieved</p> <p>Spontaneous speech production</p> <p>Baseline writing skills without VR</p> <p>Support for editing</p> <p>Does autonomy matter more than quality?</p>

skills will be acquired including the ability to identify and correct 80% of errors in the text and to improve recognition accuracy during dictation. Basic VR skills (including good microphone coordination) are an absolute minimum requirement and will depend on learning ability, previous skills level and support during practice. Finally, benefits to writing must be clear in order to

motivate the use of VR rather than alternative modes. For this reason those for whom no alternative mode is available may be more likely to use the software, that is autonomy in writing counts for more in motivating use than improved quality or quantity.

Chapter Seven: Discussion

7.1 Introduction

This chapter will evaluate the extent to which the research presented in this thesis achieves the aims set out in Chapter One. In order to do so it will first examine findings of each study in its own right in the context of previous research and discuss to what extent each study individually meets the aims and objectives of the research. Following examination of the contribution of each study individually, the extent to which the objectives for the research have been met by the two studies in combination will then be considered. Included in the analysis of each study and the two in combination will be a critical appraisal of study methods. A final summary of findings and their implications for future clinical practice and research is given in Chapter Eight. This final chapter includes an explicit statement of the contribution made by the thesis to existing knowledge.

7.2. Research objectives and findings

The research presented in this thesis investigated the outcome of computer therapy from the perspective of people living with aphasia. The investigation took the form of two complementary but contrasting case series studies: 1) an investigation into the outcome of using computers to target word finding abilities (treatment which targeted impairment only); and 2) an investigation into the outcome of learning to use voice recognition software as a writing aid (treatment aiming to overcome activity limitations resulting from writing impairment). Both studies consisted of a qualitative investigation of the views of participants on the outcomes and process of using computers in this way. Both studies supplemented this qualitative data with complementary evaluations seeking to quantify key aspects of outcome identified as relevant by the qualitative findings.

For each study the objective was to:

- Investigate in what ways people with aphasia may benefit from using computers in therapy;
- Develop hypotheses as to who may benefit from computer therapy;
- Develop hypotheses as to the key components contributing to a positive outcome

The following hypothesis was tested:

- Computer therapy for people with aphasia will bring benefits that impact more broadly than simply on impairment.

7.3 Discussion of study one

An investigation into the process and outcome of word finding therapy delivered remotely via computer for people with aphasia

7.3.1 Introduction

For each of the questions posed in study one, qualitative findings will be considered first, before examining quantitative findings and discussion will include an examination of the extent to which qualitative and quantitative findings converge. Discussion will also include a critical appraisal of how these findings relate to previous research and how methodology of study one might be improved. First the ways in which people may benefit from such therapy will be considered. From this, hypotheses will be developed as to who is likely to benefit from remotely monitored word finding therapy and what the key components may be that are critical to a positive outcome in this intervention and potential barriers to success.

7.3.2 How may people with aphasia benefit from computer therapy targeting word finding delivered remotely?

Benefits will be described in four sections. The evidence for benefit to word finding skills as measured by picture naming will be considered first. This will be followed by discussion of evidence of benefit to word finding in conversation. Evidence of increase in activity and participation will then be considered and finally, more general benefits will be discussed.

7.3.2.1 Evidence of benefit to word finding in picture naming

Qualitative findings indicated that all six participants and all five carers believed that word finding improved and that the degree of improvement had been very substantial. Improved performance on computer tasks or post therapy picture naming assessments (reported by all) was used as evidence to justify this belief. Quantitative findings confirmed these beliefs: all participants showed a significant improvement in the number of pictures named after therapy, an effect that was maintained six weeks after therapy was withdrawn. These results occurred in the context of stable baseline measures on word finding, no evidence of significant change to non-treatment measures and no change on control assessment of sentence comprehension, suggesting that changes were indeed specifically related to impairment therapy rather than being the result of spontaneous recovery or non-specific treatment effects.

These findings indicated conclusively that a significant improvement in ability to name pictures took place and maintained for all study participants (total items targeted was 266 and 214 for one participant). These findings compare favourably to Pederson, Vinter and Olsen 2001 who found improvement, which was maintained at follow up (eight weeks post therapy) for only one of three participants following unsupervised independent practice with a computer (total items targeted 101 and 104 for one participant). Findings were similar to those of Fink, Brecher, Schwartz and Robey 2002 who found significant improvement in the word finding of all six participants in their study maintained at four weeks post therapy (total of 40 items targeted). However, the number of items targeted in therapy in the latter study was considerably fewer and all participants in the

latter study had face-to-face contact with the clinician during at least one third of total therapy time. Further analysis of how these studies compare will be included in the discussion of the key components facilitating benefits (section 7.3.4) below.

7.3.2.2 Evidence of benefit to word finding in conversation

Qualitative findings showed that all participants reported benefit at the level of activity in the form of improved ability to find words in conversation and improved ability to hold conversations. Detailed and specific examples of how word-finding behaviour in conversation had changed for three participants gave weight to the evidence that improved ability to name pictures had indeed generalised to improved ability to find words in conversations. These findings occurred in the absence of any therapy to specifically target the transfer of such gains to conversation.

Quantitative analyses of connected speech samples were used to establish whether there was quantitative evidence that improvement to word finding in the picture-naming task had generalised to word finding in connected speech. The results of these analyses were inconclusive, contradicted each other and failed to provide clear evidence for any participant that improvements in word finding had generalised to connected speech. There are two interpretations that can be made of this finding. First, it may reflect the inadequacy of the methodology used to measure generalisation. Alternatively, it may indicate that this generalisation did not take place. Each of these possibilities will be considered in turn.

Adequacy of methods

Other attempts to quantify evidence of generalisation of improved word finding in picture naming to everyday speech have provided mixed findings (Herbert 2004, Herbert, Best, Hickin, Howard and Osborne 2003). Herbert et al. 2003 found only small improvement in participants' production of target words in the relevant context provided by a task designed to simulate everyday communication (Noun production in everyday communication, NPEC) and this improvement did not reach significance for any participant. Herbert (2004) attempted to evaluate generalisation to connected speech using pre and post therapy comparison of a measure designed to quantify benefits to real conversation (POWERS, Herbert,

Best, Hickin, Howard and Osborne, in progress). Again, there were mixed findings with regard to whether improvements in word finding were reflected in measured improvements in conversation. Whereas one participant did show improvements on both measures, two others showed improvements in picture naming but failed to demonstrate change in measures of conversation.

Possible reasons for these findings are discussed in Herbert 2004 and Herbert et al. 2003. First, where it is assumed that therapy effects are item specific, there is the issue of whether a connected speech sample will allow production of a sufficient number of words targeted in therapy to determine significant change. A connected speech measure may simply be insensitive to the small changes in word finding ability, which can nonetheless be demonstrated by picture naming measures. Second, there is the issue of the test-retest stability of parameters chosen for measurement. Although, parameters chosen in this study were those that had previously shown test-retest reliability (Herbert 2004, Nicholas and Brookshire 1993) and were found to show good intra-rater reliability in this study, controversy continues over the reliability and validity of these measures (Herbert 2004). In particular Herbert notes that there is no guarantee that these measures will show stability when transferred to the analysis of data from other participants. Similarly, there is no guarantee that test-retest stability would be found on these parameters for connected speech data elicited via video description. The application of an analysis like the POWERS, developed with the aim of analysing conversational speech, to connected speech data elicited via video description is controversial as parameters that have been demonstrated to show stability across samples of conversation, may not necessarily show stability across narrative samples of the kind elicited here. Study one's design would be improved by incorporating multiple baselines on these measures, in order to establish stability on chosen parameters for these participants therapy.

Possibility that no benefit to spontaneous speech took place

The alternative interpretation is that no benefit to connected speech took place. However, quantitative findings must be considered in the context of the qualitative data regarding perceived benefit to everyday communication. The qualitative data showed that all participants believed benefit to conversation had

occurred and three participants were able to give a range of evidence to support this belief. This included examples of words or family names that had previously caused difficulties but which were now being produced regularly. It also included citing a range of ways in which word finding behaviour had changed in conversation. For example, people were observed to be better at self-correcting errors; were noted to take their time to find a word and eventually retrieve it successfully; or simply attempted to find words where previously they would not have done. Interestingly, this reported increase in attempts to retrieve words in conversation might be reflected in an increase in word finding failures or errors in attempts to quantify word finding in connected speech.

For P1, P2, and P6 the breadth of qualitative evidence for benefit to word finding in conversation was substantial. Evidence for benefit to P3, P4 and P5 was less clear. For P4, this was in part due to the lack of partner interview data for him and a reluctance to draw conclusions on the basis of his evidence alone. For P3 and P5 evidence was less conclusive in part due to limitations on their expressive language and in part due to the less detailed or specific information from carers.

Evidence does suggest that improvements in picture naming can generalise to connected speech even in the absence of therapy targeting generalisation (Hillis 1998, Hickin, Herbert, Best, Howard and Osborne 2002b). In the former study, the case for perceived improvement was argued on the basis of descriptive evidence. In study one, the strong qualitative evidence of benefit to word finding in everyday communication provided convincing evidence that some improvement took place in each case. Several participants also reported during interviews that *any* gains would be very welcome. It may be that gains were too minimal to be detected as statistically significant using quantification by this or indeed any other method. However, even the experience of retrieving one previously unretrieved word in conversation may be highly significant in the mind of the person with the communication impairment.

7.3.2.3 Evidence of increased activity/participation

Qualitative findings indicated that people perceived therapy to have impacted in a broad range of ways on activity and participation. There were two key ways in which these effects took place. First, improved word-finding abilities as a result of therapy led to an increase in ability to engage in a range of communication activities such as initiating conversation with family, friends or strangers. Second, increased confidence which stemmed generally from therapy resulted in new activities being taken up for the first time since the stroke: shopping alone, learning to drive again, decorating and rewiring the house, carrying out car maintenance and DIY tasks by following a manual and cooking meals independently. Although these activities were far removed from the target of therapy (improving word finding), in the minds of participants and carers alike the confidence to undertake these new activities was clearly attributed to therapy.

For those who had not used a computer much (either pre or post stroke), participants reported an increase in computer usage, which went beyond therapy activities and encompassed use of the Internet, email or games. Use of the phone increased in part due to phone calls with the therapist to discuss therapy progress. Some participants valued the occupational benefit of having a new pastime that they could carry out independently of their partner.

The design of the study did not incorporate any attempt to quantify increased activity/participation. This reflected the fact that many published assessments of communicative activity and participation in aphasia (for example the Functional Communication Profile, Sarno 1969, Communicative Activities of Daily Living, Holland 1980) have been criticised for representing the clinician's view of the communication priorities of individuals with aphasia. Most were developed without consulting people with aphasia themselves (Worrall 2000, Parr and Byng 2000) and may fail to take account of issues that are critical to the individual. The in-depth interview was used to enable individual benefits to be established and illuminate the processes by which they occurred.

7.3.2.4 More general benefits

Benefit to autonomy, confidence and self esteem

All participants reported a sense of increased autonomy or independence as a result of learning how to carry out practice unassisted. All participants reported benefits to confidence and self-esteem, which had had a positive impact on communication in their own right quite apart from specific benefits to language processing as measured by picture naming. Specific examples were given in the qualitative investigation to justify the belief that confidence in communication had improved for all participants, even in the absence of measurable benefits to word finding in conversation. Participants placed strong emphasis on these gains and clearly these were highly significant to them, not only in their own right, but also as a catalyst to promote further benefits in a positive cycle of improved confidence leading to improved communication.

The design of the study did not include any attempt at quantitative measurement of these benefits, because the level of significance attached to them by participants was not anticipated at the outset.

7.3.3 Who may benefit from therapy?

The second aim of the investigation was to develop hypotheses as to who may benefit from word finding therapy delivered remotely via computer. Several factors deserve comment here: the nature and degree of impairment and the time post onset of stroke. Each of these will be discussed in turn. A final section will discuss additional factors that may influence benefit.

7.3.3.1 Nature and degree of impairment

All participants showed significant benefit in terms of word finding as measured by picture naming. However, the extent of the benefit did vary within the group, with some showing more gains than others. There is evidence in the literature that response to therapy will depend on the nature of the underlying processing difficulties, causing the word finding impairment (Best, Herbert, Hickin, Osborne and Howard 2002). The latter study showed that the greatest therapy effects using phonological cueing was found for people with less impairment at both

semantic and phonological levels. This raises the question whether response to therapy was dependent on overall semantic and phonological processing ability of each participant.

Findings from study one confirm this argument. Two participants, who were hypothesised to have impaired phonological processing in the form of impaired access to word forms, but showed little evidence of semantic impairment or impaired phonological encoding after accessing the word form, showed the most gains in therapy (P1 and P2). Next in terms of gains were two participants who were hypothesised to have impaired semantic processing in addition to difficulty with phonological access to the word form (P3 and P5). The study by Pedersen et al. 2001, examining unsupervised computer therapy, likewise found most improvements for a participant with impaired phonological access to the word form. Study one findings confirm the suggestion put forward by Howard (2000) and reinforced by Nickels (2002b) that tasks that improve mapping from semantics to the word form can be effective in benefiting both semantic processing and phonological processing as they function by simultaneously activating both the semantic and the phonological representation and the mapping between the two. The least gains were made by two participants who showed evidence of difficulties with phonological encoding in addition to difficulties with the phonological word form. This confirms the suggestion by Best et al. 2002 that those with greater phonological impairment will benefit least.

Whatever differences in degree of benefit were found between participants, the fact remains that all made highly significant gains in a study where the number of therapy items targeted was considerably greater than in previous studies of independent computer therapy (Fink et al. 2002, Pedersen et al. 2001). All of these gains were made without a therapist present (discussed further in section 7.3.4.4).

7.3.3.2 Time post onset

Participants in this study were all between 1 year 7 months and 11 years post onset of stroke. All demonstrated measurable benefits to impairment and reported broader benefits to confidence and self-esteem, activity and

participation irrespective of time post stroke. Participants also reported believing that this form of therapy would be appropriate from six months post stroke onwards.

Evidence of positive benefits 11 years post stroke which included both statistically significant gains at the level of impairment and perceived benefits to activity/participation, confidence and self-esteem, confirms the increasing body of evidence that benefits can continue many years post stroke (Aftonomos, Appelbaum and Steele 1999, Holland 1998, Werner and Kessler 1996). It also confirms evidence that significant improvements to word finding can be demonstrated three or more years post onset (Herbert et al. 2003, Hickin et al. 2002a).

The significance attached to gains in confidence during therapy and the anxiety reported that gains would be lost when therapy ended, begs the question of how to maintain benefits over the longer term, especially when therapy ends. This issue has been addressed elsewhere (Kagan 2003, LPAA 2001) in ways that challenge traditional models of therapy delivery. Self-monitored remote based therapy may offer a novel mode of working with people with aphasia several years post onset, a mode of therapy which offers the opportunity to target and benefit impairment, but also has potential to address other issues as well (activity, participation, confidence and autonomy).

7.3.3.3. Other factors

All participants in this study were highly motivated and self-selecting in that they had chosen to take part in a research study that offered them the opportunity to try computer therapy. All participants also came from middle to upper social classes. It is not clear what impact these factors had on their ability to benefit.

7.3.4. What key components facilitate benefit?

The third aim of study one was to develop hypotheses as to what the key components in facilitating benefits from remote-based therapy may be. A number of factors emerged from the findings and these will be considered in turn. The impairment underlying the word finding difficulty has already been discussed

above. This section considers the nature of therapy tasks; total therapy time; intensity of practice; independence and control in carrying out therapy tasks; therapist supervision; partner support and the cyclical nature of benefits.

7.3.4.1 Nature of therapy task

The tasks in this study were multi-modal and aimed to improve links between phonology, orthography and semantics, incorporating a range of tasks that have been found to be beneficial in treatment of naming disorders arising from impaired semantic or phonological processing (Nickels 2002b). As a range of tasks were used, it is not possible in this study to draw hypotheses regarding the impact of a clearly defined task for each participant.

However, qualitative findings indicated that being able to make multiple attempts at naming and to self-monitor production was highly valued by participants. This implies that multiple productions of the target word and the opportunity for over learning was believed to be crucial by them. The perceived value of repetition confirms the hypothesis that gains result from strengthening item specific mapping between semantic representations and phonological representations. The emphasis on production in this study and that by Fink et al. 2002 contrasts to the study by Pedersen et al. 2001 where it was hypothesised that improvements in naming would result without spoken production of the target. Pedersen and colleagues found only one participant of the three showed significant gains to naming that were maintained using tasks that did not involve production. However, the hypothesis that production of the word is crucial does not explain previous study findings that indicate benefits in response to tasks where no production of the target is required (for example word-picture matching: Marshall, Pound, White-Thomson and Pring 1990, Nickels and Best 1996a, Pring, White-Thomson, Pound, Marshall, and Davis 1999, section 2.8.4). One solution is to argue that the latter tasks do benefit mapping between semantics and phonology but that effects are greater when spoken production of the word occurs in therapy.

Participants also cited the benefits to them of seeing their progress on exercises represented graphically on screen. A percentage score for each attempt at an

exercise was given so progress over time towards 100% could be visually tracked. This process seems likely to deliver a more concrete sense of progress than having scores on tasks fed back individually as numbers. No information is given in previous studies of computer therapy as to the means of feedback on progress nor on participants' responses to this feedback (Fink et al. 2002 Pedersen et al. 2001), therefore these findings cannot easily be compared to previous research. They do raise questions for future research.

The large number of different exercises assigned to each participant (between 44 and 70) also compares favourably with the range of exercises available for independent practice in both previously published studies of unsupervised computer therapy to target word finding. Fink et al. 2002 used only one task, picture naming, and the only variation was in the type of cue (phonological versus orthographic) to facilitate naming. Pedersen et al. 2001 used three different tasks (word to picture matching, written word completion and written naming) however this still fell far short of the range of tasks used in study one. The latter included word to picture matching, semantic association, spoken and written naming, reading and repetition tasks, with additional variation provided by the type of cueing given in all these tasks and the range of target items. Participants commented that the large number of exemplars per exercise (for example up to 20) was helpful in maintaining motivation. The variety that this range of exercises gave may have been crucial in maintaining motivation and facilitating intensive practice. This issue deserves further investigation.

7.3.4.2 Total therapy time

With reference to aphasia therapy in general Robey (1998) has commented that

'the optimal number of trials-on-task per session, the number of hours spent in treatment per day, the distribution of treatment time throughout the day, the number of treatments per week, the duration of treatment, and the total number of treatment hours are not well understood'

Robey 1998: 179

However, he concludes that there is a positive relationship between the duration of treatment and the magnitude of change. In study one, total therapy time

ranged between 46 hours and 92 hours total, with the total number of items targeted over this time being 266 with the exception of one participant who worked on 213 items. This amount of therapy time was considerably greater than that reported by Fink et al. 2002 (6-9 hours maximum to target 40 therapy items), reflecting the tremendous potential for this mode of therapy in enabling far more intensive practice (all therapy in Fink et al. was at least partly clinician guided). Participants in this study however, engaged in less practice to greater effect than in the study reported by Pedersen et al. 2001, where total time ranged from 59 to 192 hours and the only participant to show maintained change recorded 39 hours of practice to achieve significant change on only 51 words. Both this study and Pedersen et al. 2001 demonstrate the huge potential for increasing therapy practice via independent use of computers. In study one therapy practice time of between 46 and 92 hours total was achieved in the context of between 8 and 12 hours of input in terms of therapist time, representing a relatively efficient means of increasing therapy practice relative to therapist time.

However, within the group, total number of hours practice did not show a simple relationship to percentage gains made. The participant who engaged in most practice was not in the top three of the group in terms of gains made (P5). Clearly other factors such as underlying language impairment and speed of learning impacted on progress (7.3.3.1) and further research is required to tease out the relative influence on progress of hours of practice and underlying impairment.

7.3.4.3 Intensity of practice

The literature suggests that intensity of therapy can impact on benefits shown. Robey (1998) found a trend indicating that the more intense the treatment the greater the change will be. Basso, Capitani and Vignolo 1979, Katz and Wertz 1997, Wertz, Weiss, Aten, Brookshire, Garcia-Bunuel, Holland et al. 1996 conclude that therapy should consist of at least three hours per week to be of benefit (section 1.4).

'The conclusion can be drawn that people who become aphasic following a single, left-hemisphere, thromboembolic stroke and

who receive at least 3 hours of treatment each week for at least 5 months, regardless of the time post-onset of stroke, make significantly more improvement than people with aphasia who are not treated.'

Holland et al. 1996: S30.

The average number of hours practice per week in study one ranged from 1 hour 43 minutes to 3 hours 26 minutes. Significant improvement to word finding as measured by picture naming was therefore shown with as little as 1 hour 43 minutes of practice per week. This raises questions over the above conclusions regarding intensity of therapy. However, a number of issues need to be considered in interpreting this data. First, the number of hours' practice measures only the time when people were engaged in active practice on a particular exercise. It excluded time taken to sit down at the computer, switch on, access a particular exercise or take a break to answer the phone, take refreshments or stretch. All times when the software was inactive were excluded from total practice time. Conventional therapy may last for one hour, yet as was pointed out by participants during the in-depth interviews, some of this time will be 'lost' on greetings, reporting on recent events, introducing tasks, feeding back about progress, discussing homework objectives and so on. When the actual time spent on therapy tasks is extrapolated from the remainder the time on task may be considerably less than the time of face-to-face contact with the therapist. One participant raised this issue to support his argument that intensity of therapy and overall amount of therapy practice had been considerably greater via independent computer practice.

All participants believed the intensity and overall amount of time in practice possible with the computer enabled more intensive and more cumulative therapy than had been previously experienced in conventional therapy. Participants believed this had been crucial in bringing about considerably greater improvement to language skills than would otherwise have been possible.

7.3.4.4 Independence and control in carrying out tasks

Independence and control in carrying out therapy tasks brought various benefits. Firstly, it enabled participants to determine the number of repetitions or attempts

at naming before moving onto the next target item. Second, participants were able to determine the timing and duration of therapy practice and therefore practice when feeling most alert. Finally, participants valued the sense of increased autonomy or control resulting from being able to practice independently of both the speech and language therapist and the partner.

