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**Using assistive technology software  
to compensate for writing and reading  
impairments in aphasia**

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Doctor of Philosophy

City University London

Division of Language and Communication Science

May 2017



## **Table of contents**

<b>List of tables</b>	15
<b>List of figures</b>	17
<b>Acknowledgements</b>	19
<b>Declaration</b>	21
<b>Abstract</b>	23
<b>Chapter 1: Stroke and aphasia, disability, writing and social participation</b>	25
1.1 Stroke and aphasia	25
1.2 The cognitive neuropsychological (CNP) model of language processing	27
1.2.1 A description of writing impairments with reference to the CNP model	28
1.2.2 A description of reading impairments with reference to the CNP model	34
1.3 Conceptual models of disability	37
1.3.1 The medical model of disability	37
1.3.2 The social model of disability	38
1.3.3 A social model approach to communication impairment	40
1.3.4 The World Health Organisation International Classification of Functioning Disability and Health (ICF)	41
1.3.5 The current study's approach	42
1.4 Writing and social inclusion	44
1.4.1 First-hand written accounts of the psychosocial impact of stroke and aphasia	45
1.5 The impact of stroke and aphasia on relationships and social participation	47
1.6 Research questions for this thesis	49
1.7 Outline of the empirical study	50
1.7.1 Training intervention and participants	50
1.7.2 Research questions for the empirical study	51
1.8 Summary	51

<b>Chapter 2: Assistive technology (AT) software</b>	<b>53</b>
2.1 What is AAC?	53
2.2 Hi-tech AAC and aphasia	54
2.3 Speech-to-text AT software	57
2.3.1 Speech-to-text software and the non-impaired population	57
2.3.2 Speech-to-text software studies with impaired users from disabled populations other than PWA	58
2.4 Text-to-speech AT software	60
2.5 Selection of speech-to-text and text-to-speech software packages	62
2.5.1 An overview of speech-to-text AT used in this study: Dragon NaturallySpeaking™	65
2.5.2 An overview of text-to-speech AT used in this study: ClaroRead™	66
2.6 Summary	66
<b>Chapter 3: A systematic literature review of studies aimed at improving writing for people with aphasia</b>	<b>69</b>
3.1 Literature review methods	69
3.1.1. Eligibility criteria	69
3.1.2 Sources of information	70
3.1.3 Search strategy	70
3.1.4 Screening	70
3.1.5 Data extraction	72
3.1.6 Critical appraisal	72
3.2 Literature review results	73
3.2.1 Study design	73
3.2.2 Participants	75
3.2.3 How was writing gain following treatment assessed?	77
3.2.4 What aspects of writing did treatment target?	80
3.2.4.a Single word level treatments	80
3.2.4.a.i Pen and paper single word treatments using writing to supplement speech (N = 11)	82
3.2.4.a.ii Pen and paper single word treatments to	82

remediate spelling (N = 12)	
3.2.4.a.iii Technological single word treatments adapted from pen and paper (N = 5)	83
3.2.3.a.iv Single word treatments designed solely for technological delivery (N = 6)	84
3.2.4.b Phrase and sentence treatments (N = 7)	85
3.2.4.c Narrative level treatments	86
3.2.4.c.i Remeditory narrative treatments (N = 4)	86
3.2.4.c.ii Compensatory narrative treatments (N =8)	87
3.2.5 What gains were made, did they generalise beyond treated items, and were they maintained?	87
3.2.5.a Single word level treatments	87
3.2.5.b Phrase and sentence treatments	89
3.2.5.c Narrative level treatments	90
3.2.6 Were participants' reading requirements addressed?	92
3.3 Gaps in the literature and implications for this study	93
<b>Chapter 4: A pilot study to test the acceptability of an AT training intervention, inform its design and delivery and select outcome measures</b>	<b>101</b>
4.1 Aims	101
4.2 Methods	104
4.2.1 Pilot study participants	104
4.2.1.a Inclusion criteria	104
4.2.1.b Demographic and language information	106
4.2.1.c Prior computer use	106
4.2.2 Measures	108
4.2.2a Quantitative assessments	108
4.2.2.a.i Measures of language, writing and reading	108
4.2.2.a.ii Measures of cognition, quality of life, mood and social participation	108
4.2.2b Qualitative data collection	108
4.2.2.b.i In-depth semi-structured interviews	108

4.2.2.b.ii Video recording	110
4.3 Results and implications for the main intervention study	110
4.3.1 Acceptability of the training intervention	110
4.3.1.a Dragon NaturallySpeaking™	111
4.3.1.b ClaroRead™	112
4.3.1.c <i>Learning skills and preferences</i>	112
4.3.2. Design and development of the training intervention and materials	113
4.3.2.a More detailed goal setting	114
4.3.2.b Extending Dragon NaturallySpeaking™ initial voice training	115
4.3.2.c Mode switching between Dragon NaturallySpeaking™ editing and dictation	116
4.3.3 Selection of assessments to measure outcomes	116
4.3.3.a Language, writing and reading	116
4.3.3.b Cognition, quality of life, mood and social participation	118
4.3.3.c Qualitative data	119
4.4 Summary	121
<b>Chapter 5: Methodology</b>	123
5.1 Research questions	123
5.2 Design	123
5.3 Participants	124
5.3.1 Inclusion criteria	124
5.3.2 Recruitment	125
5.3.3 Ethical considerations	125
5.4 Procedure	127
5.4.1 The assessment protocol	127
5.4.2 The training intervention protocol	127
5.5 Measures	129
5.5.1 Screening assessments	129
5.5.1.a Of language: Comprehensive Aphasia Test (CAT)	129



language battery	
5.5.1.b Of cognition: Cognitive Linguistic Quick Test (CLQT)	130
5.5.2 Profiling assessments: Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) subtests 24, 40, 41, 42, 43, 45, 50, 53 (three formats)	131
5.5.3 Monitoring assessments: Cognition	131
5.5.4 Outcome measure assessments testing compensation	133
5.5.4.a Writing	133
5.5.4.a.i Constrained writing task	133
5.5.4.a.ii CAT written picture description	134
5.5.4b Reading	134
5.5.4.b.i Gray Oral Reading Test version 4 (GORT-4)	134
5.5.5 Outcome measure assessments testing remediation	136
5.5.5.a. Writing: PALPA subtest 40 – imageability and frequency spelling; Reading: PALPA subtest 50 – written synonym judgements	136
5.5.6 Group outcome measure assessments of social participation, quality of life and mood	136
5.5.6.a Social Network Analysis (SNA)	136
5.5.6.b Stroke & Aphasia Quality of Life scale – 39 item generic version (SAQOL-39g)	137
5.5.6.c General Health Questionnaire 12 item version (GHQ-12)	138
5.5.7 Qualitative data	138
5.5.7.a In-depth semi-structured interviews	139
5.5.7.b Participant observation	139
5.6 Data analysis	139
5.7 Summary	141
<b>Chapter 6: Participant characteristics and diagnostic profiles, the training intervention program and individual training plans</b>	<b>143</b>
6.1 Participants	143

6.1.1 Participant characteristics	143
6.2 Diagnostic assessment results	144
6.2.1 Rationale for individual diagnostic assessment and reporting	144
6.2.2 A brief picture of diagnostic results across the group	145
6.2.2a Spoken naming	145
6.2.2b Spelling	145
6.2.2c Reading	149
6.2.3 Case by case diagnostic information	150
6.2.3a Participant 1: Peter	150
6.2.3b Participant 2: Rohan	152
6.2.3c Participant 3: Sarah	154
6.2.3d Participant 4: Karen	156
6.2.3e Participant 5: Albert	158
6.2.3f Participant 6: Dean	159
6.2.3g Participant 7: William	161
6.2.3h Participant 8: Janet	162
6.2.3i Participant 9: Doreen	164
6.2.3j Participant 10: Simon	166
6.3 Participants' pre-stroke computer use and training plans	168
6.4 The AT software training intervention program	172
6.4.1 Topic generation	172
6.4.2 Trial and error dictation	172
6.4.3 Monitoring of participant performance including error management and editing	173
6.4.4 Feedback and prompts for further editing	173
6.4.5 Review of performance	174
6.4.6 Key strategy identification and reinforcement	174
6.4.7 Template for Intervention Description and Replication (TIDieR) checklist	175
6.5 Personalisation of the AT software training program	175
6.5.1 Preparing and producing speech for dictation	178

6.5.2 Limited flexibility and/or perseveration	181
6.5.3 Self talk versus 'on-task' talk	183
6.6 Summary	184
<b>Chapter 7: Results of group outcome measures</b>	187
7.1 Screening/monitoring assessments of cognition, screening assessment of language and monitoring assessments of single word spelling and reading	187
7.1.1 Cognition: the CLQT	187
7.1.2 Language: the CAT language battery	189
7.1.3 Single word spelling: PALPA 40: imageability spelling	190
7.1.4 Single word reading: PALPA 50: written synonym judgements	190
7.2 Outcome measures for research question 1, of narrative writing and reading comprehension	191
7.2.1 Individual differences in performance on narrative writing and reading comprehension	199
7.3 Outcome measures for research question 2, of social participation, mood and quality of life	203
7.3.1 Assessment of social participation: SNA	203
7.3.2 Assessment of mood: GHQ-12	205
7.3.3 Assessment of quality of life: SAQOL-39g	206
7.4 Summary	207
<b>Chapter 8: Findings from qualitative observation and interviews</b>	209
8.1 Qualitative data collection and analysis	209
8.2 Participants' former employment and training program plans	211
8.3 Reflecting on life before and after stroke	211
8.3.1 Writing	212
8.3.2 Reading	215
8.3.3 Computer use	216
8.3.4 Social participation	219
8.3.5 Mood and quality of life	222
8.4 The software packages: participants' evaluation	224

8.4.1 Dragon NaturallySpeaking™	224
8.4.1a Interactive tutorial	224
8.4.1b Initial voice training	225
8.4.1c Dictation	226
8.4.1d Commands	228
8.4.1e Editing	229
8.4.2 ClaroRead™	231
8.4.2a Prosody	231
8.4.2b Navigation	232
8.4.2c Personal preference	233
8.5 Written outputs	234
8.5.1 Genres and activities	234
8.5.2 Writing samples with observation notes on editing	236
8.5.3 Completed writing samples	239
8.6 Further observations from training sessions	239
8.6.1 Software, hardware and technical support	239
8.6.2 Additional writing and computing support requirements	240
8.6.3 Independence versus support	242
8.6.4 Potential for benefit to participants	242
8.7 Summary of barriers and facilitators, strategies and support	243
8.8 Summary of Chapter 8	244
<b>Chapter 9: A discussion of study findings</b>	247
9.1 Returning to the research questions of this thesis	247
9.2 How do this study's participants compare with a 'typical' stroke population?	249
9.3 Group outcome measures of narrative writing and reading comprehension	252
9.3.1 Writing	252
9.3.1.a CAT written picture description	252
9.3.1b Constrained writing task	252
9.3.2 Reading	255
9.4 Group outcome measures of social participation, mood and	255