As Robey (1998) indicates (section 7.3.4.2) the optimum number of trials-on-task is not known and is likely to vary considerably with individuals. By enabling participants to determine how many trials on task they engage in before moving onto the next item, the person with aphasia is given greater control over the learning process. Qualitative findings indicated that people with aphasia may judge better how many repetitions are needed than can a speech and language therapist. Participants reported enjoying the freedom in working with the computer to repeat items as many times as they wished, implying that they engaged in more repetition than if the therapist had been present.

Participants also demonstrated individual preferences as regards manner, timing, and duration of therapy practice. The increased autonomy for participants which this control gave may have positive implications for learning: participants were able to practice when most alert and some reported a process of growing insight into patterns of practice that were most beneficial to them. It is possible that a self-directed and self-monitored practice of this kind offers a qualitatively different learning experience to face-to-face therapy with a therapist. It is also possible that the increased autonomy experienced may have contributed to the perceived benefits to self-esteem reported, independently of any gains in communication ability. This would confirm the suggestion by Farrell (2004) that increasing control in the therapy process can lead to greater confidence and greater patient satisfaction. The development of therapy software that can be used to deliver therapy in this way has created a tool with which to investigate such issues further in future.

The findings of this study challenge the idea that the face-to-face interaction between the therapist and the person with aphasia is crucial if benefit from therapy is to result. This study provided evidence of benefit to word finding in the

absence of any face-to-face therapy. Whatever is critical in the face-to-face interaction, something replicating it or compensating for its absence in this case was facilitated by the computer therapy. Basso and Marangolo (2000) emphasise that in therapy the patient is not a passive recipient and the therapist is not a machine. Here the therapist was replaced by a machine, but evidence indicates that this served to make participants more active in the therapy process and more able to adapt the pace and style of learning to their own preferences.

7.3.4.5 Therapist supervision

Evidence from this study indicates that, although therapy was more self-directed than conventional face-to-face therapy, the remote monitoring of therapy by a speech and language therapist was still perceived as crucial to progress. The therapist was identified as having an essential role in providing motivation, and it was perceived to be important that someone outside the family should take this role. The therapist was also ascribed a monitoring role, being asked to modify exercises in response to user feedback. Therapist intervention may be crucial in maintaining motivation for continued practice, and thus facilitating the intensity of practice discussed above. Where the remote monitoring of therapy appeared to work best, it enabled a partnership to develop between the participant (and in some cases their partner) and the therapist, whereby progress through therapy was jointly planned and negotiated. Evidence indicates that the ability to contribute to the planning of intervention is highly valued in healthcare intervention (Coulter 1997). This process may also have contributed to the reported benefits to confidence and self-esteem reported by participants. Given that the input of therapist time was minimal in relation to the high intensity of practice achieved, clinical application of this mode of therapy delivery could potentially promote client autonomy at the same time as optimising the use of the therapist's time.

Quantitative findings in terms of benefit to word finding as measured by picture naming were very favourable in this study as compared to those in Pedersen et al. 2001 in which computer practice was carried out unsupervised (section 7.3.2.1). The latter observed in their discussion that therapy proved unsuitable for one of the participants involved, thus highlighting some of the risks involved

with leaving people to engage in independent computer practice without supervision. Qualitative findings in study one also indicated that participants valued being able to influence the course of therapy by requesting that an exercise be left for further practice.

7.3.4.6 Partner support

Qualitative findings revealed a range of views regarding the partner's role in therapy. Variation in the role taken by the partner reflected beliefs about the benefits of support balanced against beliefs about the benefits of autonomy in learning. It was clear that it was possible for people with aphasia to use the software without any help, as demonstrated by the participant who lived alone. Yet for others partner support had been absolutely essential. It may be that need for partner support is linked to a combination of factors including previous computing experience, severity of this person's aphasia, the degree of difficulty experienced learning the routines required to carry out exercises or physical difficulties experienced manipulating the mouse. In contrast to findings in study two, however, participants did not experience the software as difficult to learn how to use. The fact that software was purposively designed to be aphasia friendly had a positive impact on people's ability to access it relatively quickly.

Results indicated that the opportunity for the person with aphasia to carry out practice independently of their partner was welcomed by all partners in the study as liberating for both them and the person with aphasia. Yet at the same time, it did not preclude the partner from having the potential to influence the therapy process in a positive way. Results indicated that people were able to apply their personal knowledge of their partner in knowing how best to support them through the therapy process, and sensitivity to a partner's needs may have contributed to the amount of success experienced. However, evidence from one partner indicated that remotely monitored computer therapy can be potentially extremely demanding on partners and this should be borne in mind in future clinical application.

7.3.4.7 Cyclical nature of benefits

The cyclical nature of benefits appeared to influence the degree of benefit perceived. Effects on activity and participation were not only ascribed to improvements at the level of impairment but also to other benefits that included increased autonomy and confidence resulting from learning new skills on the computer and the benefits of having an occupation on which progress was perceived. Effects were experienced as cyclical with positive effects on activity/participation and confidence and mood increasing motivation for further practice.

7.3.5 Summary of findings of study one

The hypothesis that impairment focussed therapy delivered via computer would impact beyond the level of impairment was confirmed. Significant benefits to word finding as measured by picture naming were shown for all participants. Benefits generalised to a broad range of activities including examples from seven of the domains classified in the ICF for activity/participation. People also benefited in terms of computer skills and in terms of occupational activity. All of these benefits occurred in the absence of any therapy to target generalisation. Benefits combined to result in improved confidence. Those who benefited most as measured by picture naming were those whose word finding difficulties were attributed to phonological difficulties. Those who benefited least had additional phonological encoding difficulties. Those with additional semantic difficulties fell between these two groups. People showing benefit ranged from 1 year 7 months to 11 years post onset and it was suggested that 6 months post onset was the optimum time after which such therapy would be beneficial. People did not need previous computing experience to benefit. Findings suggest key factors leading to benefit were opportunity for repetition in practice, total practice time, intensity of practice, autonomy and control in carrying out tasks, therapist supervision and partner support. The degree of benefit was explained by the cyclical way in which improvements to word finding on task or in conversation combined with improvements in computing skills led to increased confidence and encouraged the uptake of new activities and increased participation.

7.4 Findings of Study Two

An investigation into the process and outcome of training people with aphasia to use voice recognition software as a writing aid.

7.4.1 Introduction

This study evaluated the outcomes and processes of computer therapy, which aimed to facilitate writing activity for people with aphasia through teaching the use of voice recognition software as a writing aid. Specifically the study:

- Investigated in what ways people may benefit from such training
- Developed hypotheses as to the key components bringing about a positive outcome in the intervention and the potential barriers to success
- Developed hypotheses as to who may benefit from training in use of voice recognition software as a writing aid

The following hypotheses was tested:

- Computer therapy targeting the activity of writing will result in broader benefits than simply to writing itself

For each of the above questions, qualitative findings will be considered first, before examining quantitative findings and discussion will include an examination of whether quantitative findings confirm or contradict qualitative findings. It will also include a critical evaluation of how these findings relate to previous research and how methodology of this study might be improved. First the ways in which people may benefit from such training will be considered. Following this there will be a discussion of who is likely to benefit from training in use of VR software

as a writing aid. From this hypotheses will be developed as to the key components critical to bringing about a positive outcome in this intervention and potential barriers to success. Finally, findings of the study will be drawn together in a concluding summary.

7.4.2 How may people with aphasia benefit from training in use of VR?

Benefits will be described in four sections. The evidence for benefit to quality and quantity of writing produced using VR will be considered first followed by discussion of evidence of benefit to language impairment. Evidence of increased writing activity will then be considered and finally, more general benefits will be discussed, including improved computer skills, occupational activity and improved confidence.

7.4.2.1 Improved quality or quantity of writing produced using VR

Qualitative findings indicated two key ways in which writing with VR was reported to be beneficial: in terms of quality and in terms of quantity of writing produced. Participants reported that the quality of their writing had improved as a result of no longer needing to focus on spelling and the physical mechanics of writing, and that this impacted on choice of vocabulary, the length of sentences and composition of the text. VR was also believed to impact positively on quantity and in particular number of words, length of words, length of sentences and length of script.

There was confirmation from quantitative written language analysis of improvements occurring at word, phrase and sentence level when participants used VR as compared to their previously preferred mode. Improvements were found for quantity (number of words, number of utterances/sentences and mean length of utterances) and to quality in terms of grammatical complexity (increased use of verb phrases). Improvements occurred most consistently across participants on the simplest measure of quantity, number of words. It was noted that improvement on sentence level measures (MLU and number of sentences) was observed in part, because in so many cases these were marked for the first time when using VR. Use of VR clearly facilitated marking sentence

boundaries, even if sentence-processing difficulties were present. There was evidence that verb phrase use increased for some. Evidence for increased complexity of sentence structures was less clear (embedded sentences).

Quantitative data therefore confirmed findings of the qualitative evaluation. Benefit in using VR was shown across a range of parameters used for language analysis identified by participants as having improved. These benefits are similar to those found for people using predictive text and text to speech to aid word processing (Armstrong and MacDonald 2000, King and Hux 1995) and have been reported in use of VR software by people with learning difficulties (De la Paz 1999) and in a previous investigation into the use of VR by a person with aphasia (Bruce, Edmundson and Colman 2003). This confirms the suggestion that use of VR facilitates writing by removing some of the competing demands on the language system, in particular the demands of spelling and reading for editing.

A number of issues should be borne in mind when interpreting the data however. First, cross comparison of qualitative and quantitative findings on a case-by-case basis does not give a clear match in outcomes. When benefits to written language produced via VR reported by T2, P2, P4 and P5 (increased word and sentence length and increased complexity of vocabulary produced, section 6.2.4.1) are compared with quantitative data for these participants (section 6.3.3.1) there is clear evidence of benefit on these parameters for T2 only. The remaining three participants had high baseline scores in the WAB section on writing, indicating that writing by alternative modes was at a relatively high baseline level. Ceiling effects in writing ability appear to have prevented measurable benefit in use of VR being demonstrated for those whose writing skills without VR were relatively intact.

Second, it is possible that a reduction in the number of words produced with VR as compared to other modes is found due to the time needed to correct errors using VR. As a result of the reduction in amount of text produced, some of the counted measures may show a decrease. Yet if this occurs in the context of a substantial reduction in the percentage errors produced, the overall impact on

writing may be perceived as positive. This was the pattern shown for P4 and it confirms the findings of Manasse et al. (2000) who found that a head injured participant preferred use of VR to word processing despite evidence that word processing enabled her to produce a greater volume of text than VR. Quality of text was more important to this user than quantity. As for P4, use of VR took away some of the fatigue and laborious nature of writing with physical motor impairment and writing with VR was therefore a more positive experience.

Moreover, these samples were all produced within a ten-minute time limit. Yet one participant reported that, to gain benefit from using VR rather than word processing, he needed at least thirty minutes in order to complete a written piece. He believed that completing a task with VR in less time than that was unlikely to show benefit due to the time needed to warm up to task and correct errors. It may be that the ten minute time limit, imposed for purely pragmatic reasons in order to keep written language samples to a manageable size for analysis, was simply too short in some cases for benefits to be demonstrated. Previous studies have been able to demonstrate benefits for use of VR within a shorter period (for example, eight minutes reported by Bruce et al. 2003) but in this case the person had been using VR for a much longer period (8 months) before reassessment.

A number of methodological issues arose in analysing quantitative data. First, although good reliability in terms of agreement for reanalysis was found for the number of words, the number of utterances and the number of verb phrases, poor levels of agreement for reanalysis of the data on the number of words with seven letters or more, number of word errors and number of embedded sentences was found (Appendix 17). Poor reliability is explained largely by difficulties deciphering the handwritten text. The poor reliability on the three parameters listed above was disappointing but not surprising given the poor legibility of some scripts.

Second, these findings are based on observation of trend, not statistical analysis. Considerable variation within both baseline and post therapy scores precluded statistical analysis even on measures that showed good levels of agreement and

have been interpreted with caution. The methodology used to evaluate the language samples shared parameters that were used in two previous single case studies investigating use of VR by people with language difficulties (Bruce et al. 2003, Manasse et al. 2000). Manasse et al. 2000 found no substantial differences in the frequency of structural writing errors between samples generated using word processing and VR for their participant although a downward trend for VR in the number of words produced (number of words produced via word processing was actually greater) and an upward trend for VR in the percentage of complex sentences (comparable to embedded sentences) produced were noted. The authors argue that, with such a small trend towards improvement using VR, the overall impact is questionable. Bruce et al. (2003) by contrast carried out a primarily descriptive comparison of language samples, and made no attempts to determine the reliability of analysis procedures. There was some overlap with parameters used in study two. Bruce et al. (2003) report an increase in the number of words, improved use of capitalisation and punctuation (equivalent to marking sentences in this study) and an improvement in number of verb phrases and embedded sentences. Overall the positive impact of VR on writing reported for the participant in Bruce et al. (2003) is comparable to the findings for T2, the participant in study two who showed the clearest benefits in using VR. Evidence for benefit to language for T2 is comparable to that reported by Bruce et al. across all parameters.

Taking the qualitative and quantitative data from this study in the context of these two previous studies, there is clear evidence for benefit to language produced using VR and this benefit is reflected in the number of words, utterances and verb phrases produced. However, quantifying changes on any more parameters than these in a reliable way poses challenges, which this study did not resolve. Benefit in terms of measurable benefit to language produced with VR will vary with individuals and will depend on levels of competence achieved using the software, levels of software accuracy achieved and levels of written language impairment, as will be discussed further below (section 7.4.4).

7.4.2.2 Improvements to writing impairment

From qualitative findings, use of VR was perceived as potentially beneficial to language skills including writing ability. Participants believed use of VR would impact directly on language impairment. However, qualitative findings did not provide any examples of this having occurred, simply a belief that it would occur as a result of general language stimulation or use.

Quantitative evidence for benefit to writing impairment was minimal. There was evidence of an increase in the number of words produced but poor evidence to indicate reduction in the number of errors produced, so evidence of an increase in quantity was not accompanied by evidence of any increase in quality. It is possible that the increase in quantity observed was simply the result of increased confidence from using VR, with participants prepared to attempt more writing in post therapy assessments than pre therapy. This has been observed in relation to use of assistive word processing software in aphasia (MacDonald and Armstrong 1998)

The question of whether use of VR software may lead to improvements at the level of impairment has been raised elsewhere and is currently under further investigation (Bruce et al. 2003). The findings of study two showed no clear evidence of benefit to language impairment. It may be that improvements were too small to be detected by the quantitative evaluation in this study. It may also be that proficient use of VR over a longer period of time than the four months in this study is necessary to bring about measurable change.

7.4.2.3 Benefits to writing activity

Qualitative findings showed that a range of writing activities were taken up that served social, leisure, business, health-related purposes, acted as a memory aid or addressed issues surrounding identity. The most common use of VR by those who succeeded with its use was social: to maintain written or email contact with friends, family or other people with aphasia. Email, in particular, because of its instant turnaround, was perceived as a means of reducing the social and physical isolation, which for many people had become the norm for them since their stroke. However, letters were equally valued and some participants had no

desire to learn to access email. Achievements such as being able to write a personal letter or card may seem insignificant, but participants repeatedly stressed how important these achievements were. Application of VR in this way was very similar to those spontaneously adopted by the participant with aphasia described by Bruce et al. (2003).

Some participants explicitly wanted to contact others who had had stroke and who had aphasia. Contact with others with aphasia has been identified as important for people with aphasia in order for them to compare themselves with others and to understand their own progress and limits and potential for progress (Kagan 2003, Parr et al. 1997). Findings indicated that isolation associated with aphasia was compounded by physical isolation in some cases and electronic communication was seen as an ideal way of circumventing this.

7.4.2.4 Increased autonomy in writing

VR was perceived as beneficial for those whose writing was so severely impaired as to prevent them making any attempt at writing unaided, in that it simply enabled them to attempt writing independently. These people had been previously unable to write as a result of a combination of physical difficulties forming letters, spelling difficulties and language difficulties affecting sentence formulation and composition. By removing the physical and spelling difficulties, these people were able to produce text via dictation and valued the increase in autonomy that ensued. Most acknowledged the need for continued support in editing.

It has been argued that autonomy rather than independence may be more relevant in goal setting for people with aphasia (Parr 1993). These findings confirmed this assertion: most people continued to depend on family or friends for editing and correction. Findings do demonstrate however, that an increase in control is highly valued, even in cases where a supportive partner was available to help. If no partner help was available, people strove for independence rather than autonomy. In some cases, independence in writing was valued more highly than grammatical correctness.

These findings confirm those of Parr, Byng, Gilpin and Ireland (1997) in describing the significance of apparently minor consequences of literacy problems which result in loss of control over the maintenance of relationships, the organisation of personal time and over the help and support offered by others. They also confirm the comments made by Boazman (2003) that apparently small steps forward can be life changing for people with aphasia:

'I have become increasingly aware that for some clients their own perceived level of control and confidence is paramount to their ability to work with a way of life that has become their new reality....I found that in counselling people with aphasia, in particular, what seems to be a minor incident can be life changing.'

Boazman 2003: 40

7.4.2.5 General benefits

Reconstruction or reconnection with identity through writing

Several participants used the VR software to create a written account of their life pre stroke or a written account of the stroke itself. The use of VR to aid this process was adopted spontaneously by five of the six participants who became independent users of the software and was clearly of great personal relevance to these people. This application of writing skills was unexpected and adopted spontaneously by participants. It is very similar to an application reported by Bruce et al. (2003) who noted that their participant used VR to start writing an account of his life following his stroke.

Some participants in study two were motivated by the desire to reconnect with their pre-stroke identity by recounting the story of their working life or early life experiences. Some of the desire to do so stemmed from a desire to create a record of themselves for their children or grandchildren, aware that it was now difficult for them to tell these stories face to face. Others were more preoccupied with recording the story of their stroke and how this impacted on their lives. These people appeared to recreate a new sense of identity by recording and working through these events.

The healing power of writing has been noted in relation to other disorders (Bolton 1999). Many of the functions listed above echo those identified by Arthur (1998) for writing in the face of terminal illness (self-presentation, handing on, enabling communication that is not possible face to face). They also echo those identified by Ireland and Pound (2003) with reference to poetry in aphasia. Despite the fact that poetry is creative rather than narrative writing, the benefits appear to be similar. Ireland and Pound emphasise the healing power of writing: by writing new identity and dignity is gained, strong emotions can be released and the writer gains a sense of ownership and control over language and with it a sense of self-respect.

Benefits to memory through writing

Writing with voice recognition provided a means to aid memory for people with aphasia. This was in the form of keeping a journal as a reference and reminder rather than using writing to note down appointments prospectively. Having a written record provided people with reference when trying to recall names or places. Having access to writing therefore enabled participants, to counter some of their memory difficulties. This application of writing to keep a retrospective journal rather than a prospective diary was unexpected and reflected the greater value of the former to people with aphasia. Again Bruce et al. 2003 report a similar finding in their case study investigation of a person with aphasia who became a proficient user of VR and started to keep a diary, not something that he had done before his stroke. It may be that this journal did not just serve as a memory aid but also functioned to confirm a sense of self as discussed above.

Computer skills gained

Qualitative findings showed that all participants perceived themselves to have made tangible progress in terms of basic computer skills, irrespective of whether they demonstrated ability to use VR successfully to write. This gave new confidence, which in turn made them consider trying new projects at the time of the post therapy interview. Those who had not been successful in using VR did not appear to have been discouraged from using a computer in future. On the contrary, participants expressed the desire to learn more, progress to using email or the web and considered the possibility of enrolling on basic computer courses as a next step.

Quantitative data on the profile of computer skills acquired showed that all participants did indeed gain basic computing skills, even those who did not gain basic VR skills. Wide variation was shown both in the baseline skills participants had at outset but also in the extent to which new skills were acquired. All participants were given the same number of training sessions, but each started from a different baseline of skills and the speed at which skills were acquired varied considerably and was not related solely to time spent dictating. P3, P8 and P10 started from a similar baseline of skills, yet P3 acquired a greater number of skills in the ten sessions than P8 or P10 did in 20 sessions. This may explain her positive evaluation of the training process, despite failing to achieve basic skills in independent use of VR. The acquisition of new computing skills still left her with a feeling of achievement. Similarly, the substantial gains in computing skills shown by other participants may in part explain the positive responses of these people to VR.

Benefit of gaining an occupational activity

Participants who failed to use VR successfully to write reported valuing having an activity and a focus for new learning. Participants spoke of feeling they were generally 'stuck' or 'in a rut'. The impact of losing literacy skills was of great significance to several participants in creating 'empty' spare time. The potential impact of this loss is captured in the following quotation:

'Reading is still hard and less pleasure than before...So frustrating: means me cut off to learn knowledge. Belong in my own private world...world. Miss reading novel. Catch expression and inner feelings more like poetry. A big loss. Last evening I tried to read again Lord of the Rings but I cannot read in the evening. I so weary and ache.'

Ireland & Pound 2003: 146

These findings echoed those of study one, which had found that people valued computer therapy as an occupational activity in its own right, independent of gains made for communication.

Cyclical nature of benefits

As in study one, some of the positive response reported in the qualitative findings for study two stemmed from some of the more general benefits that were perceived and which contributed to an increased sense of general well being, irrespective of gains to either language impairment or language activity. The value of gaining computer skills or an occupational activity contributed as much to a sense of progress and achievement as benefits to writing or writing activity. This explains the positive response of those for whom no tangible benefit in using VR was demonstrated.

7.4.3 Who may benefit from using VR?

The discussion of who may benefit from training in use of VR will be divided into the following sections. Language characteristics will be discussed first, in particular characteristics of spontaneous speech and writing abilities, followed by a discussion of time post onset. For each, qualitative findings will be presented first followed by quantitative data where relevant.

7.4.3.1 Nature of the language impairment

Severity of impairment

All participants in this study were classed as having relatively high level aphasia as determined by the WAB Aphasia Quotient (AQ, range = 70-97) and all had anomic or conduction aphasia. However, findings indicated that the overall AQ was of less relevance in determining who might succeed with the software than specific characteristics of spontaneous speech and the potential gains to be made by being able to write independently.