quality of life	
9.4.1 Social participation	255
9.4.2 Mood and quality of life	257
9.5 How do participants' responses to AT software compare to those of non-impaired users and those with disabilities other than aphasia?	258
9.5.1 Non-impaired users	258
9.5.2 Users with other disabilities	259
9.6 How do the gains made by this group compare with other AT users with aphasia?	261
9.7 What factors may have influenced AT training success and satisfaction for this group?	262
9.7.1 Personal attitude and approach	262
9.7.2 Ideas and creativity	263
9.7.3 Dysgraphia and dyslexia diagnosis and other aphasic traits	263
9.7.4 Speech production	266
9.7.5 Therapeutic goals	267
9.7.6 Degree of cognitive impairment	267
9.7.7 Further reflections on candidacy	269
9.8 How could improvements in mainstream AT design improve its usability for PWA?	270
9.8.1 Dragon NaturallySpeaking™	270
9.8.2 ClaroRead™	270
9.9 Strengths of the study	271
9.9.1 Methodology	271
9.9.2 Sample	272
9.9.3 Program content	272
9.10 Limitations of the study	273
9.10.1 Data collection	273
9.10.2 Dosage, experience and AT access	274
9.10.3 Sample size	276
9.11 Clinical implications of the study	276
9.12 Further research	279

9.12.1 Conducting a larger scale feasibility study	279
9.12.2 Maximising the impact of the study findings	280
9.12.2.a Development of screening and training intervention materials for speech and language therapists	280
9.12.2.b Liaising with software developers and providers	280
9.12.2.c Engaging PWA in long-term, independent writing projects	281
9.12.2.d Peer support and participatory design	282
9.12.2.e Supporting self-directed attempts at remediatary writing tasks	283
9.13 Conclusion	283
<b>References</b>	285
<b>Bibliography</b>	299
<b>Appendices</b>	
3.1 Data extraction table for the systematic literature review	317
3.2 Quality ratings tables for the systematic literature review	355
4.1 Pre-training (T2) topic guide for in-depth semi-structured interview	364
4.2 Post-training (T3, T4) topic guide for in-depth semi-structured interview	366
4.3 Goal setting power-point presentation	367
4.4 Participant progress form for self-completion	369
4.5 Sample of supporting notes for participant	370
5.1 Ethics application form	374
5.2 Project flyer	408
5.3 Project information sheet	409
5.4 Project consent form	414
7.1 Outcome measures descriptive statistics for Participant 1: Peter	417
7.2 Outcome measures descriptive statistics for Participant 2: Rohan	418
7.3 Outcome measures descriptive statistics for Participant 3: Sarah	419
7.4 Outcome measures descriptive statistics for Participant 4: Karen	420
7.5 Outcome measures descriptive statistics for Participant 5: Albert	421

7.6 Outcome measures descriptive statistics for Participant 6: Dean	422
7.7 Outcome measures descriptive statistics for Participant 7: William	423
7.8 Outcome measures descriptive statistics for Participant 8: Janet	424
7.9 Outcome measures descriptive statistics for Participant 9: Doreen	425
7.10 Outcome measures descriptive statistics for Participant 10: Simon	426
8.1 Thematic Index	427
8.2 Sample chart to illustrate the Framework process	428
8.3 Dragon NaturallySpeaking™ commands prompt sheet	431
8.4 Completed writing samples	432





## **List of tables**

1.1 The individual model versus the social model of disability	40
2.1 Evaluation of AT packages	64
3.1 Aspects of writing targeted by treatment in the 53 reviewed studies	81
3.2 Features of narrative compensatory studies using technology	96
4.1: Pilot training intervention protocol	106
4.2 Pilot participant CAT spoken and written picture description	107
5.1 PALPA diagnostic subtests	132
6.1 Participant characteristics	146
6.2 Participant PALPA scores	148
6.3 PALPA scores: Peter	152
6.4 PALPA scores: Rohan	153
6.5 PALPA scores: Sarah	155
6.6 PALPA scores: Karen	157
6.7 PALPA scores: Albert	158
6.8 PALPA scores: Dean	160
6.9 PALPA scores: William	162
6.10 PALPA scores: Janet	163
6.11 PALPA scores: Doreen	165
6.12 PALPA scores: Simon	167
6.13: TIDieR checklist overview of the AT software training intervention program	176
7.1 Group screening and monitoring assessment scores	188
7.2 Group descriptive statistics for assessments of narrative writing and reading comprehension	192
7.3 Group descriptive statistics for assessments of social participation, mood and quality of life	204
8.1 Choice of passages to be read aloud for voice training	226
8.2 Written outputs	235