Characteristics of spontaneous speech – quantitative data

This study found that the best measure of language to predict who may succeed using VR was a descriptive analysis of spontaneous speech. In particular production of few speech sound errors or ability to self-correct speech sound errors appeared to be the most favourable characteristic for using VR.

Study two is the first case series investigation of people with aphasia to explore which language characteristics are most suited to facilitating use of VR for

writing. Previous studies with people with dysarthria have found that speech intelligibility is likely to be critical in obtaining good accuracy levels and hence functional use of the software. Speech sound errors are likely to impact negatively on speech intelligibility and hence software accuracy (Doyle, Leeper, Kotler, Thomas-Stonell, O'Neill, Dylke, and Rolls 1997, Ferrier, Shane, Ballard, Carpenter and Benoit 1995, Thomas-Stonell, Kotler, Leeper and Doyle, 1998).

Previously research investigating the use of VR by people with aphasia comprises a single case study (Bruce et al. 2003) with additional information on use of VR in aphasia being taken from a study of a user with dysarthria and acquired reading and writing difficulties (Manasse et al. 2000). In Bruce et al.'s study, the successful user of VR had particular difficulty producing polysyllabic words, making speech sound errors (for example *whisping* for *whisking*). His speech was also characterised by sound and syllable repetition (dysfluency). No information is given as to whether he was able to self-correct these errors. He was able to use the software effectively despite these problems and occasional grammatical errors (for example *they is eating*). Manasse et al. 2000 describe their participant as showing slightly reduced intelligibility due to dysarthria with speech characterised by a slow speaking rate, breathy vocal quality, reduced vocal loudness and imprecise pronunciation.

As in Bruce et al. 2003 the presence of dysfluency in the form of sound or syllable repetition or sound prolongations did not prevent participants in this study from achieving high levels of accuracy. Interestingly dysfluency was rarely observed during dictation and if it was, usually occurred during the rehearsal of phrases before the microphone was switched on. If dysfluency did occur during dictation, participants were able to delete and repeat the phrase for dictation.

Likewise, as in Bruce et al. 2003, participants in this study were also able to use the software to write effectively despite evidence of morphological and sentence processing impairments. The writing produced by such participants was not error free and all continued to rely on others for corrections when writing formal letters. However, VR enabled them to translate their own thoughts to paper first or communicate informally with friends.

Participants in this study who demonstrated successful use of VR included those who had more impaired spoken language than has been reported in previous studies (Bruce et al. 2003, Manasse et al 2000). Findings of study two suggest that a broader spectrum of people in terms of language impairment will be able to access VR than the limited research to date has indicated (for example P7 with an Aphasia Quotient of 73). However, successful use does not depend on language impairment alone as will be discussed further in section 7.4.4 below.

Characteristics of writing –qualitative and quantitative data

This study showed that level of written language impairment at baseline as measured by the WAB (Kertesz 1982) predicted who would go on to benefit from using VR. Those whose baseline language skills were so poor that they were totally dependent on others to write were more likely to perceive benefit from use of VR software and be motivated to continue using it, than those who had access to writing via another mode, but sought to improve quality or quantity of writing. Those who started with relatively good baseline skills in writing were less likely to demonstrate benefits to language produced using VR and were less likely to continue to use the software to write. These findings agree with findings from Kotler and Tam (2003) and Hawley (2003) that access to an alternative mode for writing will influence a user's perception of the value of VR.

Other speech and language characteristics

P4 was the exception to this pattern. She demonstrated good ability across spoken language modalities. Her reading was significantly more impaired than writing and she reported that reading was her main concern. The difficulties she had reading made handwriting totally impossible for her, as she was unable to read back what she wrote and hence correct spelling or grammar errors. Use of VR enabled her to use the text to speech facility to hear read back what she had written, simultaneously overcoming difficulties with spelling and difficulties with reading or editing what was written. Thus despite her relatively high-level writing skills at the outset, writing with VR offered concrete benefits. These benefits are similar to those reported by users of text to speech feedback to support word processing (Armstrong and MacDonald 2000).

P6 as a non-native speaker of English (first language Punjabi) also demonstrated that having English as first language was not essential in order to use the software effectively. The flexibility of the software in enabling training of specialist vocabulary (in this case Punjabi names and terms) and the flexibility of the software in progressively adapting to individual pronunciation patterns appeared to counter initial difficulties with recognition accuracy for this participant.

The success achieved by these two participants and those with significant language impairment suggests adoption of a broad pragmatic approach when selecting appropriate candidates on the basis of language impairment. It is likely that other factors (discussed in section 7.4.4 below) will be as influential as the person's language impairment in determining success.

7.4.3.2 Time post onset

Similar to findings of study one, study two findings indicated a potential to benefit from using the computer for people from as early as 1;4 years post stroke and ranging up to 14 years post stroke. These findings are comparable to the findings of Bruce et al. (2003) whose participant was 18 months post stroke when he started to use VR and Manasse et al. (2000) whose participant was 15 months post head injury when she started to use VR.

Study two provided evidence from one participant, that if training is started as early as 7 months post stroke, this might reduce ability to benefit. She was one of only three participants to fail to acquire skills. Further research is required to determine whether people less than one year post onset can benefit from computer therapy and if so what other factors prevented this participant from benefiting. One hypothesis is that she failed to succeed because she had no support for practice between sessions and simply did not have the confidence to engage in practice alone.

7.4.4. What are the key components facilitating benefit to writing activity using VR?

Several issues arise in consideration of the findings of the qualitative and quantitative evaluations, which illuminate what components of the intervention might be crucial in facilitating benefits. Elements of spontaneous speech that are likely to impact on software recognition accuracy have already been considered (section 7.4.3.1). Other key issues are highlighted here. The significance of software accuracy levels are discussed first, followed by a discussion of how VR skills are acquired and what benefits to writing result. All of the above are in turn influenced by contextual factors and these are considered last.

7.4.4.1 Software recognition accuracy

Previous research has highlighted the impact of levels of software recognition accuracy on whether users will go on to use the software regularly (Koester 2001, Thomas-Stonell et al. 1998). In study two, software recognition accuracy did impact on whether participants went on to use the software independently. The participant who achieved less than 50% software accuracy asked to stop training. All those continuing to use the software at 12 months post training had achieved an accuracy level of 80% or more. These levels are similar to those achieved in previous investigation of use of VR by a person with aphasia who went on to use the software regularly (Bruce et al. 2003, 84-92%).

Bruce et al. conclude that to achieve good software recognition accuracy, users with aphasia need to be consistent in production. They do not define any more narrowly what characteristics of speech this implies or excludes. Findings from study one shed more light on the relationship between spontaneous speech and accuracy levels. They indicate that what is crucial is the ability to self-correct errors or if necessary circumlocute speech errors. Successful avoidance of speech sound errors or dysfluency in dictation therefore depends on skilful coordination of the microphone during dictation: by switching off the microphone as soon as an error is made, the user can avoid transcription of errors and the time taken for correction. This is an area, which has received relatively little attention in the literature, but was crucial in enabling people to circumvent

speech sound errors. Application of this strategy can broaden the range of people who can potentially access the software.

7.4.4.2 Acquisition of VR skills

Some participants achieved only basic use of the software whereby accuracy obtained during enrolment was maintained but never enhanced. Others went on to acquire the necessary skills to enhance accuracy during dictation. Ability to enhance software accuracy with time was clearly an advantage in maintaining motivation to continue using the software over the long term, particularly if software accuracy levels achieved with standard enrolment were not particularly high. It was disappointing but perhaps not unexpected that some participants, particularly those starting from a lower skills base, did not acquire the more advanced level skills. Similar findings (namely that users fail to acquire more advanced skills) have been reported for users of assistive word processing software (Armstrong and MacDonald 2000). Training time in study two was restricted to a total of 20-30 hours over a period of approximately three months. This compares to training given by Bruce et al. (2003 – 17 one hour training sessions over 8 months where advanced VR skills were acquired). However, it was considerably less than the 40 hours of training that van de Sandt-Koendeman (2004) suggests as a minimum for teaching functional use of a communication aid to someone who does not have any of the concomitant memory difficulties associated with aphasia. The time given to training may have been too short to teach more advanced skills. A recurrent theme from interviews was the difficulty participants had with learning.

However, not all participants who went on to use the software at 12 months post training acquired the advanced skills. Two who failed to do so compensated by reliance on support from a partner or volunteer to repeat the standard enrolment periodically and to assist in correcting text. It is therefore possible to use the software with basic skills if support is available.

Ability to identify and correct errors rapidly and easily may enable users to tolerate a lower recognition accuracy rate (Rosen and Yampolsky 2000). Computer skills data showed that ability to identify and correct more than 80% of

errors was not achieved by the majority in the study and this may have contributed to the decline in use over time and reliance on others for editing.

7.4.4.3 Benefits to writing

Perceived improvement to quality and quantity of writing was not enough to bring about longer-term use of the software. Those who continued to use it long term were those who benefited by being able to write independently for the first time. The significant increase in autonomy provided motivation to overlook errors in writing produced and overcome difficulties using the software. This confirmed suggestions elsewhere in the literature that access to alternative modes for writing will influence a user's perception of the value of VR and hence longer term use (Kotler and Tam 2002, Hawley 2002).

7.4.4.4 Contextual factors

Computer skills: baseline and acquired

The importance of basic computer skills, in particular coordination of the microphone with dictation has been discussed above. Ability to coordinate the microphone depended in turn on computer skills at baseline and speed of acquisition of computer skills. Findings from the qualitative evaluation indicated that those with basic computing skills at the outset perceived this to have been an advantage. Those without these skills reported that acquisition of new skills was a challenge.

Quantitative data showed that in general, those starting from a higher baseline of skills were likely to achieve a greater level of competency using VR. However, good baseline skills were not a prerequisite: some participants with little or no previous computing skills went on to acquire both basic computing skills and basic VR skills. Previous skills or levels of practice alone however, did not account for all the variation found between participants. It became apparent that some participants experienced the training as more difficult than others, with some commenting explicitly on how challenging it had been.

Unlike the previous study, this study used standard off-the-shelf software, rather than software purposively designed with for the user with aphasia and associated

deficits. Nonetheless, people with no previous computer experience were able to acquire skills to go on to use the software over the longer term.

Support during practice

Those making the most gains were those who had previous computing experience, support during practice between training sessions or engaged in much practice of dictation between sessions. It may be that support during practice was critical for those with little computing experience, when fear and anxiety associated with using the computer may be an inhibiting factor. The three participants who failed to acquire any basic skills with VR had no access to support. One attributed her failure to acquire skills to this factor. Amongst those who achieved basic skills and who continued to show regular use, two of these attributed their success in part to the support they had during practice.

Time in practice

There was no facility within the VR to capture the amount of practice that participants engaged in between sessions, so no direct comparisons can be made with the practice times recorded in study one. However, the number of independent dictations carried out functioned as a gross measure of usage. There was no clear link between usage and gains made. These findings imply that, as in study one, there were differences in the speed of learning demonstrated by participants, which only became apparent during the training process.

7.4.4 Summary of findings of study two

These findings confirmed the hypothesis that benefits from therapy aiming to improve writing activity through teaching use of VR software would result in broader benefits than simply to writing activity. No benefits occurred to impairment. Benefit to quality and quantity of writing produced was found as well as benefits to autonomy in writing. A range of new writing activities were undertaken as a result of these gains which served a range of functions: social, leisure, business, health related, aiding memory and reworking identity. Other benefits included improved computing skills and access to a meaningful leisure occupation. All of these effects led to improved confidence. Improvements to confidence occurred in the absence of benefits to writing and were clearly the

result of more general benefits such as improved computing skills. Findings showed that people who are able to self-correct speech sound errors are more likely to be able to use VR effectively as a result of achieving higher rates of software accuracy. Poor writing skills and dependence on help for writing also act as strong motivating influences. People with no previous computer experience and non-native English speakers can succeed with VR. Benefits from using VR may occur many years post stroke. However, there may be a minimum time of approximately one year post stroke, before which benefits are less likely. Key components in bringing benefit are speech sound production, software accuracy rates, VR skills achieved and perceived benefits to writing. These in turn are influenced by contextual factors in particular baseline computer skills and speed of acquisition of skills and support during practice or long-term use.

7.5 Implications of findings of the two studies

This section highlights the commonalities and differences of the two studies and summarises broader themes arising from the research. This section will include an evaluation of the extent to which the ICF (WHO 2001) provides an adequate framework for the context of this research.

7.5.1 Common themes emerging from the two studies

Figure 7.1 summarises the key findings of both studies with reference to study objectives. Study one demonstrated that broader benefits were found in the context of computer therapy that targeted impairment alone. There was conclusive evidence (converging qualitative and quantitative findings) of benefit to word finding as measured by picture naming. There was evidence (qualitative only) that gains of this kind at impairment level impacted on communicative activity. Qualitative findings also indicated benefit to social participation, confidence and sense of self. Benefits to confidence were attributed to acquiring computer skills as well as to improvements in language skills. Evidence of a positive cycle emerged in which cumulative benefits to confidence had positive benefits for communication. Some people with aphasia valued computer assisted therapy as an occupational activity irrespective of gains to language. These

benefits were demonstrated from 18 months to 11 years post onset by people with a range of underlying speech and language impairment, some of whom had no previous computer experience.

Study two demonstrated that broader benefits were found in the context of computer therapy that targeted language activity (writing) alone. There was no evidence that impairment levels had changed, so these positive results can occur in the absence of benefits to impairment. Benefits to quality and quantity of language produced were found (qualitative and quantitative) and benefits to autonomy in writing. Benefits to language activity resulted in increased writing activity for social, leisure, business, health-related, memory purposes and to address issues of identity, thus impacting on participation and on levels of confidence. Benefits to confidence were reported in the absence of benefits to writing activity. This study also suggested that computer use is valued as an occupational activity in its own right. These benefits were demonstrated by people ranging from 16 months to 14 years post onset. People most likely to benefit were those who were able to correct speech sound errors and who had no other means of writing. People with no previous experience of using computers were able to benefit.

These findings directly contradict the suggestion (Robertson 1990) that computer therapy can result in gains that have little relevance in the life of the user, can compound social isolation or divert attention from more functionally or recreational skills. Both studies show broader benefit than what was targeted in therapy and both resulted in benefits to activity and participation and confidence, irrespective of the focus of therapy. Both highlight the benefits of learning new skills in improving self-confidence generally. Both highlight the positive impact of increasing confidence on communication. Both show the value of independent activity (therapy practice or writing) in increasing autonomy and a sense of control for people with aphasia. Both showed that gains can be made many years post stroke. Both showed that previous computer experience was not necessary for gains to be made. All these issues have been discussed with reference to the individual studies above (section 7.3 and section 7.4). The following section will briefly discuss issues that have not yet been addressed.

Figure 7.1 Summary of findings of two studies

Study one	Findings
What are the benefits?	<ul style="list-style-type: none"> • Independent computer therapy monitored remotely by a speech and language therapist can bring significant change to word finding (impairment). • Benefits to impairment appear to carry over into activity and participation. • Benefits to confidence result from perceived improvement to communication and computing skills and led to a positive cycle in which further gains were demonstrated in levels of activity/participation
Who may benefit?	<ul style="list-style-type: none"> • People with a range of levels and underlying nature of word finding difficulty • Gains can be made from 18 months to 11 years post onset. • All highly motivated and self-selecting • Previous computer experience not necessary
What are the key components in bringing benefits?	<ul style="list-style-type: none"> • This mode of therapy brings increased autonomy for people with aphasia enabling them to control timing and intensity of practice and may result in more intensive practice and more significant gains. • Increased autonomy brings benefits to confidence and self-esteem, which in turn impact on a person's willingness to engage in communication and social participation. • All these gains made in the context of computer therapy without the therapist present but the monitoring role of the speech and language therapist may be critical in the degree of benefit achieved.
Other issues	<ul style="list-style-type: none"> • People with aphasia vary in the speed with which they acquire both computer and language skills in computer based therapy and this variation is not simply related to degree of impairment • Some people with aphasia value computer therapy as occupational, irrespective of benefits to communication

Figure 7.1 Continued

Study two	Findings
<p>What are the benefits?</p>	<ul style="list-style-type: none"> • Use of VR brought improved quality/quantity of writing and increased autonomy in writing • Use of VR as a writing aid in aphasia resulted in increased writing activity for social, leisure, business, health-related, memory purposes and to address issues of identity • Participants reported an increase in confidence that stemmed not only from the improvements to writing but from learning computer skills and increasing writing activity. • There was no evidence of change to underlying writing impairment or language skills generally.
<p>Who may benefit?</p>	<ul style="list-style-type: none"> • Those able to self correct speech errors and those with no other means of writing are more likely to benefit • Gains can be made from 1;4 to 14 years post onset • Previous computer experience not necessary
<p>What are the key components in bringing benefits?</p>	<ul style="list-style-type: none"> • Characteristics of spontaneous speech production, levels of software accuracy achieved and the degree of gain to writing will influence success • Contextual factors such as previous computer skill, speed of skills acquisition, support in practice also impact on outcome
<p>Other issues</p>	<ul style="list-style-type: none"> • People vary in the speed at which they acquire computer skills according to previous skills level, learning abilities and support in learning. • Small gains in writing activity may be highly significant to people with aphasia in terms of increasing autonomy and accessing a medium for self-expression • Some people with aphasia valued computer use as an occupational activity regardless of benefit to communication

Flexibility in training

Both studies showed that previous computer experience was not required for successful use. However, both also revealed the importance of flexibility in therapy or training procedures and the need to adapt procedures to individual needs. The value of such flexibility has been highlighted in previous studies targeting computer-assisted word finding (Pedersen et al. 2001) and use of VR by people with aphasia (Bruce et al. 2003). It is argued that the level of benefit reported in response to both studies was a consequence of this flexibility and adaptation of procedures to individual needs.

Aspirations for continued computer use

Both studies highlighted the value to participants of acquiring basic computer skills and in both studies participants went on to acquire further skills, using email, word processing, the Internet and computer games. In both studies, participants raised the possibility of accessing existing adult computer training. It may be that computer assisted therapy of this kind, by teaching basic computer skills, can act as a stepping stone to accessing a broader range of computer training than would otherwise be available to people with aphasia. Egan et al. 2004 note that little is known of the training needs of people with aphasia. It is likely that once very basic training needs are met, some people with aphasia can access training that is more generally available.

Reasons for improved confidence

The acquisition of computer skills was cited as a reason for increased confidence in both studies. This raises the question of whether increased confidence was the result of an opportunity to learn a new skill per se or whether these reported benefits are linked to acquisition of computer skills specifically.

Findings showed that both of these interpretations could be applied equally well to the data. Both studies indicated the value placed by people with aphasia on experiencing a sense of progress per se. However, both studies also revealed that acquisition of computer skills were associated with a rise in status. It may

therefore be that the effects on confidence of acquiring computer skills are greater than for some other skills. In computer therapy the impact on confidence may be even more significant than in conventional therapy.

Another element in computer use was highlighted by this research that may explain why it is particularly attractive to people with aphasia. Procedures on a computer are made very concrete and tangible by the need to proceed through a determined routine in order to achieve a task. Acquisition of the skills to complete the task is made very visible and concrete, that is, the task is achieved via a series of different screen presentations. It is very clear to the user when a task has been achieved or not. This contrasts with the intangible nature of language and the perhaps even more intangible nature of a language disorder, which is far less visual and concrete. It may be this sense of concrete and tangible progress in skills acquisition that makes computer use so attractive and had such a positive impact on participants' levels of confidence.

7.5.2 Contradictions emerging from the two studies

More commonalities than contradictions arose from study findings. Two contradictions are discussed here.

7.5.2.1 Benefits to impairment, activity and participation

Study one showed benefits to impairment may generalise to benefit activity and participation. Study two did not show any evidence that benefits to writing activity subsequently generalised to impairment. However, both therapies showed evidence of benefit to levels of activity and participation resulting from increased confidence and self-esteem associated with acquisition or facilitation of language skills or acquisition of computer skills or both.

These findings beg the question of what the target of therapy should be. It has been argued that since levels of activity and participation have been demonstrated to correlate most closely with quality of life issues then these should be the prime focus of therapy (Cruise, Worrall, Hickson and Murison

2003). However, findings of this research show that therapy to target impairment can have as much effect on activity/participation and confidence as therapy to target activity. Both therefore remain a legitimate focus of computer therapy.

7.5.2.2 Partner support

Study one findings highlighted the value of partner support in computer therapy. The findings of study two highlighted the variability of individual experience, showing that the partner may not be the best person to offer support. It may be that participants in study one were particularly fortunate in the support they received from partners. This should be borne in mind in future application of remote based therapy.

Both studies, however, reinforced the value of support in practice particularly for those who had relatively little experience. In study two, one participant had support from a volunteer and this may be an alternative way forward if access to computer use by people with aphasia is to be promoted more widely. Use of volunteers to provide basic computer skills training has already been shown to have positive results (Egan et al. 2004).

The differences between the two studies in terms of the degree of partner involvement in the research process highlighted to what extent partner support and involvement may vary. The largely positive evaluation of partner role in study one contrasted with the absence of partner involvement in some cases in study two or even the desire to exclude the partner completely from the process of therapy (section 5.5.6). This raises questions concerning the influence of the partner's role in therapy generally and clearly deserves further investigation in its own right. It was not felt that this could be accommodated within the confines of this study.

7.5.3 Relevance of the ICF to findings (WHO 2001)

The ICF (WHO 2001) provided a useful framework for this study by bringing together social and medical model perspectives within one conceptual

framework. It foregrounds activity and participation as key components of functioning and acknowledges the impact of contextual factors as well as impairment on levels of activity and participation. It fits with the findings of this research regarding the strong cyclical effects in therapy. In particular, the idea that increased confidence may lead to increased activity /participation and that this increase in activity/participation may in turn lead to increased confidence is explained by the multi-dimensional and multi-directional relationships between component parts of the model.