## List of figures

1.1 The cognitive neuropsychological model of language processing, adapted from Whitworth, Webster and Howard	28
1.2 Written picture naming and writing to convey meaning	29
1.3 Copying written words	29
1.4 Writing to dictation via the lexical semantic route	30
1.5 Writing to dictation via the sub-lexical route	30
1.6 Writing to dictation via the direct lexical route	31
1.7 The Living with Aphasia Framework for Outcome Measurement (A-FROM)	43
3.1 The review process flow diagram	71
4.1 Pilot assessment protocol	105
5.1 The assessment protocol	128
5.2 Accessible social network diagram	137
6.1 Participant recruitment flowchart	144
6.2 Individual single word total correct spellings on PALPA subtest 40 at baseline	149
6.3 Individual single word total correct judgements on PALPA subtest 60 at baseline	151
7.1 Group CLQT mean composite severity score over time	189
7.2 Group mean PALPA 40 scores over time	190
7.3 Group mean PALPA 50 scores over time	191
7.4 CAT written picture description pen and paper version, mean scores over time	195
7.5 Pen and paper constrained writing task, group mean tokens produced over time	195
7.6 Pen and paper constrained writing task, group mean % lexical density over time	196
7.7 Pen and paper constrained writing, group mean social validity judgement rating over time	196
7.8 GORT-4 pen and paper version, group mean score over time	197
7.9 CAT written picture description keyboard version, mean score	197

over time	
7.10 Keyboard constrained writing task, group mean tokens produced over time	198
7.11 GORT-4 keyboard version, group mean score over time	198
7.12 Keyboard constrained writing task, mean % lexical density over time	200
7.13 Keyboard constrained writing, group mean social validity judgement rating over time	200
7.14 Keyboard CAT written picture description individual scores	201
7.15 Keyboard constrained writing total token individual scores	201
7.16 GORT-4 comprehension individual scores	202
7.17 Group mean size of social network over time	205
7.18 Group mean GHQ score over time	206
7.19 Group mean SAQOL-39 score over time	207
8.1 Dragon NaturallySpeaking™ Interactive Tutorial screenshot	225

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Becky Moss, May 2017



**Declaration**

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## Abstract

**Background:** Aphasia is a language impairment affecting approximately one third of people after stroke. It can disrupt speaking, comprehension, reading and writing. This thesis concerned people with aphasia (PWA) with spelling and writing impairments (some also had reading difficulties) but relatively preserved speech and comprehension.

### Aims:

1. Consider the evidence for writing treatment interventions with a systematic review of the literature;
2. Conduct a pilot study testing the acceptability of a compensatory narrative writing treatment intervention using assistive technology (AT) software;
3. Report an empirical study which designed, delivered and evaluated a program to train ten PWA to operate two mainstream AT packages (Dragon NaturallySpeaking™, a voice recognition software (VRS) to support writing via dictation, and ClaroRead™, supporting reading via auditory processing). The study tested whether: a) AT could be used to produce functional narrative writing, b) reading support promoted writing success c) the intervention could be customised to suit individual goals.

### Methods:

#### 1. Systematic literature review

Electronic databases were searched; 53 papers meeting inclusion criteria were identified. Data were extracted, papers were critically appraised and their findings described.

#### 2. Pilot

Ten week AT training with two PWA to test acceptability of the intervention, design training schedule and materials, and test quantitative assessments and qualitative data collection methods for the main study

#### 3. Main study

*Design and setting:* Small group study with mixed methods, repeated measures design. Assessments and AT training in participants' homes or at City, University of London.

*Participants:* Ten participants meeting eligibility criteria (over 18 years old, medically stable, no significant cognitive impairment, aphasia due to stroke, presenting with acquired dysgraphia) were recruited via convenience sampling. They were not receiving speech and language therapy, had no marked evidence of neuromuscular, structural or motor-speech impairments, nor self-reported history of developmental dyslexia.

*Measures and procedure.* Participants received 7-10 one-hour individual training sessions. Screening (language, cognition) and diagnostic (single word writing, single word reading) assessments took place at T1 (first baseline). Outcome measures (narrative writing, reading comprehension, quality of life, mood) were taken at T1 and repeated at T2 (second baseline), T3 (end of intervention) and T4 (three month follow up). Participant observation occurred throughout training; qualitative semi-structured interviews, a social participation assessment and cognitive monitoring took place at T2, T3 and T4.

### Results:

#### 1. Systematic literature review

Writing treatments were effective but often focused on single word production and seldom tested functional generalisation. Most were single case or small case series studies with remedial goals; few used qualitative methodologies or investigated the impact of reading deficits. All narrative writing therapies were delivered via technology.

#### 2. Pilot

The intervention was acceptable to participants. Training schedule and materials were created and refined; quantitative outcome measures were finalised; emphasis on participant observation was increased.

3. Main study: Keyboard narrative writing was significantly improved by AT (Friedman's  $\chi^2(3) = 8.27$ ,  $p = .041$ ), as was keyboard reading comprehension (Friedman's  $\chi^2(3) = 21.07$ ,  $p < .001$ ), indicating compensatory effects of both AT. There was no change over time in pen and paper assessments of writing or reading, indicating no remedial effect. A wide range of written genres were produced. Social network size significantly increased. There were no significant changes in mood or quality of life. Individual success rates varied; diagnostic and observation data suggested contributing factors were attitude, creativity, preserved speech production skills, spectrum of other aphasic traits, therapeutic goals, and cognition.

**Conclusion:** The compensatory customisable AT training was acceptable to eight of ten participants, and resulted in significantly improved narrative writing performance.

**Implications:** Compensatory AT interventions serve as a useful adjunct to remedial spelling interventions, and are particularly useful for supporting functional narrative writing.