However, the model did not predict the extent to which issues of self-esteem and confidence were foregrounded by participants. This confirms the criticism of the ICF that it retains an essentially 'other than patient' view of functioning (Wade and Halligan 2003, Cruice, Worrall, Hickson and Murison 2003) which sat uneasily in a study in which the perspective of the person with aphasia was adopted as the primary focus of investigation. The latter was perceived to be a particular strength in this study as it revealed the important role in therapy played by what has been termed the 'subjective' dimension (Post, de Witte and Schrijvers 1999). Elements of the subjective dimension crucial to the process of therapy in this research included issues of confidence and identity. It is argued that these elements are crucial to the process of aphasia therapy generally. They may be even more significant in computer therapy, resulting from the high status ascribed to computer skills, from the increase in autonomy associated with computer use or the degree of benefit to language skills or activity experienced.

7.5.4 Relevance of other models of aphasia rehabilitation to findings

An alternative to the ICF (WHO 2001) is provided by the 'integrated' framework for therapy intervention (Byng, Pound and Parr 2000, Pound, Parr, Lindsay and Woolf 2000). Like the ICF, this model seeks to accommodate a social model perspective without losing sight of the variation at an individual level of the impact of the impairment.

The six goals identified by this model and the way in which benefits from this research map into these goals is shown in Figure 7.2. This model acknowledges the importance of issues such as adaptation of identity, the promotion of a healthy psychological state and the promotion of autonomy and choice in keeping with the emphasis given to them by participants in this study. The findings of this research confirm the value of computer-assisted therapy in achieving the equilibrium that Byng and colleagues advocate:

An equilibrium has therefore to be achieved in intervention between working to enhance communication skills – by working directly on the impairment and on strategies to use skills most effectively – and working on achieving a satisfactory sense of identity, making appropriate and acceptable lifestyle choices. Intervention that focuses on only one side of this equation is not going to be satisfying for the aphasic person or therapist; the interrelatedness and interdependency of communication skills and identity is critical.

Byng, Pound and Parr 2000: 52

This research confirms the value of these goals to people with aphasia. Although the goal of therapy was focussed on word finding impairment in study one and writing activity in study two, benefits were found across all six goals identified in the framework. The mode of therapy delivery, computer therapy, contributed to benefits across these areas, many of which were not targeted explicitly in the study design. Promotion of autonomy and choice was a motivating factor and a hypothesised benefit of computer therapy but the promotion of a healthy psychological state and the adaptation of identity were not perceived to be integral goals at the outset. Findings revealed however, that computer therapy had been experienced in this way, even in the context of impairment or activity focussed therapy.

Figure 7.2 Effects from computer therapy mapped onto goals of Integrated Therapy Framework (Byng et al. 2000)

	Enhance communication	Identify/remove barriers to participation	Adaptation of identity	Promote healthy psychological state	Promote autonomy & choice	Health promotion
Study 1	↑word finding* ↑conversation ↑participation	↑confidence ↑access to computers, email, Internet		↑sense of self/well being ↑ occupational activity	↑autonomy over time/intensity of therapy practice	↑sense of well/being
Study 2	↑ writing ↑communication with friends/family & others	↑confidence ↑ access to computers, email, Internet	through written narratives	↑ confidence ↑ occupational activity	↑ increased autonomy over writing	

* ↑ denotes improvements or increase in

7.6 Critical appraisal of study methodology

A critical appraisal of the individual study methods has been included in the discussion of each study (section 7.3 and section 7.4). This section critically appraises the methodology of the research as a whole.

7.6.1 Involvement of people with aphasia

This research set out to determine the views of people with aphasia on using computers in therapy, by establishing the qualitative evaluation as primary data. However, the study did not involve people with aphasia in the original study design, reflecting a participatory rather than emancipatory model of research and remaining essentially 'research on people' rather than 'research with people' (Kiernan 1999). Nonetheless, the iterative design of study two enabled feedback from study participants to influence procedures for subsequent phases. The invaluable contributions made by study participants via the qualitative evaluations, testifies to the added benefits and feasibility of such involvement in any future research design.

7.6.2 Convergence of findings

Qualitative and quantitative methods were combined in this research and did not always converge. The question arises of how to interpret these differences. The expectation that findings will corroborate is perhaps a misleading one as the following quote from Snape and Spencer indicates:

'We acknowledge that qualitative and quantitative data do not calibrate exactly, but see this as a manifestation of the different ways in which each method contributes to an understanding of the research question. Inconsistency and contradiction need to be acknowledged and explanations for them sought, but we do not believe this undermines the value of either. But more crucially, we see the quest for replication of evidence produced by different research methods as a false trail. Instead our search is for complementary extension – that is using different forms of evidence to build greater understanding and insight of the social world than is possible from one approach alone.'

Snape & Spencer 2003: 21-22

Some of the particular reasons why the two forms of evidence failed to coincide in this research have been discussed above. Perhaps the most obvious in both studies has been that benefits may have been too small to be detected by the quantitative measures applied yet were nonetheless significant in the eyes of participants.

Applying the principle of 'complementary extension', ultimately the key to proof will be replication of research findings (Olswang 1998). It is argued that similar findings as described here can be replicated independently using qualitative methods. It is also possible that the quantitative measures described here can be refined to enable them to capture benefits not captured quantitatively here. These are clearly areas for further research.

7.6.3 Reliability and validity of qualitative methods

Much debate surrounds the application of the terms reliability and validity to qualitative methods (Marshall and Rossman 1995, Murphy et al. 1998). Seale (1999) argues that reliability is best demonstrated by

'showing the audience of research studies as much as is possible of the procedures that have led to a particular set of conclusions'
1999:158

Clear exposition of the processes of data collection and analysis are essential (Murphy et al. 1998). Lewis and Ritchie (2003) argue that reliability is generally understood to concern the replicability of research findings and whether they would be repeated if another study, using the same or similar methods, was undertaken. Key factors determining reliability will be the sample selection, the consistency with which fieldwork was carried out, the consistency with which analysis was carried out and whether the interpretation was supported by evidence. Sample selection and fieldwork will be considered here followed by a discussion of internal and external validity.

Sample selection

The total number of people with aphasia taking part in this research was 18. Small numbers were crucial in enabling the perspective of people with aphasia to be explored in-depth and in the case of the second study in enabling the intensity

of training to be delivered. However, conclusions to be drawn on the basis of these findings, particularly on the basis of the six participants in study one, are limited. Saturation of the qualitative data and the opportunity to recruit further participants who might contradict hypotheses as recommended in the literature (Ritchie, Lewis and Elam 2003) was not possible within the design of study one. The second study overcame this weakness as people were purposively recruited to the successive phases to reflect a range of language abilities, previous computer experience and a variety of social backgrounds in order to seek confirmation of developing hypotheses.

Fieldwork

All post therapy interviews but not all pre therapy interviews were carried out by the author (JW) in study one. Consistency was achieved in study two with the author (JW) carrying out all interviews, pre and post. However, in study two, in-depth interviews were carried out by the author (JW), who was also involved in delivering computer training. This contrasted with study one, where the author was able to carry out in-depth interviews after therapy, having not been involved in its delivery. The fact the author was known to study participants in study two will have influenced the interview process and findings. Study participants may have been more positive in their evaluation of therapy than they would have been if interviewed by a stranger. However, two facts should be borne in mind before this conclusion is reached. First, participants in study two were still prepared to be openly critical of procedures used by the author (JW) in training. This implies that when interviews are conducted appropriately participants feel able to express negative opinions, regardless of the identity of the interviewer. Second, in study one, the knowledge that the interviewer was a speech and language therapist (and therefore a stakeholder in the research project) may equally have influenced participants' responses. Yet again in this context participants were able to be openly critical. In recognition of these factors however, the most cautious line of interpretation was always followed and where doubt regarding a person's meaning arose this was always acknowledged in interpretation.

Internal validity

Internal validity of data is understood to refer to the extent to which the research investigates what it claims to be investigating (Arksey and Knight 1999) and can

be construed as the extent to which judgements and interpretations of the data are agreed or replicated between judges (Lewis and Ritchie 2003, Murphy et al. 1988). Internal validity was evaluated by asking an independent author to read transcripts, develop charts and summarise key themes arising from two interviews (study one) and from ten interviews (study two). Good convergence of data interpretation was found in both cases. The process was more robust as applied in study two than in study one.

External validity

In discussing external validity, Hammersley (1996) argues the key issue is whether findings are of wider interest. As indicated above, the small number of participants in qualitative research can restrict the generalisability of findings. Murphy et al. (1998) suggest 'transferability' or relevance as a more appropriate term. 'Transferability' assumes that similarities between settings do exist and that a conceptualisation of how findings from one setting can be transferred to another is possible. Murphy et al. argue that relevance can be demonstrated if sufficient detail of the original research is described.

The key strengths of this research regarding transferability of findings lies in the similarity of benefits achieved with two contrasting studies, targeting two different aspects of communication. Findings common to both strengthen the claim that these findings have more general applicability.

7.6.4 Language measures: stability and reliability

A number of methodological issues arose concerning the quantitative evaluation of connected speech samples in study one and the quantitative evaluation of written language samples in study two. These have been discussed above but will be touched on briefly again here.

Absence of multiple baseline data in study one

There is consensus in the literature that in order to assess change in connected speech over time it is essential first to establish stability of baseline measures across at least two baseline sessions (Nicholas & Brookshire, 1993). In study one no multiple baseline data was collected and clearly this was a weakness in

the study design, which was corrected in the design for study two. To compensate for this gap in the data, the methods and parameters selected for analysis were ones, for which session-to-session stability in previous studies had been demonstrated (Herbert 2004, Nicholas and Brookshire 1993).

Lack of reliability in written language analysis applied in study two

In study two there were difficulties with developing a reliable methodology for written language analysis. This reflected the highly exploratory nature of the research: very little previous data is available to guide techniques on analysis of written language produced by people with aphasia. Techniques adapted from the area of learning difficulties (Manasse et al. 2000) were rejected as inappropriate for application to aphasic writing as these techniques stressed the importance of grammatical correctness when qualitative data showed this was less of a priority to participants than communicating a message or writing autonomously. Good reliability across all the parameters identified for analysis was not achieved. However, some parameters of the analysis nonetheless showed good reliability and confirmed qualitative observations regarding impact on writing.

7.6.5 Quantitative data regarding impact on activity/participation and confidence

Both studies would be strengthened by quantitative confirmation of increased levels of activity/participation and confidence. For the latter, a tool such as the Visual Analogue Scale of Self Esteem Scales (Brumfitt and Sheeran 1999a) would provide a quantitative measure of self-esteem. This measure has been shown to be valid and reliable in measuring change to self-esteem in aphasia (Brumfitt and Sheeran 1999b). Measuring change in levels of activity and participation using quantitative measures whilst still retaining the flexibility to capture what is relevant to the individual is hugely problematic (Parr and Byng 2000) which is why the qualitative approach was chosen in this case. Any standardised assessment immediately removes the ability to take individual needs into account. It is argued that there is still place for qualitative evaluation of these issues.

7.6 Summary of discussion

This summary has discussed findings of both studies with reference to the study objectives and to previous literature. It has concluded with a critical appraisal of study methods. The next chapter will sum up the contribution of the study to the field and implications for clinical practice and research.

Chapter Eight: Summary and conclusions

This research investigates the broader effects of computer therapy from the perspective of people with aphasia. It also examined who may benefit from computer therapy and what the key components contributing to benefits may be. This chapter provides a summary and conclusion to this thesis. It begins with a reflection on how the study has evolved during the course of data collection, data analysis and interpretation as this evolution has affected the presentation of data in this thesis in several key ways (section 8.1). It then summarises key findings (section 8.2). It then highlights the implications of these findings for clinical practice (section 8.3) and the implications for future research (8.4). Finally, it outlines the contribution of the study to the existing body of knowledge (section 8.5).

8.1 Evolution of the thesis

The research reported in this thesis was originally conceived as an investigation, which started from the premise that computer therapy was likely to impact on levels of impairment and activity in aphasia but that broader effects of therapy were also possible as a result of effects on impairment and/or activity. It also incorporated the principle that an appropriate method of evaluating these broader benefits was to include a substantial evaluation of participant views on the process and outcome of computer therapy, something that had not been attempted before. However, the author (JW) conceived the research on the basis of her clinical and research experience. It did not therefore accommodate or reflect the views of people with aphasia in the conceptualisation of either its goals or in terms of selecting its outcome measures.

The research has evolved in response to findings from both studies and this evolution has been reflected in the presentation of data and the conclusions that are drawn. The key finding to influence both presentation and conclusion in this way is the emphasis placed on the subjective dimension of the benefits reported from therapy. These included the benefits to confidence, self-esteem and sense

of self or well-being reported from both studies, and in some cases reported in the absence of benefits at the level of impairment, activity or participation (for example P10 in study two).

Representation of data

The emphasis placed by participants on these subjective elements has led to a representation of the data in writing this thesis in a way that reflects some of the tensions between the position of the author at the time of the original research proposal and the position of the author following analysis of the findings. It is reflected in the content of the literature review, which includes literature reviewed during the course of data collection and analysis as well as literature reviewed prior to data collection. It is reflected in the order of presentation of outcome data for both studies: originally the qualitative evaluation of participant views was conceived as a supplementary evaluation to complement quantitative methods, which have been traditionally more commonly associated with aphasia research. Following data analysis it became clear that the qualitative findings shed more light on the process and outcome of therapy in terms of highlighting the subjective elements that were of most importance to study participants and they were therefore reported first.

It could be argued that the literature review might have better reflected this process of evolution by foregrounding and expanding on issues surrounding identity in aphasia with reference to the wider disability literature and by incorporating background literature concerning the debate between 'participatory' research and 'emancipatory' research models (Kiernan 1999) (section 7.6.1). However, as with any piece of writing, at some point revision has to end. Rather than attempting to incorporate discussion of these very important issues as part of the literature review, these issues will be highlighted as key areas for future research.

A key finding of the research was the weight given to the subjective benefits of therapy by the people with aphasia. This begs the question of whether these elements may be more important from the perspective of people with aphasia than those aspects that have been traditionally singled out by professionals for

investigation (change to impairment or activity for example) and may temporally precede benefits to impairment or activity. In presenting data from the qualitative interviews, benefits have been divided into primary and secondary benefits. This division was made on the basis of how themes emerged from the interview data and may reflect a tendency for people to report more concrete benefits first then proceed to elaborate on the more subjective elements of benefit. It is not intended to exclude the possibility that some of the more subjective benefits may occur first and lead to more concrete benefits as a result.

8.2 Summary of findings

First, by investigating computer therapy from the perspective of people with aphasia, this thesis has demonstrated that computer based therapy can serve a much broader range of purposes than the improvement of impairment alone. Computer therapy can impact significantly on impairment (study one) but it can also impact on communication activity either indirectly (study one) or directly (study two). It can impact on social participation both as a result of increased communication activity generally (study one) and as a result of facilitating access to letter writing, email and the Internet through teaching of basic computer skills (studies one and two). Transfer of benefit to activity and participation occurs spontaneously without specific therapy to target generalisation.

Second, findings indicated that people with aphasia show these benefits from computer therapy targeting either impairment or activity from as little as 1;4 years to as many as 11-14 years post stroke. People with a range of speech and language profiles can benefit and previous computing experience, although an advantage, is not required.

Third, a key novel finding in respect of aphasia research was the importance played by subjective effects of therapy, in particular levels of confidence in contributing to perceived benefits. The level of importance assigned to these effects was not anticipated at the outset. It demonstrated that, from the perspective of people with aphasia, improvements in confidence can influence

communication in the same way as improvements to impairment (study one) or activity (study two). It also demonstrated that improvements in therapy are cumulative and cyclical (study one and two). An increase in confidence feeds onward to encourage an increase in activity and participation, which in turn increases confidence. The result is a positive cycle in which the whole is greater than the sum of its parts. It is likely that this is a feature of therapy in general. However, in computer therapy, increased confidence associated with learning new computing skills played a key role. Increased confidence may have been proportionally greater than would be found in conventional therapy as a result of the increase in autonomy associated with gaining computer skills, the association of high status with computer use or the degree of benefit resulting to impairment or activity from computer use.

A second key novel finding was the potential occupational benefits of computer use for some people with aphasia. The challenge of how to fill large amounts of free time in a way that has purpose and meaning was a recurrent theme in both studies. Computer therapy was perceived as a pastime that had purpose and meaning on a number of levels. First, it had potential to improve or facilitate language skills (study one and two). Second, it brought increased autonomy in therapy practice (study one) or written communication (one and two). Third, it provided a means to acquire basic computer skills and hence access email and the Internet. Finally, for some it represented a pastime in its own right that brought satisfaction associated with the acquisition of new skills.

8.3 Implications for clinical practice

Two key implications arise from these findings for use of computers in aphasia therapy. First, the goals of computer therapy should be viewed as multidimensional. Therapy using a computer has potential to bring benefit at various different levels. These different levels will be considered in turn. The multidimensional nature of computer therapy will also have implications for who is appropriate for this therapy and these will be considered last.

Computer therapy to address impairment

Firstly, computer therapy is a valuable medium for delivering high intensity therapy to target language impairment (for example, word finding in study one). Gains demonstrated entirely with computer therapy, compared very favourably with gains demonstrated in previous studies targeting word finding with or without a computer. The intensity of practice, which is facilitated by independent computer therapy, may be critical in bringing about the levels of change in impairment reported in study one and these levels of intensity may only be achievable via independent practice using computers.

Computer therapy to address activity/participation

Computer therapy can address communicative activity and social participation in three ways. First significant benefits to language impairment spontaneously generalise into communicative activity (for example, improvements to word finding in picture naming generalised to conversation and engagement in social interaction, study one). Alternatively, the computer can function as a tool to facilitate communicative activity such as writing thus compensating for writing impairments associated with aphasia (study two) without attempting to bring change to the level of impairment. Finally, benefits to activity and participation can occur as a result of increased confidence arising more generally from the computer therapy. Computer therapy is thus an appropriate medium to address issues of confidence themselves.

Computer therapy to address issues of confidence

People with aphasia valued the opportunity to learn a new skill. Rehabilitation focuses too easily on restitution of skills and can tend to forget that the learning of new skills can be a rejuvenating experience at any stage of life. The significance attached by people with aphasia to the increase in self-confidence associated with learning new computer skills had not been anticipated at the outset of the research and appeared to be as critical in contributing to improved communication activity, social participation and self esteem as any improvements to language skills themselves. Use of computers in therapy enables issues of confidence to be addressed as a by-product of the mode of therapy delivery.

Computer therapy to address issues of autonomy

Use of computers in therapy can increase the autonomy of people with aphasia in a two ways. First, delivering therapy using the remote-based model described in study one increases the control of the person with aphasia over the therapy process. Timing and intensity of therapy practice is determined by them and dependence on either partners or the therapist is reduced. Second, use of VR software as a tool to facilitate writing can increase autonomy and control over the writing process and reduce dependence on others. The increase in autonomy associated with using the computer independently, also increases self-confidence and a sense of control.

Computer therapy as a pastime

Some (though not all) people with aphasia report ongoing difficulties filling the large amounts of free time available to them with meaningful occupation in the context of limited physical mobility and limited social interaction resulting from this and their aphasia. Use of a computer provided them with a meaningful pastime that was compared favourably to alternatives such as watching television. These benefits are quite independent of any benefit to language but have potential to impact on psychological well-being and can therefore be justified in their own right.

Implications for people who may benefit

The conceptualisation of computer therapy as being multi-dimensional in its objectives has implications for the range of people who may potentially benefit from computer therapy in aphasia. This range will be broader than would be assumed if the focus of therapy is to target impairment or even communication benefits alone. Those aspiring to access computers as an occupational activity have the potential to benefit in terms of increased autonomy, increased confidence and a sense of purpose independently of any gains to communication. As a consequence, criteria for selecting people for computer therapy must also be broadened beyond examination of language impairment. Findings of this research indicate a potential to benefit from computer therapy from as early as one-year post stroke. Previous computer experience (although an advantage and increasingly common amongst the general population) is not necessary for people to benefit, in particular if software is purposively designed

to accommodate the learning needs of people with aphasia (study one). Acquisition of computing skills requires a degree of learning ability, basic visual skills and repetitive practice to become familiar with routines. People with significant levels of aphasia can learn these skills with practice, even where software has not been adapted specifically to their needs. However, the development of software designed for the specific needs of people with aphasia will reduce the burden of learning (study one). Support from a third party (a volunteer may be as much help as a partner) may be critical for those with little experience in the early days (study one and two), but an increase in levels of autonomy using the computer is possible for even those with considerable difficulty acquiring skills (study one and two).

8.4 Implications for research

The findings of this research have implications both for the manner in which future research is carried out and for the focus of future research. The extent to which participants highlighted the subjective benefits of therapy raises the issue of how future research is conceived and designed. It is essential that future research includes people with aphasia in the development of the research proposal, objectives for evaluation and the means by which outcomes will be evaluated. This will ensure that the issues of relevance to people with aphasia are identified as research objectives and that any measures used to evaluate progress to objectives are likewise relevant. This will require breaking away from the paradigm in which the researcher is seen as expert and embracing a more symbiotic relationship between researcher and person with aphasia as partners in the research process from the stage of study design onwards.

Given the broad range of potential benefits from computer therapy in aphasia, it is recommended that the focus of computer therapy research be broadened from the current focus on benefits to impairment. The importance of research into impairment focussed computer therapy is not denied. One of the findings of study one is that more research is needed to determine precisely which computer based therapy tasks brought benefits for each individual participant. However, this study indicates that further research is needed into the potential benefit of

computers as a means of increasing autonomy of practice in therapy (study one), as a means of facilitating writing (study two), as a means of imparting basic computing skills to users with aphasia (study one and two) as a means of increasing confidence by acquisition of new skills and as an occupational pastime.

Research to address benefits to impairment from computer therapy

Future research must continue to establish what computer therapy tasks impact on what kind of language impairment. Focussed investigation of the different impact of particular therapy tasks on different individuals according to their language impairment was clearly indicated by the variation in response to therapy shown by the six participants in study one. The use of computers to carry out this kind of rigorous evaluative research can only add to the existing body of knowledge developing around the treatment of word finding difficulties in aphasia, using both computer and conventional therapy tasks. Possible key factors identified as contributing to gains in word finding in study one were the opportunities for repetition of the target, intensity of practice, total cumulative time in practice, underlying language impairment and the increase in autonomy associated with this mode of delivering therapy. Some of these are common to all investigations of word finding. Others are unique to this mode of delivering therapy. It therefore offers a unique mode by which to conduct further research in order to isolate further what may be the crucial variables.