## **Chapter 1: Stroke and aphasia, disability, writing and social participation**

This chapter gives background information about causes, typology and outcome of stroke. It describes the nature of aphasia, a language and communication impairment which can occur after brain injury, including stroke. It outlines a conceptual model of language processing, the cognitive neuropsychological model, and describes the impact of writing and reading impairments in relation to the model. The chapter goes on to discuss different ways in which impairment and disability can be conceptualised, both in general terms and in the specific context of language impairments, with reference to the medical and social models of disability and how these two theoretical perspectives may be blended. It considers the role of writing in social inclusion in the non-impaired population and for those with aphasia, then describes the literature on the impact of stroke, and of aphasia, on relationships and social participation. Finally, the chapter sets out the research questions addressed by this thesis as a whole, and outlines the empirical study reported in the thesis, including research questions specific to the study.

### ***1.1 Stroke and aphasia***

Aphasia is a language and communication disorder which occurs when language centres in the left hemisphere of the brain are damaged [1] [2] [3]. This can either be as a result of traumatic brain injury (TBI) such as a car accident or a blow to the head, tumour or other neurological insult; or as a result of a degenerative condition known as Primary Progressive Aphasia (PPA), or – most commonly – as a result of stroke. Sometimes known as a cardio vascular accident (CVA), a stroke occurs when blood flow within the brain is interrupted, either by a clot blocking a blood vessel, accounting for around 80% of CVAs and known as an ischaemic stroke [4], or more rarely a bleed rupturing a blood vessel, known as a haemorrhagic stroke. Risk factors for stroke include high blood pressure, diabetes, high cholesterol and atrial fibrillation; lifestyle choices such as smoking and excessive alcohol consumption also raise the risk of stroke, as do certain hereditary conditions such as sickle cell anaemia. Stroke is more common

in those of South Asian, Black African and Black Afro-Caribbean descent [5], and risk increases with age, with average ages at first stroke of 71 for men and 77 for women [6]. Having experienced a stroke also raises the risk of recurrence, particularly in the phase immediately post-onset. Blood-thinning medications are sometimes prescribed for those at increased risk of ischaemic stroke, along with lifestyle recommendations. Stroke is fatal in one in eight cases within 30 days, and one quarter within a year, however there are over 1.2 million stroke survivors in the UK [5], and around one third of them have some degree of aphasia [7].

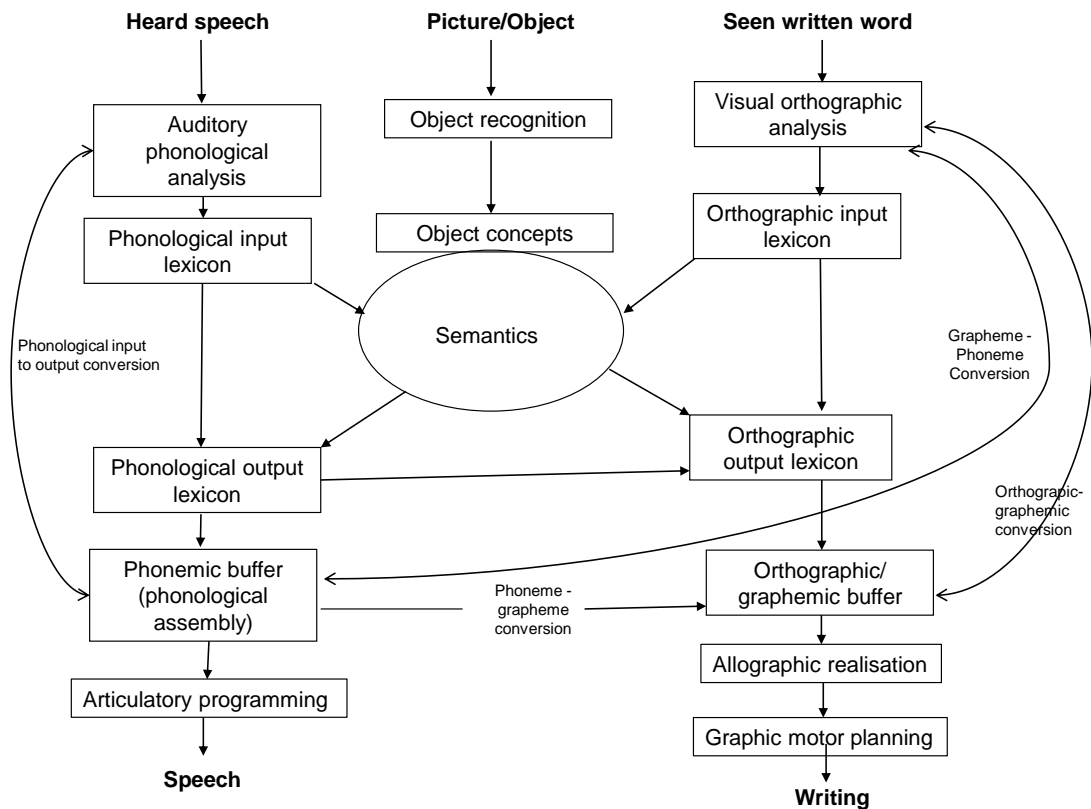
Besides language deficits, stroke can also result in a range of motor and cognitive impairments, and the severity of all of these outcomes varies widely between individuals depending on the exact locus and extent of their brain injury. The effects of stroke can sometimes be remediated with physical, occupational and speech and language therapy (SLT), and rehabilitation is often undertaken for many weeks or months. Furthermore, spontaneous recovery often occurs, initially as swelling of the brain subsides, and later owing to neural plasticity [8], whereby alternative processing routes within the brain develop and strengthen over time. Nevertheless, many individuals who have a stroke will be left with residual, chronic impairments.