Research to address benefits to language use (conversation or writing)

First, there is the challenge of how to demonstrate that benefits at the level of impairment (for example word finding) have impacted significantly on language use. The findings of the research reported in this thesis revealed the methodological challenges inherent in demonstrating this form of carryover (for example showing that improved word finding in naming pictures transferred to improved word finding in connected speech; demonstrating improved quality and quantity of writing produced using VR). Although participants experienced and reported benefits in everyday communication, which were clearly of significance to them, quantitative measures used failed to demonstrate significant change (study one) or demonstrated it on a limited number of parameters only (study two). The problems of how to capture such changes are noted elsewhere in the

literature (Herbert 2004, Herbert et al. 2003) and it may well be that connected speech measures of this kind are simply too insensitive to detect the small changes in word finding that have occurred. However, gains may nonetheless be highly significant in the eyes of the person with aphasia. In the context of these methodological difficulties it seems advisable to accept that a range of methods will continue to be needed in future to demonstrate benefits at the broader level of language use.

Research to address benefits to social participation and self esteem

A similar challenge arises in demonstrating benefits at the level of social participation, confidence and self-esteem. In the two studies reported here, no attempt was made to quantify the change in levels of social participation, confidence or self-esteem that was reported in the qualitative findings. Future research needs to incorporate quantitative measures highlighted in qualitative findings in this research as significant, in order to confirm or contradict the findings reported here. As such, quantitative measures of social participation, confidence and self-esteem should be incorporated. Suitable measures include disease specific quality of life measures such as the SAQoL-39 (Hilari, Byng, Lamping and Smith 2003), aphasia specific measures of self-esteem such as the Visual Analogue Scale of Self-Esteem (VASES, Brumfitt and Sheehan 1999a) and quantitative measures of interactive communication such as the Communication Effectiveness Index (CETI, Lomas, Rickard, Bester et.al. (1989). These measures have the advantage of permitting a rating by people with aphasia themselves rather than simply relying on the judgement of a clinician or partner.

Research to address benefits to confidence more generally in aphasia

During the design phase of the study, the author did not anticipate the relative value placed by people with aphasia on the increase in confidence associated with therapy. Findings from these two studies indicated that this increase in confidence was a key factor in people perceiving a benefit from therapy. It was not possible to tease apart whether these benefits actually preceded the other perceived benefits and may even have led to them. Future research needs to explore further these subjective changes associated with therapy and their

relationship with other reported benefits at the level of impairment, activity or participation.

Research to address issues of identity in aphasia

One key theme to emerge from subjective benefits reported was the importance of rebuilding identity post onset of stroke and aphasia. This process is likely to result from interaction between a range of factors that include pre-aphasic identity (biography, achievements and prospects to date, personal attitudes, attributes and beliefs) and post-aphasic coping mechanisms (revised biography and adopted narrative of stroke and aphasia, support available from family or friends). The process of rebuilding identity in aphasia is likely to be highly individual and have a dynamic component. Further research into key influences surrounding the rebuilding of identity will benefit from application of qualitative methodologies, to capture both the full range of individual responses and the dynamic nature of the process of adaptation.

8.5 Contribution of the study to existing knowledge

First, this thesis is novel in that it provides a detailed examination of the views of people with aphasia on the process and outcome of receiving therapy via computer. It set out to determine whether computer therapy impacted more broadly than simply on language impairment and if so what these other effects might be. By taking the perspective of people with aphasia as its starting point, it captured the range of benefits that people with aphasia perceive to result from computer therapy and illuminated the processes by which these benefits can occur. It did so by investigating the views of participants in two complementary but contrasting studies, one targeting language impairment, the other targeting language activity.

Second, this thesis provides strong qualitative evidence that the positive impact of using a computer in aphasia therapy will be multidimensional. Benefits will be experienced not only at the level of language impairment, but on levels of activity and social participation and on levels of confidence, autonomy and self esteem.

Both studies found a broad range of benefits in all these dimensions, one as a result of therapy focussing exclusively on word finding skills and one as a result of therapy focussing on the facilitation of writing. Broader effects were found without any therapy to target generalisation of skills to other contexts.

Third, this research revealed the cyclical nature of benefits resulting from computer therapy. Both studies demonstrated how benefit to language skills and/or computing skills can lead to improved levels of confidence which in turn can impact on communicative activity and participation and acts. It was not always possible to separate these effects out in terms of temporal sequence and it may be that effects on confidence are at times crucial in leading to effects on activity and participation. These findings act as a timely reminder of the crucial role of improving confidence as an integral part of any therapy process. They suggest that the full potential of using computers in therapy to promote confidence has yet to be tapped.

This research confirms the increasing body of evidence to suggest that people with aphasia can experience a range of benefits many years after stroke. It also suggests that substantial occupational benefits can be obtained from using computers irrespective of benefits to specific language skills.

This research demonstrates that previous computer skills may be an advantage in terms of speed of learning but are not a pre-requisite for success in using computer software, whether this software is designed for people with aphasia or not. However, more progress is likely if people have appropriate levels of support during practice.

This thesis provides further confirmatory evidence of the value of using qualitative methodologies, in particular in-depth interviews, in order to illuminate the experiences of people with aphasia and determine their priorities for therapy. It adds to the growing body of knowledge regarding the views and experiences of people with aphasia, which can only serve to enhance the relevance of therapy goals.

Finally, this research highlights issues of autonomy, confidence and identity in aphasia. It was not anticipated that a study investigating use of computer in therapy for people with aphasia would raise these issues to the extent that they did. This in part no doubt reflects the adoption of the perspective of people with aphasia in the study. It also reflects how important such issues are more generally in aphasia therapy.

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Appendix 1
Software and hardware suppliers

Creative Labs SoundBlaster 16® Creative Labs Inc (1999) Creative Labs Inc.
1901 McCarthy Boulevard, Milpitas CA 95035, USA.

Co:Writer® Don Johnston (2000) 26799 W Commercial Drive, Volo, IL, 60013,
USA.

Dragon NaturallySpeaking® version 7 ScanSoft (2003) ScanSoft Inc.9
Centennial Drive, Peabody, MA 01960, USA.

Dragon NaturallySpeaking® version 6 ScanSoft (2002) ScanSoft Inc.9 Centennial
Drive, Peabody, MA 01960, USA.

Dragon NaturallySpeaking® version 4 Dragon Systems (1999) Dragon Systems,
Inc. 320 Nevada Street, Newton, MA 02460. (Subsequently taken over by
ScanSoft Inc.)

DragonDictate Classic® ScanSoft (1997-1999) ScanSoft, Inc.9 Centennial Drive,
Peabody, MA 01960, USA.

Keystone ScreenSpeaker® Words Worldwide (2000) Words Worldwide, Ash
House, Bell Villas, Ponteland, Newcastle Upon Tyne NE20 9BE, UK.

Microsoft Dictation® Microsoft (1999) Microsoft Office, Microsoft Corporation,
One Microsoft Way, Redmond, WA 98052-6399.

Microsoft Word® Microsoft (2000) 2000 Microsoft Corporation, One Microsoft
Way, Redmond, WA 98052-6399.

Plantronics® SR1 noise cancelling headset Plantronics (2000), Plantronics
Headsets, Daniel Burnham Ct., 310c, San Francisco, CA 94109, USA.

StepbyStep® (2004) Steps Consulting Ltd. stepstherapy.co.uk.

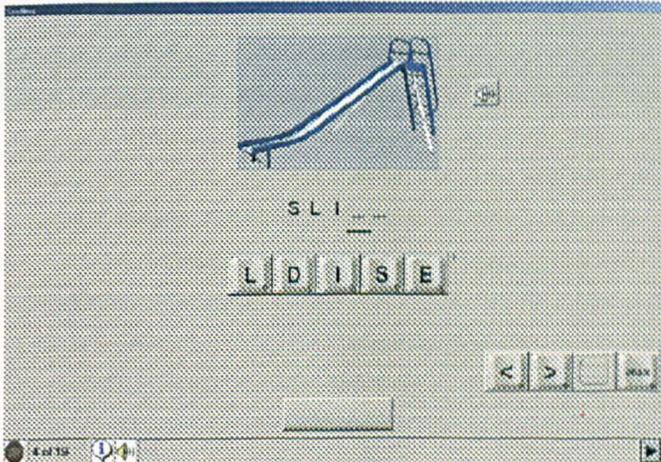
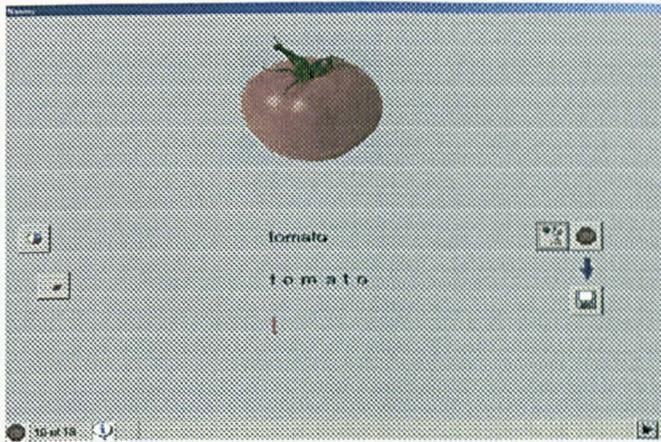
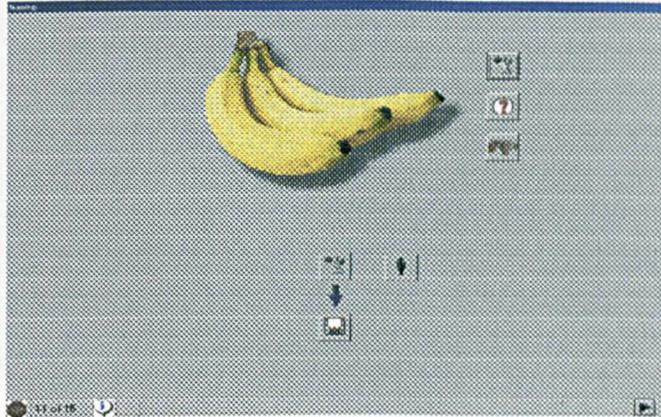
VoiceXpress ScanSoft (1999-2002) Inc.9 Centennial Drive, Peabody, MA
01960, USA.

VoicePad Platinum® Kurzweil Education Systems (1998) Kurzweil Education
Systems, Inc., 411 Waverley Oaks Rd., Waltham, MA 02154, USA.

Write:OutLoud® Don Johnston (2000) 26799 W Commercial Drive, Volo, IL,
60013, USA.

Appendix 2

Screen shots from *StepByStep*© software showing a naming task, repetition task, anagram spelling task (this page) word to picture matching task and the update screen (next page).



Topic Guide – Personalized Learning

Objectives

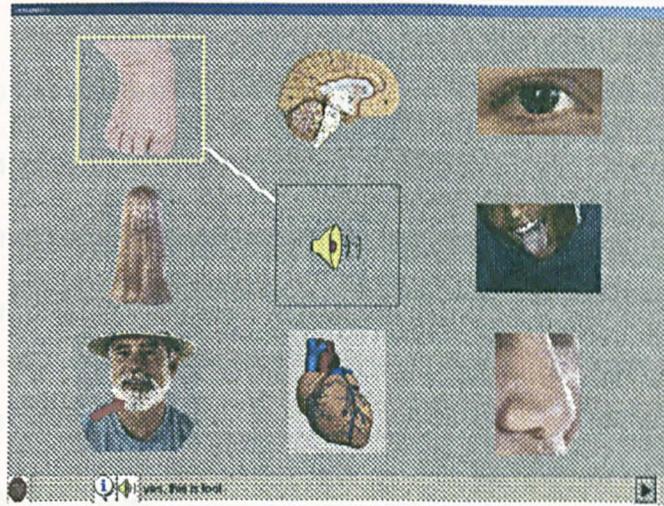
To establish a picture of life

To establish

To establish

To explore

To explore



Introduction

Introduction

Explain Stroke Association

Confidentiality rules

About you

- home, family

- how do you

- how did the

- Activity/

- Family/

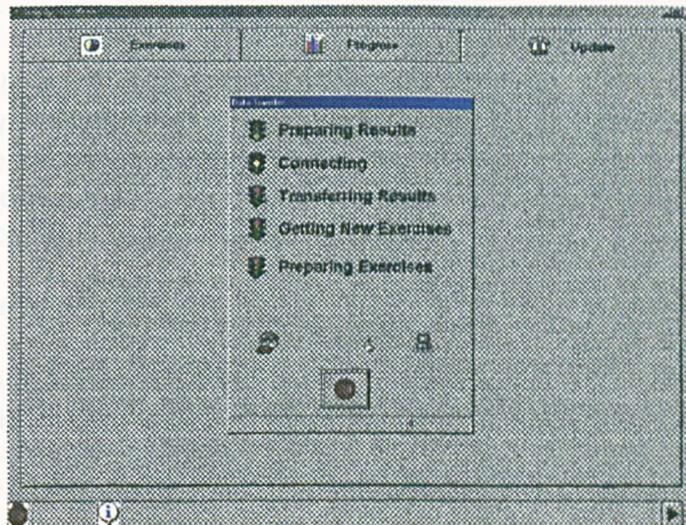
Computer

- use of computer

- use of computer

- use of computer

- use of computer



Expectations of computer

- what do you expect

How do you see the future?

Any questions?

Appendix 3
Topic Guide – Pre therapy interviews – Study One

Objectives

To establish a picture of how person perceives stroke to have affected their life

To establish the person's current view of their communication skills

To establish previous computer experience

To explore expectations of remote based word finding therapy

To explore expectations/aspirations for future in general

Introduction

Introduction to the study

Explain Stroke Association/investigation of project

Confidentiality/tape recording/consent

About you

- home, family, work current/previous
- how do you describe your personality?
- how did the stroke affect your life?
- Activities/work
- Family/friendships

Computer use

- use of computer before the stroke
work/leisure/email/Internet/software
- use of computer since stroke
in therapy?

Expectations of computer therapy

- what do you expect from this computer therapy?

How do you see the future?

Any questions?

Topic Guide – Post therapy interviews – Study One

Objectives

To evaluate the remote based therapy project.

To establish expectations of therapy

To explore experiences of the therapy

To identify views on effects of participating in project on person generally and on their communication in general

To explore views on future access to such therapy

1. Introduction

Introduction to the study

Explain Stroke Association/investigation of project

Confidentiality and tape recording

2. Expectations of the project

- of process – assessment, therapy, reassessment, remote sessions
- of technology/software
- of activities
- of time

What was different in reality?

3. Experiences of the project – what's happened?

- different stages of project
 - activities/tasks – more/less helpful
- how often
- how long
- most liked
- most disliked

(no SLT contact, home, self help, passing time)

- comparison to previous therapy
- comparison to other activities done alone
- comparison to previous computer use
- anything that was missing?

4. Perception of effects

- use of computer generally
- self esteem
- communication
 - word retrieval
 - everyday communication
 - independence in communication
- anything else

(examples of new activities undertaken)

- needs and desires for future therapy

5. Ideas for future remote based computer therapy

- availability for person – why
- availability for others –why
- timing of availability –why

6. Key messages

Most important thing for each person

One key message to take back to funders for future projects?

Appendix 4

Rules for applying POWERS analysis (Herbert, Best, Hickin, Howard and Osborne, in progress)

NUMBER OF SPEECH UNITS

Include

Count all words, non word errors and other tokens such as non-word fillers (e.g. eh? Oh, mm etc).

Treat contractions such as **can't** as one unit.

Include part word responses and false starts/revisions.

Exclude

Do not include sections of unintelligible speech.

NUMBER OF CONTENT WORDS

Include

Content words are defined as nouns, proper nouns, verbs, adjectives, adverbs and numerals.

Adverbs are defined as words ending in **-ly**

Where common verbs such as **get, have, be, do, know** are main verbs they are included.

If an item is repeated count each occurrence separately.

Paraphasias: include all phonological errors and all semantic errors where the target is identifiable.

(Phonological errors are production errors resulting in words or non-words where the target is apparent. The error should contain 50% or more of the target phonemes in the correct order. Semantic errors are word errors where the target is or is not apparent but the word is inappropriate in context.)

Exclude

All neologisms (Neologisms are classed as production errors where it is not possible to identify the target or production contains less than 50% of the target phonemes.)

Part word attempts at production if production contains 50% or less of target.

Generic terms such as **stuff, thing, something**, etc

Modal verbs (**can, must, should, might**) and auxiliaries **be, have, do, will** and **shall**.

Pronouns.

NUMBER OF NOUNS

Extract number of nouns from above. If a word could be assigned to either noun or verb class it was assigned as a noun on the principle that this was more likely.

NUMBER OF FILLED PAUSES

For example **err, um, uh**.

Appendix 5

Rules for applying CIU analysis (Nicholas and Brookshire 1993)

Rules for scoring and counting words and correct information units (CIUs)

Delete statements that are made before or after the speaker performs the task or suggest that the speaker is ready to begin or has finished the task and do not provide information about the picture or topic itself.

- I hope I can remember how I did this before.
- I'll start by saying this
- I'm supposed to tell you about washing the dishes.

These statements should be grammatically separate from discussion of the picture(s) or topic. The following first statements by a speaker would be included in the word count.

- In the first picture, the man is angry.
- Well first of all, there's a couple fighting.
- Okay, there's a man and a woman.

This does not include commentary on the task or on the speaker's performance that occurs while the speaker is discussing the picture(s) or topic. (See 1.22 for rules about commentary.)

Instructions: draw a horizontal line through the middle of words that are to be deleted prior to making decisions about the word count. (~~That's about it~~).

1.0 Counting words

Definition: To be included in the word count, words must be intelligible in context to someone who knows the picture(s) or topic being discussed. Context refers to what the scorer knows about the picture(s) or topic and what the scorer knows from the speaker's prior words. Words do not have to be accurate, relevant, or informative relative to the picture(s) or topic being discussed to be included in the word count.

Instructions: Cross out with red Xs words that are not to be included in the word count.

Rules for counting words

1.1 DO NOT COUNT THE FOLLOWING

1.11. Words or partial words that are not intelligible in context to someone who knows the picture(s) or topic being discussed.

- He went to the **frampi**
- That appears to be a **norble**.

- He had a **st...sn...steak**.
- 1.12. Nonword filler (**um, er, uh**). (See 1.23 and 1.24 for a rule dealing with filler words and phrases, interjections, and informal terms.)

1.2 COUNT THE FOLLOWING

1.21 All words that are intelligible in context. Count words that contain sound substitutions, omissions, distortions, or additions if the word is intelligible in context (**hiscup** for hiccup). If the incorrect production results in another real word that does not appear to be the target word, it is still included in the word count (**paper** for pepper).

1.22. Commentary on the task, on the speaker's performance, or on the speaker's experiences.

- **This is pretty hard**
- **I can't think of that word.**
- **My wife and I used to fight like that.**

1.23. Filler words and phrases (**you know, I mean, okay**). Do not count nonword fillers. (See 1.12.)

1.24. Interjections (**oh, oh boy, wow, golly, gosh, gee, aha, hmm**) and informal terms (**uh-huh [affirmative], uh-uh [negative], hope, yep, yeah**).

1.25. Common contractions or simplifications of words (**gonna** for **going to**, **sorta** for **sort of**, **em** for **them**). Contractions (both standard [**don't, he's**] and colloquial [**gonna, sorta**]) are counted as two words.

1.26. Each word in hyphenated words (**jack-in-the-box** = 4 words).

1.27. Each word in numbers (**twenty-two** = 2 words, **nineteen fifty five** = 3 words)

1.28. Compound words as one word (**pancake, cowboy**).

1.29. Each word in proper names (**Mary Smith, St Paul** = 2 words each)

1.30. Count acronyms as one word (**VA, VFW, TWA** = 1 word each)

2.0 COUNTING CORRECT INFORMATION UNITS (CIU's)

Definition: Correct information units are words that are **intelligible** in context, **accurate** in relation to the picture(s) or topic and **relevant** to and **informative** about the content of the picture(s) or topic. Words do not have to be used in a grammatically correct manner to be included in the correct information count. Each correct information unit consists of a single word and only words that have been included in the word count can be considered for inclusion in the correct information unit count.

Instruction: Put a diagonal pencilled slash through words that are not to be included in the correct information count (~~man~~).

RULES FOR COUNTING CIU's

2.1 DO NOT COUNT THE FOLLOWING

(In this section, words in **bold print** would not be counted as correct information units.)

2.11 Words that do not accurately portray what is in the picture(s) or that do not seem accurate in relation to the topic being discussed, such as incorrect names, pronouns, numbers, actions, etc. If a word reflects regional usage (such as calling the midday meal 'dinner' in some areas), it is counted as a correct information unit. If grammatical incorrectness would elad to misunderstanding or uncertainty about the meaning of words, the grammatically incorrect words would not be counted as correct information units. (See 3.12 for examples of grammatically incorrect words that would be counted as correct information units.)

- The girl **is** riding her bike. (The picture shows a girl with a bike nearby which she may have been riding, but which she is currently not riding.)
- The **girl** is on a **ladder**. **She fell**. (The picture shows a boy on a stool who is tipping but has not fallen yet.)
- The **boys** and **girls** are arriving. (The picture shows only one boy and one girl arriving.)

If several people are involved in an action and only one of them is mentioned, the mentioned one is still counted as a correct information unit. This constitutes an incomplete description but not an inaccurate one.

The boy is arriving. (The picture shows a boy and a girl arriving.)

The man drove away. (The picture shows a couple driving away.)

2.12 Attempts to correct sound errors in words except for the final attempt.

He put **paper popper** pepper on his food.

She say her with her **mass...mack...mask**.

2.13. Dead ends, false starts, or revisions in which the speaker begins an utterance but either revises it or leaves it uncompleted and uninformative with regard to the picture (s) or topic.