The area of brain damage visible on neuroimaging is known as a lesion. The rapid progress of brain imaging over the past two decades means that mapping of parts of the brain to their functions has become increasingly precise, largely owing to the study of lesion location and the corresponding impairments to which they give rise. This may have promising implications for tailoring therapeutic treatment in order to maximise benefit, and also on predicting recovery over time [9]. Clinicians may find it useful to classify aphasic traits as broad sub-types, the two most common of which are named Broca's and Wernicke's aphasia, after the scientists who identified the areas of the brain which correlate with their symptomatology. Broca's aphasia is characterised by non-fluent language production, coupled with relatively intact comprehension: individuals with non-fluent aphasia

typically have impaired spoken output, but are able to understand and process the speech of other individuals relatively well. Those with more severe non-fluent aphasia may find it difficult to produce short sentences, or even single words. Wernicke's aphasia by contrast is characterised by fluent language production, usually coupled with poorer comprehension of language input. Some individuals with fluent aphasia find it difficult to monitor their own spoken output, which may be circumlocutory and/or have reduced informative content. Those with more severe fluent aphasia may produce neologisms and/or jargon, making their output difficult for others to understand, and may have only limited awareness of this.

### ***1.2 The cognitive neuropsychological (CNP) model of language processing***

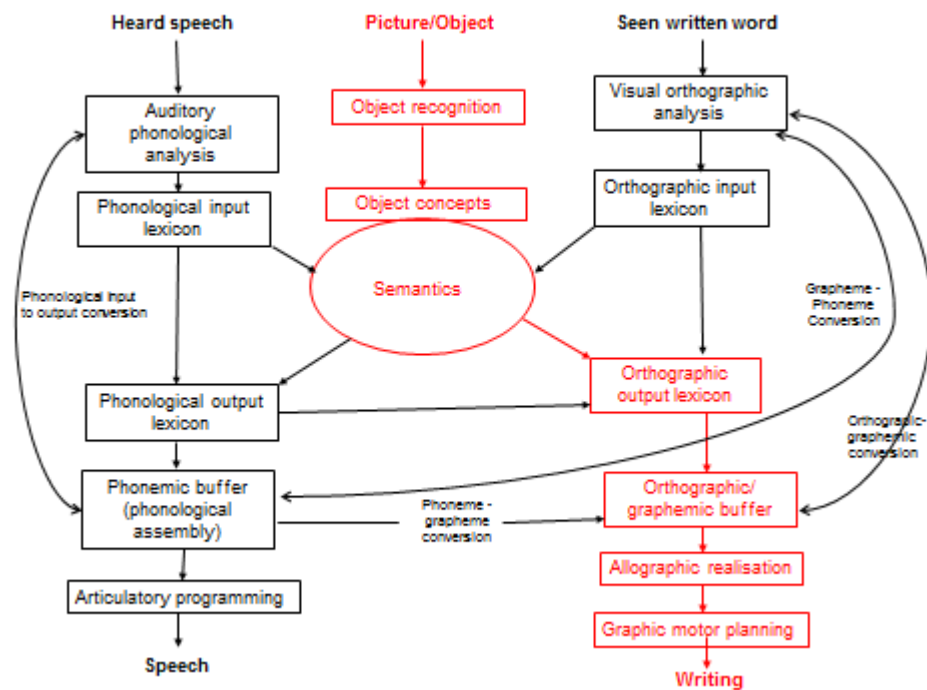
The cognitive neuropsychological (CNP) model [10], [11], [12] (Figure 1.1) illustrates the normal human language processing system. Other models of language processing and production, such as computational [13] [14] [15] and top-down [16] models were considered for inclusion in this thesis; however, the CNP model was selected because it is widely used and frequently cited in SLT and the related body of literature, particularly in remediation studies of reading and writing impairments (see Chapter 3). Furthermore, the model has been used to diagnose and differentiate stroke related writing impairments in more detail than other models, for example in detailed linguistic assessments such as the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) [17]. The CNP model aims to cover all types of input requiring language comprehension and all types of output involving language production. The model incorporates a number of different routes, meaning that language comprehension and production, from input to output and vice versa, can take place in a number of different ways. The sequenced and inter-linked nature of the model also indicates that levels are interdependent, and that interruption – or impairment – at any one level may impact on the levels which follow, on the route that processing and production will take, and on the eventual output itself.