- **My si...no no not my sister...my fa...** with my wife.
- He goes over to her and **puts his** wants to give her a hug.
- He looks out and sees that **she had** the car ran into the tree.

If an utterance is incomplete, but some information about the picture(s) or topic has been given, count that information.

- The kitchen window was...

In this example the words the kitchen window was would be counted as correct information units (if they meet the other criteria). Even though the entire statement was not completed, the words are informative.

Words that express some legitimate uncertainty or change in perception about characters, events, or settings in a picture are counted as correct information units (if they meet the other criteria). See 2.18 for further examples.

- Her dad or maybe a neighbour was in the tree.
- From the looks of the candles, he must be four. No there is another candle on the table so he must be five years old.

2.14 Repetition of words or ideas that do not add new information to the utterance, are not necessary for cohesion or grammatical correctness, are not purposely used to intensify meaning.

- The blue truck was **blue**.

- **The restaurant was a new one.** It was a new restaurant.
- She was **cleaning** washing the dishes.
- The mother was very angry. The daughter was crying. **The mother was very mad.**

Exceptions:

(a) If the repeated words are necessary for cohesion, they are counted:

- She went to the store. The store was closed.

(b) If words are repeated to achieve effect or intensify the statement they are counted:

- The girl was very, very sad.

(c) If repeated words are used to expand on previous information they are counted:

- He put on a shoe... a left shoe.
- There were some people... a man and a woman.

2.15 The first use of a pronoun for which an unambiguous referent has not been provided. Subsequent uses of the pronoun for the same unspecified or ambiguous referent are counted as correct information units (if they meet other criteria).

- **She** (no referent) was doing the dishes. I think she was day-dreaming.

If an inaccurate referent is provided but it is clear that a pronoun refers back to it, the pronoun would be counted as a correct information unit.

The fox (inaccurate referent) ate some of the cake and it was hiding.

2.16. Vague or non-specific words or phrases that are not necessary for the grammatical completeness of a statements and for which the subject has not provided a clear referent and for which the subject could have provided a more specific word or phrase.

- The mother is drying one of those **things**.
- She gave him some **stuff**.
- We had pancakes or **something like that**.
- I wash the glasses and plates **and so on**.

The words **here** and **there** frequently fall into this category.

- **Here** we have a boy.
- This **here** boy is crying.
- That mother **there** is doing the dishes.

The following are examples of uses of **here** and **there** that are necessary for the grammatical completeness of the statement and cannot be replaced by a more specific word. These uses of here and there would be counted as correct information units.

- There is a boy.
- Here comes the same couple.

The following is an example of a non-specific word that is preceded by a clear referent and would be counted as a correct information unit.

The boy opened the cupboard. The cookies were up there.

2.17 Conjunctive terms (particularly **so** and **then**) if they are used indiscriminately as filler or continuants rather than as cohesive ties to connect ideas.

- There is a man. **Then** there is a woman and **then** a cat.

When used cohesively, 'then' indicates the temporal order or sequential organisation of things or events.

- She had lunch and then she went to the store.
- When you go into my house you see the living room first, then the dining room, then the kitchen.

When used cohesively, 'so' indicates a causal consequence.

- He was thirsty so he drank some juice.
- The mother was after the dog so the boy was crying.

2.18 Qualifiers and modifiers if they are used indiscriminately as filler or are used unnecessarily in descriptions of events, settings, or characters that are unambiguously pictured. The following examples concern unambiguously pictured information.

- **Apparently** this is a kitchen.
- **Evidently** the boy is on a stool.
- **I think** that the cat is in the tree.

When used informatively qualifiers and modifiers suggest legitimate uncertainty on the part of the speaker about events, setting, or characters portrayed in the picture(s) or modify associated words in a meaningful way. The following examples concern ambiguously pictured information.

- Apparently this is a mother and her two children.
- I think she is his sister.

2.19 Filler words and phrases (**you know, like, well, I mean, okay, oh well, anyway, yeah**), interjections when they do not convey information about the content of the picture(s) or topic (**oh, oh boy, wow, gosh, gee, golly, aha, hmm**), and tag questions (It is really smashed up, **isn't it?**)

2.20 The conjunction '**and**'. **And** is never counted as a correct information unit because it is often used as a filler and we have found that its use as a filler cannot be discriminated reliably from its uses as a conjunction.

2.21 Commentary on the task and lead-in phrases that do not give information about the picture(s) or topic and are not necessary for the grammatical completeness of the statement.

- **These pictures are poorly drawn.**
- **This is kind of hard**
- **In the first picture**

2.22 Commentary on the subject's performance or personal experiences.

- **I can't think of the name of that.**
- **I can't say it.**
- **No, that's not right.**

Some statements that contain personal information may be appropriate in procedural and personal information descriptions and, in such cases, they would be counted as correct information units (if they meet the other criteria).

See 3.16 for embellishments that are counted as correct information units. See page one for statements that are deleted before beginning the word and correct information unit counts.

3.1 COUNT THE FOLLOWING (if they meet all other criteria)

(In this section, words in bold print would be counted as correct information units.)

3.11 All words (nouns, adjectives, pronouns, verbs, adverbs, articles, preposition, and conjunctions) are intelligible in context, accurate in relation to the picture(s) or topic, and relevant to and informative about the content of the picture(s) or topic.

3.12 Words do not have to be used in a grammatically correct manner to be counted. Words that violate standard English grammar rules concerning appropriate verb tense and form, agreement in number between subject and predicate, agreement between subject and predicate, agreement between articles and nouns, incorrect use of articles, and appropriate singular and plural forms are counted as correct information units unless these violations would lead to misunderstanding or uncertainty about the meaning of the words.

See 2.11 for examples of words that would not be counted as correct information units.

The **firemans** are coming.

Put some **stamp** on it.

He **don't** look very happy.

3.13 Production of a word that results in another English word, if the production would be intelligible as the target word in context.

- He is standing on a **school** and it is tipping over.

3.14 The final attempt in a series of attempts to correct sound errors.

- He went to the musket..minuet...**market**.

3.15 Informal terms (**nope, yep, uh-huh, uh-uh**) when they convey information about the content of the picture(s) or topic.

She said '**Uh-huh**, I'll do it.'

3.16 Word in embellishments that add to the events portrayed in the picture(s) or express a moral, if they are consistent with the situation or events portrayed. Word that express some legitimate uncertainty about characters, settings, or events in the topic.

- **He's going to get hurt and his mom is going to be angry.**
- **Some days everything seems to go wrong.**
- **That looks like a nice way to spend a summer day.**

However, see 2.22 for examples of extraneous commentary that may resemble embellishments, but are not counted.

3.17 Verbs and auxiliary verbs (**is, are, was, were, to, has, have, will, would, has been**, etc.) as two separate correct information units - one for the auxiliary verb and one for the main verb.

- His mom **is going to be angry**. (Each word in bold print is a correct information unit.)
- 3.18 Contractions [both standard (**won't**) and colloquial (**gonna**)] as two correct information units.
- 3.19 Each word in hyphenated words (**father-in-law, good-bye**).

Appendix 6
ICF activities and participation domains
(WHO 2001)

Domains		Qualifiers	
		Performance	Capacity
d1	Learning & applying knowledge		
d2	General tasks & demands		
d3	Communication		
d4	Mobility		
d5	Self-care		
d6	Domestic life		
d7	Interpersonal interactions and relationship		
d8	Major life areas		
d9	Community, social & civic life		

Appendix 7

Reliability data on repeat analysis of connected speech data

Table 1 Noun and Verb analysis

		P1	P2	P4	P5	P6
N nouns*	1	23	22	36	34	18
	2	23	22	37	33	20
N single use N**	1	14	13	21	15	10
	2	16	14	22	15	10
Verbs***	1	41	13	21	26	36
	2	36	17	21	29	34
N single use V****	1	19	7	11	9	6
	2	18	7	10	8	6

*Mean difference = 0.4, correlation coefficient = 0.99

**Mean difference = 0.8, correlation coefficient = 0.98

***Mean difference = 0, correlation coefficient = 0.98

****Mean difference = 0.6, correlation coefficient = 0.99

Table 2 CIU analysis

CIU		P1	P2	P4	P5	P6
N wds*	1	129	131	98	121	120
	2	126	128	101	120	120
CIU's**	1	53	40	42	13	32
	2	49	50	42	13	43

*Mean difference = 0.8, correlation coefficient = 0.99

** Mean difference = 3.4, correlation coefficient = 0.90

Table 3 POWERS analysis

POWERS		P1	P2	P4	P5	P6
Speech units*	1	183	177	196	186	218
	2	182	175	195	188	219
Content units**	1	34	32	63	48	66
	2	39	33	62	49	72
Nouns***	1	12	17	31	28	15
	2	12	17	31	28	19
Filled pauses****	1	28	55	45	29	6
	2	28	53	43	29	6

*Mean difference = 0.2, correlation coefficient = 0.99

** Mean difference = 2.4, correlation coefficient = 0.98

*** Mean difference = 0.8, correlation coefficient = 0.97

**** Mean difference = 0.8, correlation coefficient = 0.99

Appendix 8
Software accuracy scores for T2

Comparison of recognition accuracy achieved comparing live training and
standard enrolment for T2

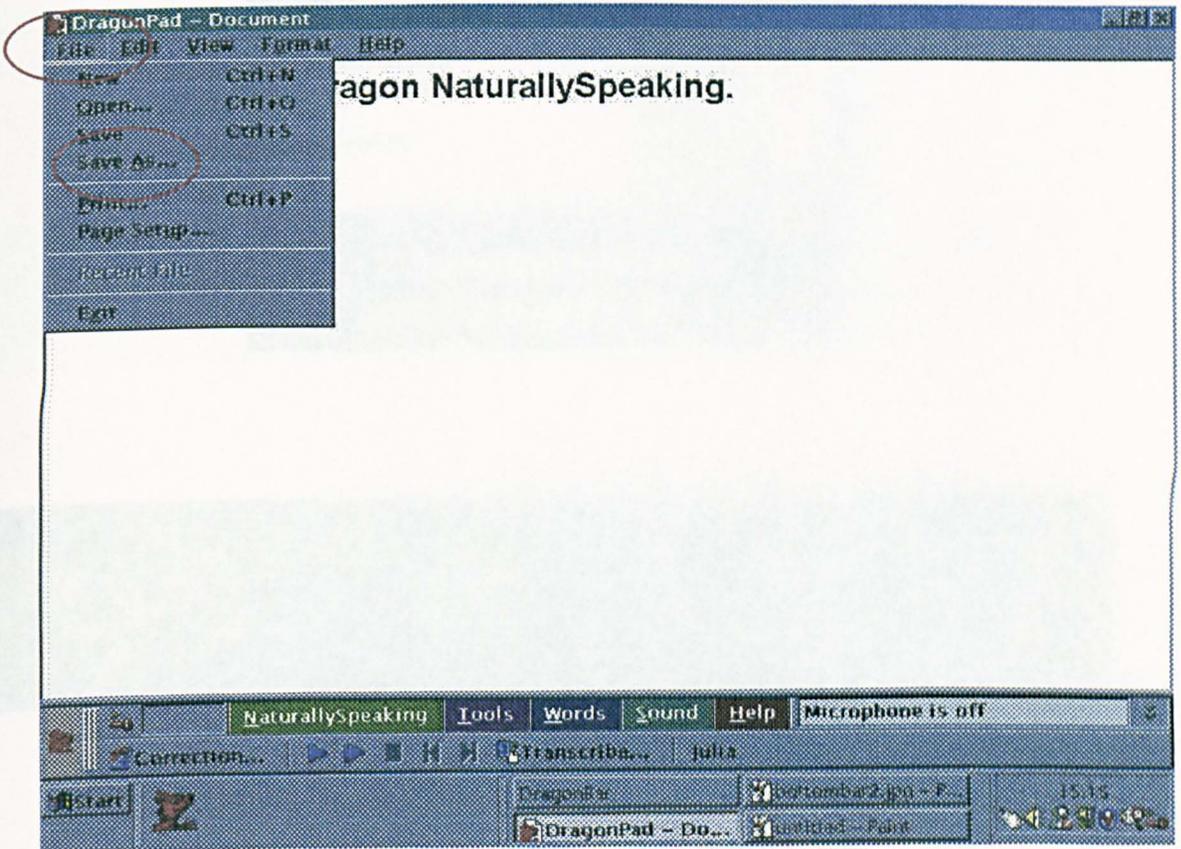
Session	%Accuracy	
	Live training	Standard Enrolment
2	58	71
4	53	-
6	52	-
8	44	85

Appendix 9

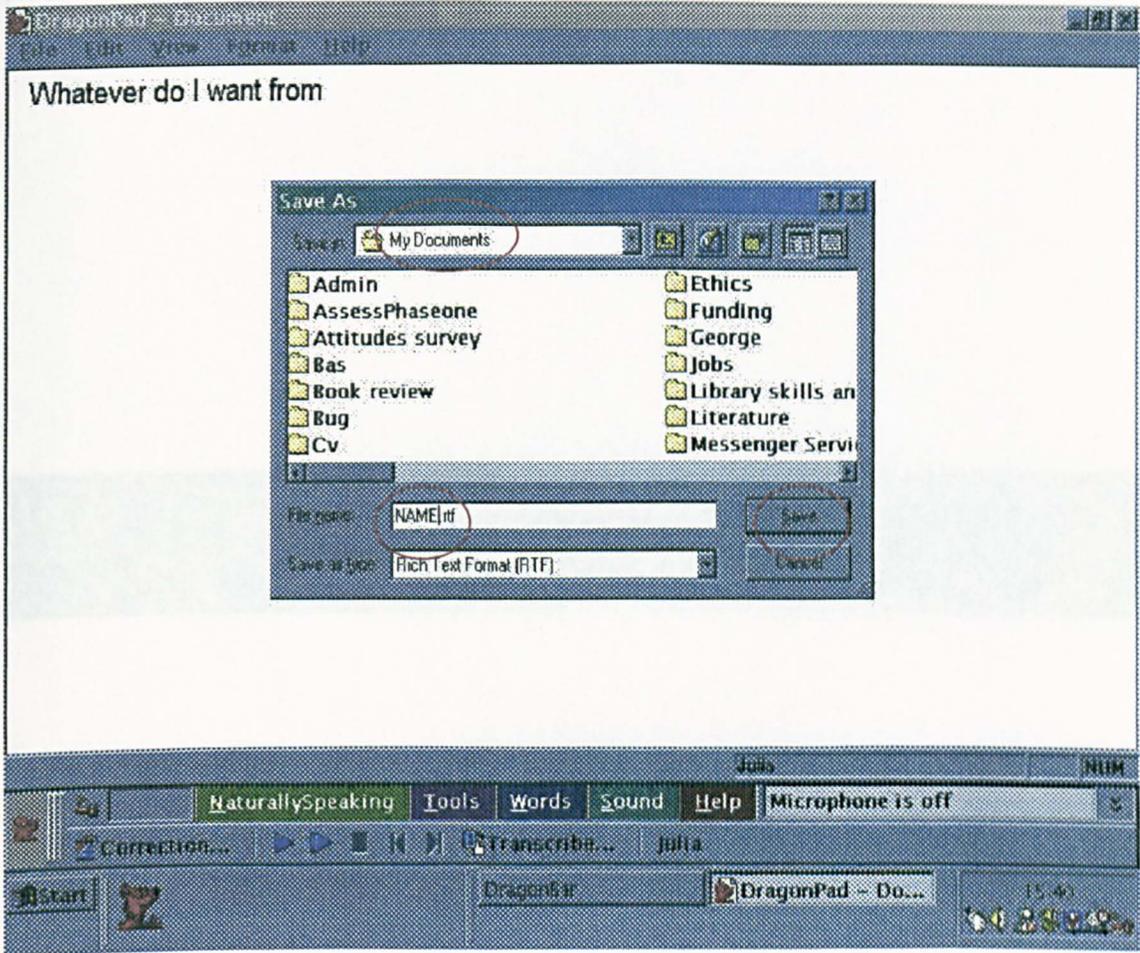
Sample guidelines for software use

Saving your work

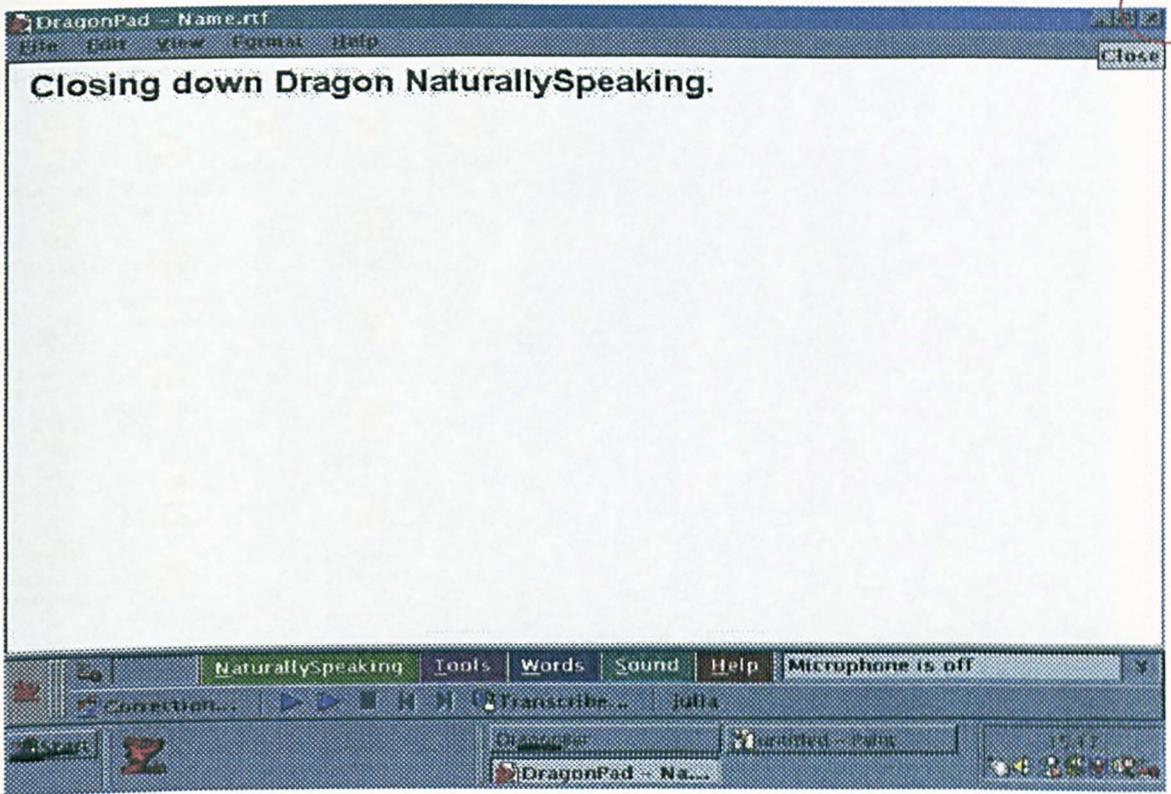
Go to **File** menu and click on '**Save As**'



1. Make sure you are saving in My Documents
2. Give the file a name
3. Click Save



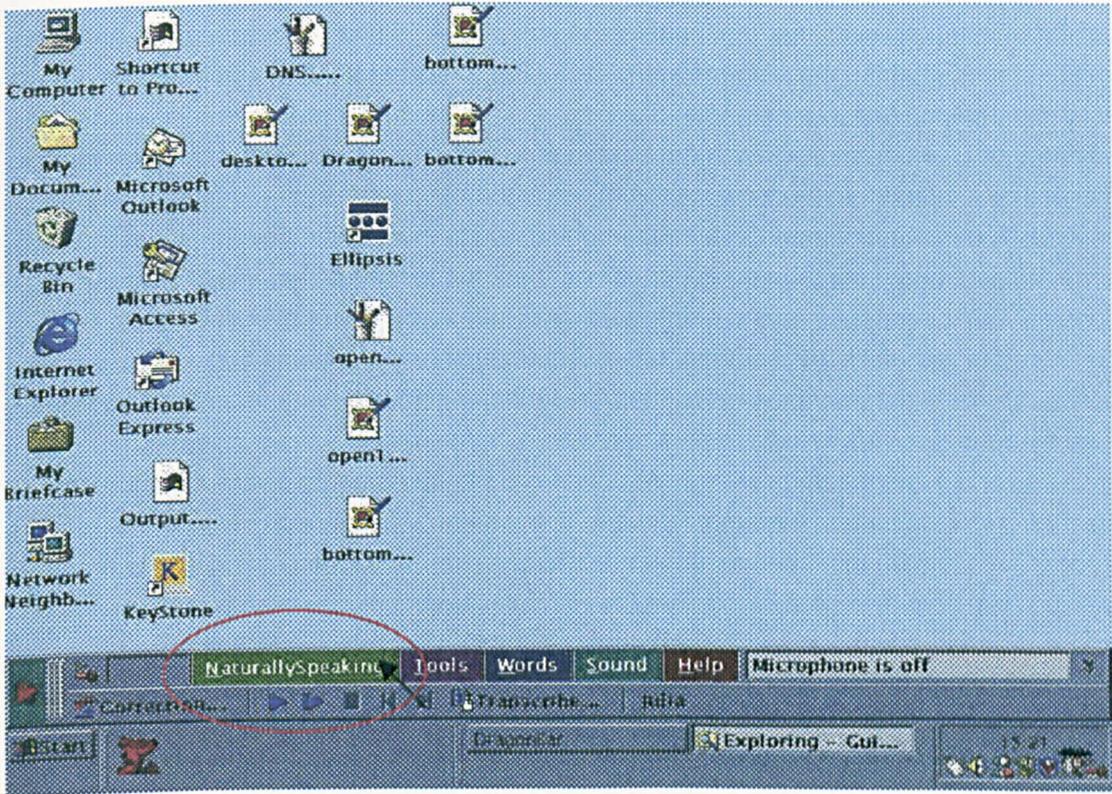
Click on X in top right hand corner



To close Dragon Naturally Speaking:

1. Click on GREEN box my last NaturallySpeaking

You should be left with your desktop

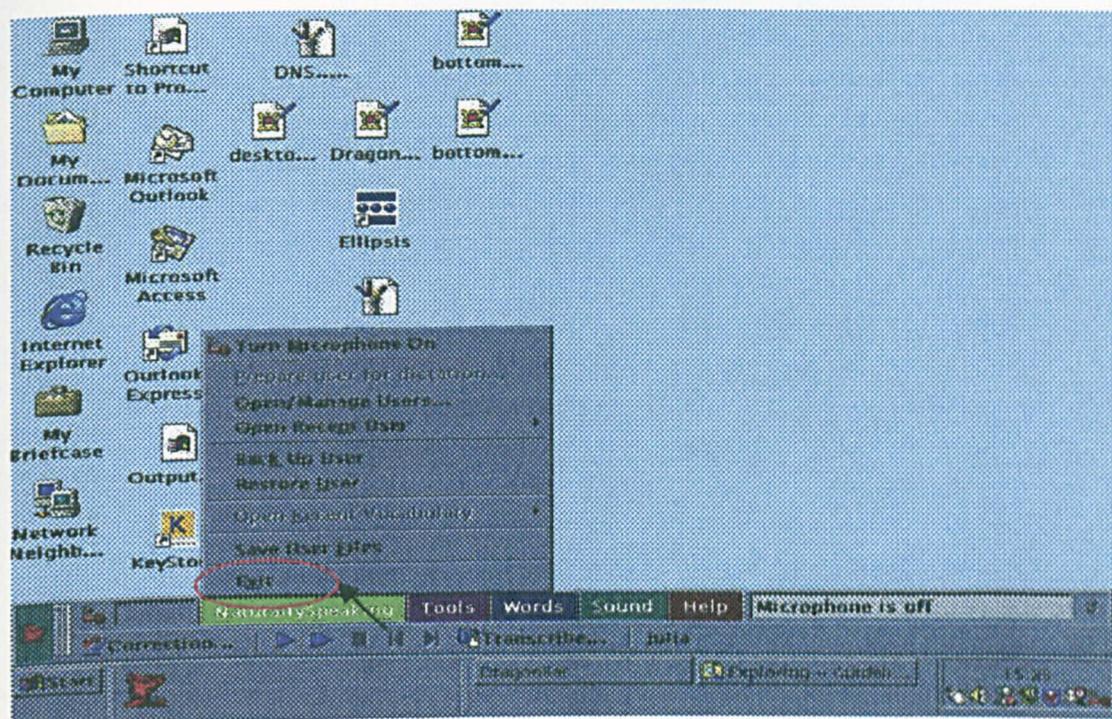


To close Dragon Naturally Speaking

1. Click on **GREEN** box marked NaturallySpeaking

IMPORTANT

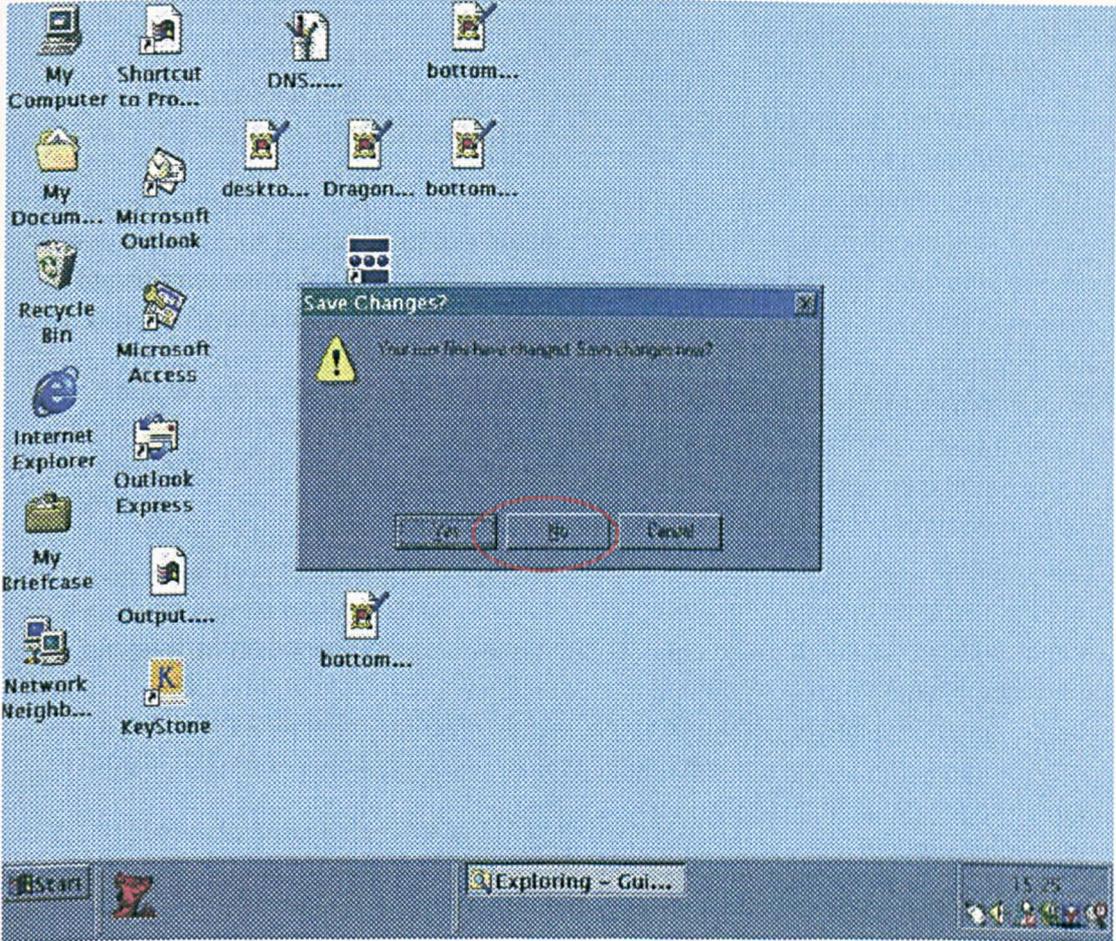
3. When asked to save changes, click **Exit**.



2. Click on **Exit**

IMPORTANT

3. When asked to save changes **CLICK ON NO**



4. What expectations will you have?

- what you can learn from
- software packages that you can use
- practical applications
- your family use computer

5. What do you expect to gain from this course?

Appendix 10
Pilot Study Topic Guides – Study Two

Pre training interview

Objectives

- To explore person's perception of communication difficulties in general
- To explore person's perception of writing difficulties in particular
- To explore previous computing experience
- To explore expectations of receiving training in VR

Introduction

- Remind about purpose of interview
- Repeat consent for recording
- Remind free to end interview at any point

1. How do you feel about your communication since you had your stroke?

- Talking/Understanding/ Reading
- Easy/Difficult?/What's changed
- Writing
 - What changed*
- Uses of writing before/after stroke
- Feelings about handwriting
- Things that need writing that you want to do

2. How has your life changed since you had your stroke?

- Things you've started / things you've stopped

2. How do you spend your time now?

- Thing that you do on your own
- What things do you get help with that you would like to do on your own?

4. What experience of computers have you had?

- What you use them for?
- software packages do you use?
- recreational/games packages?
- your family use computers?

5. What do you expect to get from the project?

Pilot Study Two Topic Guide – Study Two

Post training interview

Objectives

- To explore current use of the software/computer
- To explore motivations/expectations for being involved in this training
- To explore experience of the training & assessment process
- To explore aspirations for future use
- To explore perception of progress

Introduction

- Remind about purpose of interview
- Repeat consent of recording
- Remind free to end interview at any point

1. Current usage

How often do you use the computer/software?
What do you use it for?

2. Future usage

How do you see yourself using it in future
Plans for using the software
Projects using computers
New software/hardware

3. Training process & needs

Feelings re training process
Where what how when why who

4. Motivation

Feelings re being in research process
What made you decide to be involved?
If they were asked to be in the same project again how would they feel
What do you feel you gave to the project?
What do you feel you gained from the project?
'I get the impression you are enthusiastic about the software – have I got that right?'
Can you tell me why?

5. Assessment process

Intensity/Duration/Nature of tasks



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ORIGINAL**

Appendix 11

Topic Guide - Main Phase – Study Two

Pre training interview

Objectives

- Determine person's *perception of their current speech and language abilities and difficulties*, their *major concerns* regarding communication
- Determine person's *perception of their writing ability*
- Determine person's *previous experience of using a computer/computer software*
- Determine person's *expectations of VR software*

1. Introduction

Purpose of interview – get an idea of expectations and compare this at the end with what actually happened.

Repeat consent for recording

Remind free to end interview at any point

2. How has life changed since you had your stroke?

Things you've started / things you've stopped

3. How do you get on with communicating

Speaking

Understanding others

Reading

Prompts

What things do you find easy/difficult?

Any changes over time?

What bothers you most?

4. Tell me how you get on with writing in particular

Uses of writing before/after stroke

How often do you use writing?

Describe your writing.

How do you feel about your writing?

What would you like to do that needs writing?

5. How do you spend your time now?

Describe your average day/week

Things that you do on your own

Things you would like to do

6. What experience of computers have you had?

Tell me what you've used a computer for

When – before / after stroke

Now – how often, how long, what for?

recreational/games packages?

Does your family use computers?

7 What do you hope to get from being involved in this project/VR software?

Topic guide - Main Phase - Study Two Post training interview

Objectives

- To explore *current use* of the software/computer
- To explore *motivations/expectations* for being involved in this training
- To explore *experience* of the *training & assessment* process
- To explore *aspirations* for future use
- To explore *perception* of *progress*

1. Introduction

Remind about purpose of interview – feedback for further research & funders

End of intensive training, time to reflect, tell me what you think

What could be done better in next round of training

What was done well?

Repeat consent of recording

Remind free to end interview at any point

2. Expectations

Why did you want to be involved?

What did you hope to get out of it?

Speech & language therapy?

Someone visiting regularly?

Using computer?

Using VR software?

A challenge?

Someone to motivate you?

Writing?

-If not sure, was that always the case with all SLT or more so with this?

How did expectations compare with what happened?

If you were asked to be in the same project again how would you feel?

What would you say to someone who was trying to decide whether to be involved?

3. Current usage

How do you find using the computer?

Easy/difficult

VR software?

Enjoy/dislike

Email?

Show me how you

Switch on computer/opening software/switch on mike/get s/w to

recognise speech/spot errors/correct errors/save/printing/shut down

software/switch off computer/highlight words on screen/dele

words/email

How often do you use the computer/VR software?

How long do you spend?
What do you use it for?

4. Training process

How did you find (once) twice a week?
How was 1-2 hours?
How was it working at home?
How did it fit in with the rest of your life?
How did you find the time working between sessions?
How did you find working with SLT vs working alone vs working with partner?

What the high points of training?
What were the low points?

What would have made it easier/more enjoyable?

5 How do you see yourself using the computer in future

Plans for using the computer
Plans for using the software
Other software/hardware

6 Motivation

Feelings re being in research process

What made you decide to be involved?

If they were asked to be in the same project again how would you feel

What do you feel you gained from the project?

I get the impression you are enthusiastic about the software – have I got that right?

Can you tell me why?

7. Assessment process

video descriptions
other assessments
Any dislikes – why?
What should be left out?

8. Progress to goals

Your goals were...
How do you feel you got on with these?
How does this compare to before?
How do you feel about your writing now?

Appendix 12

Rules for applying linguistic analysis of writing samples (Study Two)

COUNTING NUMBER OF WORDS

- Counted **words as separate** even if no space between words, e.g. *inlife* = 2 words, *in life*
- Did **not** count words in word count where they had been crossed out by writer
- **Did** count words in word count if they had been repeated but not crossed out (all repetitions of same word also counted as word errors – see below).
- Title words included in total word count but not included as separate utterance in utterance count.
- Compound words were counted as a single word, e.g. *outside*, *into* = 1 word

COUNTING NUMBER OF WORDS GREATER THAN SEVEN LETTERS

- Each use of a word of 7 letters or more was credited.
- If target word was greater than 7 letters the word was included in this count even if misspelt to contain less than 7 letters, e.g. *pansey* for *pansies* was included
- Where a shortened form was substituted e.g. *TV* for *television*, *Xmas* for Christmas this was not counted as 7+ letters.

COUNTING NUMBER OF WORD ERRORS

Inclusions

- Wherever able to guess at the target and ascribe a misspelling to a word this was done, e.g. *kyye* for *key*.
- Where it was not possible to determine the target, the word was ascribed as indecipherable, and included in the error count
- Every spelling mistake was counted as an error including those where real words were substituted for target, e.g. *wet*, *the then*
- Where the plural was substituted for the singular in a context where the singular would be expected this was counted as a spelling error e.g. 'a *composts*'
- Where the keyboard was used to correct a misrecognition error but the correction misspelled this was counted as an error.
- All other recognition errors were counted as errors, including errors of omission in recognition.
- All inappropriately repeated words were counted as word errors e.g. the lady was opening her door key to open up
- Each number was counted as a single word e.g. *31/2* was 1 word.
- Road numbers were counted as a single word, e.g. *M5* was 1 word

- Titles were included in word count
- Use of incorrect morphology was counted as an error, e.g. *The chair want reworking = 1 error want*
- Included as errors single words that showed unusual usage/incorrect usage, e.g. *For the Severn we back from Oldbury on to Thornbury* was counted as 9 words correct with *For* marked as incorrect as from was presumed to be the target for this word

Exclusions

- Words which did not have a space between them were not counted as errors
- It was decided it was too speculative to attempt to calculate all omitted words as an error therefore this was NOT attempted at all. Instead, all words were simply marked according to whether they comprised an error or not and this was used to calculate a percentage error rate, e.g. *we cycling on the Thornbury* was simply counted as 5 correct words despite omission of the auxiliary, *We back to Thornbury for tea* counted as 4 correct words despite omission of verb.
- Where a 7+letter word was written in error in an attempt to write a target word with less than 7 letters this was not included
- Use of inappropriate upper case was not counted as an error e.g. *iN* , *WE*

COUNTING NUMBER OF UTTERANCES

- If no utterance boundaries were not reliably marked or if very few utterance boundaries were marked utterance boundaries were allocated on the basis of rules provided by Saffran & Schwartz (1989).

Saffran & Schwartz Syntactic indicators to determine utterance boundaries:

- Unless strong indications to the contrary **a well formed sentence is taken as an utterance.**
- Full stops, commas, colons, capital letters, new lines may all indicate utterance boundary.
- However, where full stops were used inappropriately, punctuation was overridden in favour of the syntax (e.g. P5).
- **When in doubt utterance boundaries were placed to create shorter rather than longer sentences.**
- Where writing was so poorly decipherable that it was not possible to assign boundaries this was marked in *Utterance* column as N/A.
- Where utterance boundaries were marked by participants using full stops, colon, commas, new lines and capitals, these utterance boundaries were used for the utterance count.
- Titles were counted **in word** count but not as a separate **utterance** in utterance count, since most titles were single words.

COUNTING NUMBER OF VERB PHRASES

- All recognisable attempts at a verb phrases were counted, even where not realised correctly
- Where common verbs such as **get, have, be, do, know** are **main verbs** they are included. If they were used as auxiliaries they were excluded.

COUNTING NUMBER OF EMBEDDED CLAUSES

Embedded clauses were defined as the dependent clause of a complex sentence (Saffran and Schwartz 1989).

e.g. ***When she went in**, she had the remote control.
It is a person, who lots us the amount.*

Clauses conjoined by *and* or *but* were *not* counted as embedded, e.g. *The pub is closed but we went for lunch on the mouth.*

Both a **verb** and an **overt noun phrase** after the main verb was required to give credit for an embedded clause:

I have my breakfast here after which we go to George = 1
The computer is a good catch if it works right = 1

We went to Frenchay to plant seeds = 0 (no verb)

She went out the house to plant some flower = 0 (no overt noun phrase)

CALCULATED MEASURES

% OF WORDS GREATER THAN SEVEN LETTERS

$\frac{\text{Total number of words greater than seven letters}}{\text{Total number of words}} \times 100$

% OF WORD ERRORS

$\frac{\text{Total number of word errors}}{\text{Total number of words}} \times 100$

MEAL LENGTH OF UTTERANCE

$\frac{\text{Total number of words}}{\text{Total number of utterances}}$

Appendix 13

Instructions for ranking judgement of written language samples (study two)

Instructions for ranking

You have been given two sheets of writing samples for each of nine participants (P1-P2 and P4-P10) and 1 sheet of samples for each of two further participants (T1 and T2). Each sheet presents between 4 and 6 writing samples produced by one person.

Each set will contain either repeat descriptions of a video (Functional Video Tool) or they will contain written accounts on any topic of the person's choice. In the latter, the topic will likely be different each time. At the top of each set you will find the label 'FVT' or 'Spontaneous sample' to indicate which is which.

Each person was given 10 minutes for every sample produced. This may not be immediately obvious as the samples differ considerably in length.

Samples were produced either by hand/typing or by using voice recognition and were produced either before or after training in use of voice recognition. The order in which samples are presented has been randomised. In order to remove obvious clues as to the medium in which samples were originally produced, all samples have been presented here as typewritten text.

You are asked not to pay attention to grammatical correctness but simply how well a message is conveyed. Read through all the samples in the set then rank samples in order, one representing the best and six representing the worst.

If you feel that two or more samples cannot be separated, simply rank them in equal position. It is possible, you will find that you rank each sample separately as 1-6 finding that they are all clearly separated. It is also possible that this never occurs for any of the sets and you find you rank two samples as 1, two more samples jointly as 3, a fifth and sixth jointly as 5 etc. Any configuration is possible.

Appendix 14

Scoring criteria for software recognition accuracy

The percentage accuracy of software recognition was calculated using the method proposed by Hux, Rankin-Erickson, Manasse & Lauritzen (2000), according to the formula:

$$\frac{\text{N of words recognised}}{\text{N of words dictated}} \times 100 = \% \text{ accuracy.}$$

Scoring criteria:

Each correctly recognized word counted for 1 point; incorrect representations of spoken words received no points. Punctuation was excluded from the count.

Compound words (e.g. 'into') counted for 2 point, with each segment of the word worth 1 point; this allowed for the provision of partial credit when a system correctly recognized one of two free morphemes included in a compound word.

Contractions (e.g. 'wasn't) counted for 2 points, with each word in the contraction worth 1 pint; representations of a spoken contraction as two single words, counted for 2 points; as with compound words, assigning 2 points to contractions allowed for the provision of partial credit when a system correctly recognised one of two morphemes.

Incorrect homophone substitutions did not receive any points (e.g., the system typed 'their' for the spoken word 'there').

Words with incorrect suffixes did not receive any points (e.g., the system typed 'toy' for the spoken word 'toys')

Additional words not directly attributable to the misarticulation of another word resulted in a deduction of 1 point (e.g. the system typed 'The owl hooted in the work early morning [period]' for the spoken sentence 'The owl hooted in the early morning [period]'. This would earn 7 out of a possible 8 points.

Additional words that resulted from the system's interpretation of one word as two words due to the speaker's imprecise articulation or the system's inaccurate recognition resulted in no additional point deduction (e.g. the system typed 'Five G. is often made as a Christmas time treat [period]' for the spoken sentence 'Fudge is often made as a Christmas time treat [period]'. This would earn 9 of 10 possible points).

Appendix 15

Spontaneous speech samples – Study Two: video descriptions

T1

Row row oh God uh not one house but uh (5s) row instead and then outside and first of all (1s) uh key and locked (1s) and then walk (1s) the same path and wheels three wheels (2s) and then car (1s) uh first of all uh cat and three or four times and clap (2s) uh and again uh key and open (laughs) (2s) not garage because uh flowers. Anyway space space locked. And then walk again and then keys (4s) then inside. This lady or woman (1s) uh anyway (1s) um and then I think again short time and local what the word both inside and outside (1s) /plats/ (1s) and just browse and then two flowers paid (1s) and then also chat (2s) oh yes and then that path back again and bicycle young what the word (1s) child anyway talking and then back again (1s) first of all outside and car again (2s) and open closed doors (1s) back again to that space (1s) and this time also couple of plants so much more gingerly especially only one hand (1s) and this time 2 different locks and then inside.

(5 minutes 49)

T2

Well uh (1s) first of all I saw um (1s) um a // lady about middle age uh I think it was um (1s) she had on um uh a a not a a pink dress um (2s) it was um a blue dress um and it was and and uh um and um on on on top of that she had um a coat uh not a coat but a um um um um a /muh/ mac or or some some something thing and um she was going shopping (1s) um and um she um she she um (2s) she (1s) closed the door um to the um the um house um I'm not sure whether she actually um did it um (2s) you you know when we saw her the second time um close the door um (2s) I'm not sure whether she did that the the first time or not I'm not sure but anyway um (1s) um and then we saw her walk along the the pavement to um (1s) to get the car um and um and on the way um she passed a /b/ a a boy um cycling on a trike I think it was and um and then she um she um had a Peugeot 30 not 307 but um (1s) because um it was Peugeot (2s) // 206 I think it was um and um and and she um and there was a dog a not not not a not a not a um a cat um I think it was um and um and um she shooed him off the bonnet I think um because she wanted to get into the car

(2 minutes 41)

P1

Lady (2s) went through her back door into the back /gar/ into the garden and she had her plants laid out ready // for replanting. Put her (0.5) pink gloves

on first of all (1s) drew some holes in the garden (1s) watered it (2s) put some (0.5) peat in with the (1s) mould (1s) watered the plants (1s) bedded it over (1s)

then (0.5) the next thing she saw /w/ (2s) lady (2s) sat on a chair or a settee (1s) was looking at the (0.5) television set (1s) tuning the (0.5) pictures through (1s) different (1s) and she went to a (4s) a point where she'd decided she was getting too tired and she put it down.