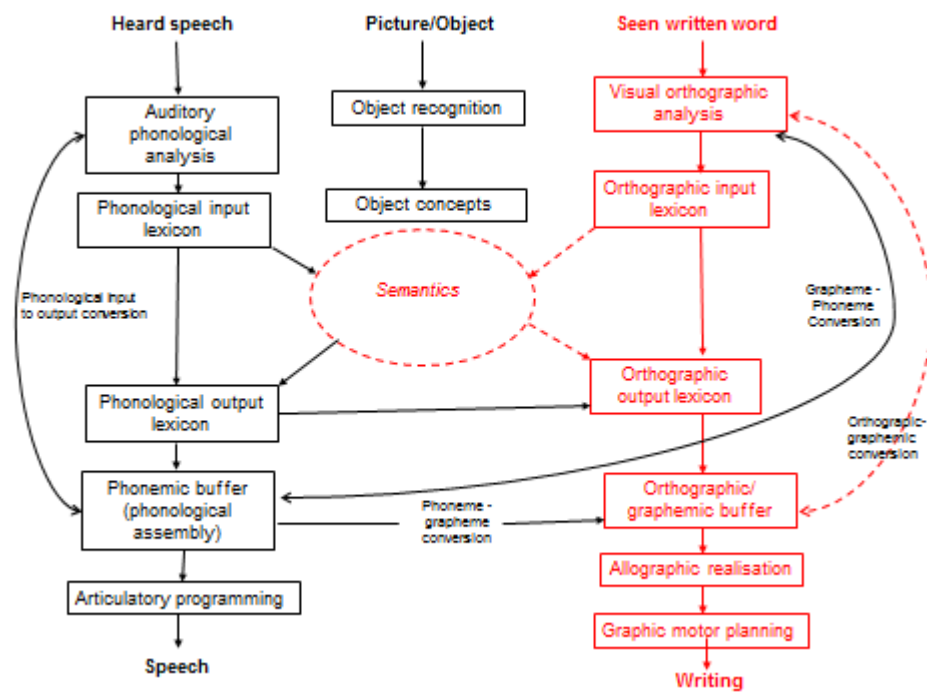
**Figure 1.1:** The cognitive neuropsychological model of language processing, adapted from Whitworth, Webster and Howard [10]

### 1.2.1 A description of writing impairments with reference to the CNP model

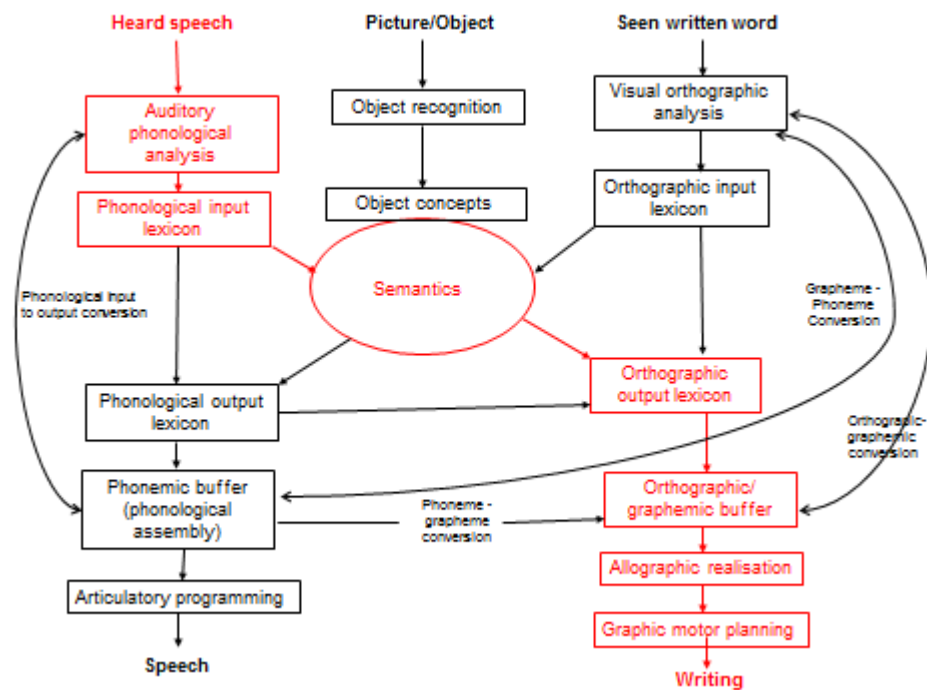
Under normal circumstances, a writer has several routines at their disposal to enable them to produce an orthographic representation of a word [11], and different tasks - such as written naming of objects/pictures, writing words to convey meaning, copying written words and writing to dictation - call on different processes. What follows briefly outlines these routes. Writing spontaneously, from an internally generated idea, involves processing in the semantic system, followed by access to the corresponding orthographic representation of the idea or object in the orthographic output lexicon. Producing the written name of an object requires very similar processing, although here object/picture recognition is additionally required; both of these processes are illustrated in Figure 1.2. Copying written words (Figure 1.3) requires visual orthographic analysis, activation of the orthographic input lexicon and conversion of the