(1 minute 2)

P2

The (5s) uh (2s) lady who is about forty five and has uh a white blouse and a sort of (2s) um blue skirt or something like that she comes out in the garden (3s) and she um (4s) what's it called um (3s) wears gloves (3s) then she drill (1s) two holes (4s) and I think uh it was um pansies (2s) and uh (3s) she start watering, normally I would have thought always later not earlier, but still that's beside the point um (6s) she um (5s) um some (1s) what is it /m/ not moss um (4s) special oh (2s) what's it called um (4s) earth but it's uh I uh from the garden centre um .(2s) and she plants it and then pushes it nicely down and then water again and that's (1s) that's fine (2s) and now we go inside (2s) and the lady switches on the television (3s) and checks channels (5s) um (3s) then she decided to get (2s) knitting out (3s) and he she does this for a while then she gets bored

(2 minutes 57)

P3

Yes, first she was doing some (2s) /gardering/ guarding, no I'm not saying it properly, I can say it, but I can't (1s) um so done all that finished at that and then she watched the /tem/ (4s) I can say it (1s) why can't I say that (4s) oh /tem/ /tel/ what oh /sent/ oh I'm looking at and I can't say it (1s) the /tending/ /telef telev/oh oh I'm sorry (2s) this is so stupid cos I [laughs] yes ok um (2s) she done that and then she oh do the knitting, so decided she would like to do some /kneeting/ and then a bit later she thinks oh I don't know I'm going to sit down and have a (1s) left ref with the dog no with the cat the cat sorry and [laughs] and and then /gradilly/ went to sleep

(1 minute 36)

P4

Um (3s) the lady (2s) um (2s) went went across the grass to (1s) put the um to see where she was going to put the plants (1s) um she she um put (1s) she dug a hole up to put one lot of plants in (1s) she then (2s) went across to no

she didn't (2s) then she went to (4s) she (2s) the next picture you see go into the living room to uh put the television on (2s) the television on with remote control and turns that over again with the remote control (1s) then (2s) seen the (4s) she got the her knitting out and um which was (2s) I think it was white (1s) knitting and then she puts um puts the knitting down and she's seen the cat (2s) and then she sat down (1s) to and she called the cat on to her lap and the she went had a nap (5s) and that was it.

(1 minute 48)

P5

The lady come out of the back door with the plants (1s) um she was wearing a blue blouse having taken her jacket off (2s) she went to /wuh/ one of the uh borders and started putting the plant the um (0.5) pansies out she poured water into the um hole first then put the plant pansies in and then patted them down to firm them, and gave them more water (2s) then went indoors uh where she sat on the settee (1s) um looking at the television, flicking from channel to channel she /wuh/ til she thought she found something she wanted (1s) but didn't in the end um (5s) she put the control on the left hand um (1s) arm of the settee we were round the other side looking at her from face on when she (3s) got a /mit/ knitting /ba/ uh basket out um bag out and started doing some knitting (1s) um for a very short time then put it away again (1s) um picked her glasses up put them on to read the magazine

(2 minutes 23)

P6

Well she was planting a flower (6s) why she she took a flower (4s) and planted it (5s). You want me to go into detail Ok (5s) Into detail how do I do that (4s) She had a a bag of (3s) a a bag of (4s). OK (5s) And then when she when she came in (1s) um she (3s) she put her specs on and she was knitting and (5s) and there was (2s) three painting on the wall one that side two that side and one that side there was another one there as well that four (2s) and (2s) there was a cat there (8s) and the cat was there (6s) was that all was that enough (2s) we said something about knitting (2s) and (3s) the cat (22s) she was on a couch as well (3s) um (4s) she had a (1s) a handbag (2s) she put something in her handbag (17s) and the the the cat well she was feeling tired and she fell asleep.

(3 minutes 52)

P7

Well the bloke um at the beginning a woman went out through the garden and got some flowers out and she was putting them in what I do with out things

(3s) um and then she put some more put some more flowers and then give it a drop some water that was the first part then (2s) I don't know if it was the same girl but another girl goes into the house and sits down to watch the television and she couldn't quite /fuh/ find all the different /chuh/ channels until eventually she did and she sat down and watched it and then the bloke the woman started doing some (2s) um warts (1s) the girl started to do (2s) the video no not video uh the uh (2s) she had to look in the book to see it was alright and then she said see yeah that's ok and he was play she was playing (3s) um she was going (3s) um um and she started she went on for for a bit (1s) with the (1s) oh I don't know and then she thought what I don't think I'm going to (1s) and then she put it down put it inside the box and put her head up on the (2s) and said to the dog the /da/ the cat come up and sit by me and she said that uh we'll we'll go to sleep

(2 minutes 12)

P8

Oh the lady came out of the house into the garden (1s) and she put on her rubber gloves and she started to (1s) garden she she she planted some plants /a/ after that she came into the house and she turned off the television and she decided to watch one programme and then she watched another one and then she /duh/ decided after that that she'd do her knitting so she picked up her knitting bag and did her knitting and and put put on her glasses and and and so she can read the (1s) the uh the uh the the the uh (1s) uh the pattern. She she she then decided that uh she she she she done enough of that so she she she decided she sits she put her feet up on the couch and and and started to have a little read of a book and and and when she read the book after she read the book for a bit she called the cat to join her and and and they both went to sleep on the couch

(1 minute 25)

P9

Maybe in the garden (1s) see the seeds /eee/ (1s) yes okay (1s) uh the woman try the scene in the (1s) inside in this (1s) maybe (7s) um /s/ seeds ok (3s) the girl is glow /glubs/ as well is mess as well (1s) okay inside the house and the sofa first (3s) the woman /sn/ knitting as well (2s) maybe maybe gloves as well don't know we try (4s) the woman /s/ sleep on the sofa as well (1s) the cat weighs (1s) see the cats (1s) /s/ /siping/ as well (1s) that's all really I think so

(1 minute 26)

P10

Now /f/ first is lady she came out on and digging in the soil (2s) then she (6s) she she (2s) put the /f/ no no (8s) then she decided that she go back in doors (laughs) she's took up some knitting (31s) She came in back indoors and then she she took her /ni/ knitting to her see that (5s) and then (2s) she cot cot cot not cot not (2s) cat in the floor yeah (4s) he uh (2s) she's picked up the cat and (1s) she stroke it a couple of times and then (3s) then well out the further then she put the (1s) knitting on the floor

(2 minutes 29)



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Appendix 16 Analysis of written language samples

Table 1 Analysis of Video description data

	Time	Mode	N wds	% 7+	Nerror	%error	N utt	MLU	V phrases	Embed S	
T1	Pre 1	Hand	8	13	8	100	N/A	N/A	N/A	N/A	
	Pre 2		-	-	-	-	-	-	-	-	
	Post 1	VR	38	21	1	3	4	10	1	0	
	Post 2		42	14	3	7	5	8	3	0	
		Post 1	Hand	7	0	3	43	N/A	N/A	N/A	N/A
		Post 2		-	-	-	-	-	-	-	-
T2	Pre 1	Hand	74	7	16	22	7	11	12	1	
	Pre 2		90	12	11	12	8	11	16	2	
	Pre 1	VR	111	12	10	9	11	10	29	2	
	Post 1		138	13	2	1	17	8	25	0	
		Post 2	227	9	3	1	17	13	41	3	
		Post 1	Hand	87	6	11	13	7	12	20	3
	Post 2	-		-	-	-	-	-	-	-	
P1	Pre 1	Type	24	4	1	13	1	24	5	0	
	Pre 2		18	22	4	6	1	18	3	0	
	Post 1	VR	46	9	2	4	3	15	10	0	
	Post 2		66	11	2	3	4	17	13	0	
		Post 1	Type	28	7	4	14	2	14	6	0
		Post 2		64	8	8	13	3	21	10	0
P2	Pre 1	Hand	53	19	1	2	12	4	16	1	
	Pre 2		61	8	0	0	8	8	11	1	
	Post 1	VR	47	13	0	0	7	7	12	0	
	Post 2		33	27	4	12	2	17	6	0	
		Post 1	Hand	71	13	0	0	11	7	13	0
		Post 2		72	14	0	0	8	9	16	0
P4	Pre 1	Hand	97	6	8	8	10	10	19	1	
	Pre 2		76	5	12	16	8	10	17	1	
	Post 1	VR	44	9	1	0	4	11	7	0	
	Post 2		64	9	1	6	4	16	12	2	
		Post 1	Hand	88	5	7	8	9	10	17	0
		Post 2		101	6	7	7	10	10	17	0

	Time	Mode	N wds	% 7+	Nerror	%error	Nutterance	MLU	V Phrase	Embed S
P5	Pre 1	Type	104	13	0	0	7	15	22	2
	Post 1	VR	106	16	11	0	7	15	21	4
	Post 2		140	12	10	0	8	18	24	3
	Post 1	Type	104	11	3	3	8	13	23	3
	Post 2		122	11	0	0	6	20	20	1
P6	Pre 1	Hand	29	3	7	24	5	6	5	0
	Pre 2		12	0	5	42	2	6	3	0
	Post 1	VR	25	8	2	8	3	8	5	1
	Post 1	Hand	33	6	5	15	3	11	7	2
P7	Pre 1	Hand	24	4	3	13	4	6	1	0
	Pre 2		21	0	5	24	4	5	4	0
	Post 1	VR	29	7	2	7	4	7	6	0
	Post 2		44	9	2	5	5	9	9	0
	Post 1	Hand	17	12	8	47	7	2	1	0
	Post 2		26	4	5	19	4	7	1	0
P8	Pre 1	Type	7	0	5	71	1	7	0	0
	Pre 2		11	0	9	82	2	6	1	0
	Post 1	VR	8	0	4	50	4	2	7	0
	Post 2		117	9	31	26	7	17	16	0
	Post 1	Type	8	0	9	113	N/A	N/A	N/A	N/A
	Post 2		29	3	27	93	N/A	N/A	N/A	N/A
P9	Pre 1	Type	23	13	1	4	5	5	3	0
	Pre 2		80	8	1	1	9	9	10	0
	Post 1	VR	65	12	1	2	11	6	10	0
	Post 2		63	8	0	0	9	7	8	0
	Post 1	Type	76	14	1	1	11	7	11	0
	Post 2		67	9	2	3	9	7	9	0
P10	Pre 1	Hand	44	5	3	7	4	11	8	0
	Pre 2		27	4	3	11	2	14	4	0
	Post 1	VR	11	9	0	0	1	11	3	0
	Post 2		19	5	0	0	2	10	4	0
Post 1	Hand	33	15	6	18	2	17	8	0	
	Post 2		42	5	2	5	2	21	8	1

N/A indicates unanalysable data P5 only 1 baseline. P6 one post therapy measure x VR & x hand.

Table 2 Analysis of spontaneous writing

	Time	Mode	N wds	%7+	Nerror	%error	N utterances	MLU	Verb phrases	Embedded Sentences
P1	Pre 1	Type	26	0	3	12	N/A	N/A	5	N/A
	Pre 2		23	0	1	4	2	12	4	0
	Post 1	VR	61	5	3	5	5	12	8	2
	Post 2		39	10	0	0	2	20	8	3
	Post 1	Type	42	7	2	5	2	21	7	2
	Post 2		46	2	6	13	4	12	6	1
P2	Pre 1	Hand	56	21	1	2	7	8	8	1
	Pre 2		55	9	0	0	7	8	7	1
	Post 1	VR	119	10	0	0	9	13	15	3
	Post 2		117	10	0	0	10	12	21	9
	Post 1	Hand	57	12	0	0	4	14	6	2
	Post 2		61	13	0	0	7	9	10	1
P4	Pre 1	Hand	25	24	3	12	N/A	N/A	N/A	N/A
	Pre 2		34	26	5	15	N/A	N/A	N/A	N/A
	Post 1	VR	29	7	0	0	2	15	4	0
	Post 2		65	14	0	0	5	13	12	2
	Post 1	Hand	67	15	8	12	6	11	11	0
	Post 2		110	10	11	10	6	18	21	3
P5	Pre 1	Type	138	12	1	1	10	14	16	0
	Pre 2		113	10	2	2	6	19	12	6
	Post 1	VR	87	11	4	5	7	12	11	2
	Post 2		111	6	0	0	8	14	16	6
	Post 1	Type	74	3	1	1	5	15	10	2
	Post 2		100	17	0	0	3	33	14	4

	Time	Mode	N wds	%7+	Nerror	%error	N utterances	MLU	Verb phrases	Embedded Sentences
P6	Pre 1	Type	12	17	4	33	1	12	1	0
	Pre 2		-	-	-	-	-	-	-	-
	Post 1	VR	32	6	0	0	3	11	4	2
	Post 2		-	-	-	-	-	-	-	-
	Post 1	Type	27	7	6	22	3	9	6	1
	Post 2		-	-	-	-	-	-	-	-
P7	Pre 1	Hand	16	6	5	31	4	4	4	0
	Pre 2		20	20	12	60	4	5	3	0
	Post 1	VR	39	8	0	0	4	10	8	0
	Post 2		30	10	3	10	4	8	4	0
	Post 1	Hand	11	9	6	55	3	4	2	0
	Post 2		35	11	12	34	7	5	7	0
P8	Pre 1	Hand	21	N/A	21	100	N/A	N/A	N/A	N/A
	Pre 2		-	-	-	-	-	-	-	-
	Post 1	VR	9	11	0	0	1	1	1	0
	Post 2		41	10	6	15	2	21	6	2
	Post 1	Hand	15	7	12	80	2	2	N/A	N/A
	Post 2		-	-	-	-	-	-	-	-
P9	Pre 1	Type	54	11	4	7	9	6	6	0
	Pre 2		93	10	8	9	11	8	8	0
	Post 1	VR	57	25	2	4	7	8	7	0
	Post 2		56	25	3	5	7	8	8	0
	Post 1	Type	125	12	6	5	14	9	12	0
	Post 2		93	10	9	10	12	8	13	0
P10	Pre 1	Type	37	8	12	32	N/A	N/A	7	0
	Pre 2		14	0	2	14	2	7	3	1
	Post 1	VR	9	11	4	44	1	9	2	1
	Post 2		15	7	10	67	1	15	4	1
	Post 1	Type	46	13	9	20	1	46	2	1
	Post 2		42	12	2	5	N/A	N/A	5	0

N/A indicates unanalysable data. - indicates no data available at this time point. No data available on spontaneous samples for T1 and T2.

Appendix 17

Reliability data on repeat analysis of written language samples (Study Two)

VR	P1						P6						P10																					
Nwords*	1	24	18	46	66	28	64	29	12	25	33	44	27	11	19	33	42	2	24	18	46	64	28	64	29	12	25	32	45	28	11	19	33	42
Nwds7+**	1	1	2	4	7	0	4	1	0	2	2	2	1	1	1	5	2	2	1	4	2	6	2	5	3	1	1	4	7	1	1	1	1	2
N error***	1	1	4	2	2	4	8	7	5	2	5	3	3	0	0	6	2	2	10	5	3	7	4	8	8	5	1	7	12	4	3	3	8	2
N utts****	1	1	1	3	4	2	3	5	2	3	3	4	2	1	2	2	2	2	1	1	3	4	2	4	5	2	3	3	3	1	1	2	2	3
N VP*****	1	5	3	10	13	6	10	5	3	5	7	8	4	3	4	8	8	2	2	3	9	12	6	10	5	3	4	7	6	4	3	4	8	8
N embed*****	1	0	0	0	0	0	0	0	0	1	2	3	1	0	1	1	3	2	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0

*Mean difference = 0.06, correlation coefficient = 0.99

**Mean difference = 0.44, correlation coefficient = 0.45

***Mean difference = 2.25, correlation coefficient = 0.41

****Mean difference = 0, correlation coefficient = 0.90

***** Mean difference = 0.5, correlation coefficient = 0.95

*****Mean difference = 0.44, correlation coefficient = 0.11

Appendix 18
Ranking agreements

Table I Intra-rater agreement

Participant	Sample	Judge 1	Judge 2	Judge 3
T1	FVT	1.00	0.80	0.75
	spon	-	-	-
T2	FVT	0.94	1.00	0.60
	spon	-	-	-
P1	FVT	0.77	1.00	0.54
	spon	0.83	0.81	0.83
P2	FVT	0.94	0.77	0.79
	spon	0.89	1.00	0.56
P3	FVT	-	-	-
	spon	-	-	-
P4	FVT	1.00	0.29	0.64
	spon	0.40	0.55	0.85
P5	FVT	0.77	0.34	0.70
	spon	0.83	0.79	0.00
P6	FVT	0.60	1.00	0.55
	spon	0.50	0.93	0.50
P7	FVT	0.86	0.99	0.94
	spon	0.81	0.77	0.91
P8	FVT	1.00	1.00	1.00
	spon	0.75	0.95	0.80
P9	FVT	0.66	0.56	0.79
	spon	0.83	0.90	0.84
P10	FVT	0.47	0.99	0.14
	spon	0.94	-0.21	0.89

Table II Inter rater agreement

Participant	Sample	J1-J2	J2-J3	J3-J1
T1	FVT	0.99	1.00	0.98
	spon	-	-	-
T2	FVT	0.98	0.78	0.86
	spon	-	-	-
P1	FVT	0.94	0.84	0.78
	spon	0.95	0.86	0.96
P2	FVT	0.90	0.38	0.56
	spon	0.53	0.76	0.25
P3	FVT	-	-	-
	spon	-	-	-
P4	FVT	0.86	0.93	0.88
	spon	0.91	0.96	0.99
P5	FVT	0.85	0.79	0.75
	spon	0.19	0.63	0.02
P6	FVT	0.65	0.41	0.91
	spon	0.97	0.97	1.00
P7	FVT	0.93	0.95	0.96
	spon	0.84	0.92	0.89
P8	FVT	1.00	0.95	0.95
	spon	0.98	0.99	0.99
P9	FVT	0.28	0.07	0.56
	spon	0.94	0.89	0.96
P10	FVT	0.80	0.77	0.96
	spon	0.43	0.63	0.64

Table III

	Sample		Mean rank	J1-J2 Relative rank	Mean rank	J2-J3 Relative rank	Mean rank	J3-J1 Relative rank
T1	FVT	Pre hand	4	3	4	3	3.75	3
		Post VR	1.5	1	1.5	1	1.50	1
		Post hand	3	2	3	2	3.25	2
					1		1	
T2	FVT	Pre hand	4.25	3	4.5	3	3.75	2
		Post VR	1.5	1	1.5	1	1.5	1
		Post hand	3.5	2	3	2	4.5	3
					1		0.94	
P1	FVT	Pre hand	5.25	3	5.5	3	5.50	3
		Post VR	1.75	1	2	1	2.88	2
		Post hand	3.5	2	3	2	2.13	1
					1		0.94	
P1	Spon	Pre hand	5.5	3	5.25	3	5.5	3
		Post VR	2.75	2	2.75	2	3.25	2
		Post hand	2.25	1	2.5	1	1.75	1
					1		1	
P2	FVT	Pre hand	4.25	2	3.5	2	5.25	3
		Post VR	4.75	3	5	3	2.5	1
		Post hand	1.5	1	2	1	2.75	2
					1		0.83	
P2	Spon	Pre hand	4.5	3	3.5	2	3.25	2
		Post VR	2.25	1	3.5	2	3.13	1
		Post hand	3.75	2	3.5	2	4.13	3
					0.94		0.94	
P3		Pre hand	N/A	N/A	N/A	N/A	N/A	N/A
		Post VR	N/A	N/A	N/A	N/A	N/A	N/A
		Post hand	N/A	N/A	N/A	N/A	N/A	N/A
			N/A	N/A	N/A	N/A	N/A	N/A
P4	FVT	Pre hand	3	2	2.88	1.5	2.88	2
		Post VR	5.5	3	4.75	3	5.00	3
		Post hand	2	1	2.88	1.5	2.63	1
					0.99		0.99	
P4	Spon	Pre hand						
		Post VR	3.25	2	2.88	2	3.13	2
		Post hand	1.75	1	2.13	1	1.88	1
					1		1	
P5	FVT	Pre hand	3	1	2.75	1	1.88	1
		Post VR	4	3	4.5	3	4.88	3
		Post hand	3.5	2	3.25	2	3.75	2
					1		1	
P5	Spon	Pre hand	1.75	1	4.75	3	4.38	3
		Post VR	3.25	2	1.75	1	3.00	1
		Post hand	5.5	3	4	2	3.13	2
			0.83		1.00		0.83	

P6	FVT	Pre hand	3.25	3	3	2.5	3.38	3
		Post VR	1.5	1	3	2.5	1.25	1
		Post hand	2	2	1	1	2	2
				0.9		0.9		1
P6	Spon	Pre hand	2.5	2.5	2.25	2	2.5	2.5
		Post VR	1	1	1	1	1	1
		Post hand	2.5	2.5	2.75	3	2.5	2.5
				0.99		0.99		1
P7	FVT	Pre hand	5	3	5	3	4.75	3
		Post VR	1.5	1	1.5	1	1.5	1
		Post hand	4	2	4	2	4.25	2
				1		1		1
P7	Spon	Pre hand	4.63	3	5	3	4.75	3
		Post VR	1.63	1	1.5	1	1.5	1
		Post hand	4.25	2	4	2	4.25	2
				1		1		1
P8	FVT	Pre hand	4	3	4	3	3.5	2.5
		Post VR	1.5	1	1.5	1	1.5	1
		Post hand	3	2	3	2	3.5	2.5
				1		0.99		0.99
P8	Spon	Pre hand	3.75	3	3.5	2.5	3.5	2.5
		Post VR	1.5	1	1.5	1	1.5	1
		Post hand	3.25	2	3.5	2.5	3.5	2.5
				0.99		1.00		0.99
P9	FVT	Pre hand	4.25	3	2.75	1	4.88	3
		Post VR	3.75	2	4.25	3	1.75	1
		Post hand	2.5	1	3.5	2	3.88	2
				0.83		0.77		0.94
P9	Spon	Pre hand	4.75	3	4.75	3	4.75	3
		Post VR	3.75	2	4.13	2	3.75	2
		Post hand	2	1	1.63	1	2	1
				1		1		1
P10	FVT	Pre hand	3.38	2	2.88	2	3.63	2
		Post VR	4.75	3	5.25	3	4.38	3
		Post hand	2.38	1	2.38	1	2.50	1
				1		1		1
P10	Spon	Pre hand	5.5	3	4	2.5	5.13	3
		Post VR	2.25	1	2.5	1	1.63	1
		Post hand	2.75	2	4	2.5	3.75	2
				0.99		0.99		1