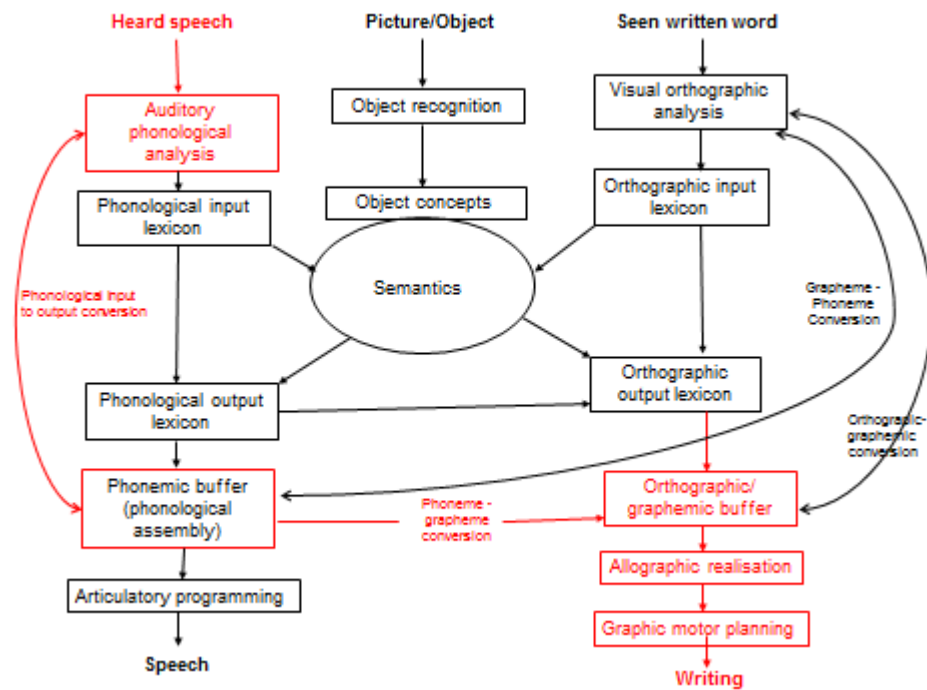
**Figure 1.2:** Written picture naming and writing to convey meaning



**Figure 1.3:** Copying written words

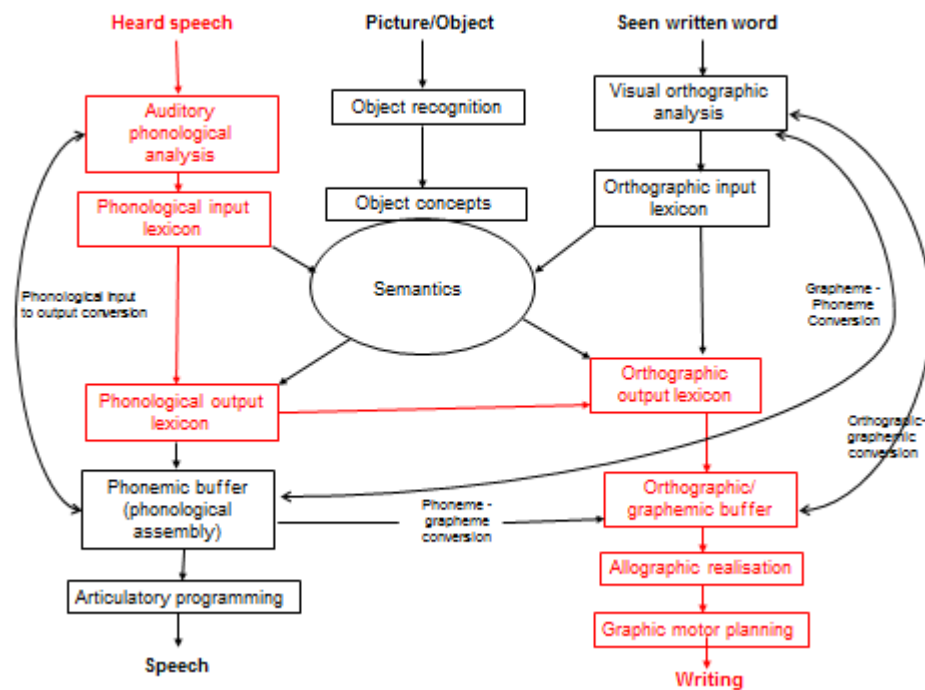


**Figure 1.4:** Writing to dictation via the lexical semantic route



**Figure 1.5:** Writing to dictation via the sub-lexical route





**Figure 1.6:** Writing to dictation via the direct lexical route

target into a written representation for output; this process can occur with or without semantic involvement, since one does not necessarily need to access the meaning of a target in order to copy it successfully.

Copying may also take place sub-lexically, via the route connecting visual orthographic analysis directly to the graphemic buffer. Likewise, there are three spelling mechanisms which can be called upon in order to write a word to dictation. One is to use the semantic lexical route (Figure 1.4), involving access to a lexical item's real-world meaning (using processes shared with written naming and writing for meaning). An alternative calls upon phoneme to grapheme conversion, also known as the sub-lexical route (Figure 1.5), which involves segmentation of the word into phonological units and the use of regular sound to letter correspondences; this is the only route that can be used to write unfamiliar words and non-words, since these do not have semantic or lexical representations. The third option is the direct lexical route (Figure 1.6): this requires lexical but not semantic knowledge, since the phonology of a whole word is first retrieved from the phonological output lexicon, which then activates the

corresponding entry within the orthographic output lexicon. The direct lexical route can only be used for real, familiar words since only they are stored in these lexicons.

When brain damage is sustained, for example as a result of stroke, language processing and production may be affected in a number of ways. It is important to note that mechanisms are rarely entirely eliminated; rather, individuals typically display patterns of strength and weakness, whereby some operations are impaired and others retained. This has implications for rehabilitation, as residual skills can be developed or used for compensatory processing.

In the case of written language production impairment, dysgraphia may either be central or peripheral. Central dysgraphia arises from impairments of cognitive processing or retrieval in either long-term memory (the orthographic lexicon), phoneme to grapheme conversion, or working memory (the graphemic buffer) [18], up to the generation of an abstract graphemic representation of a word [19]. Peripheral dysgraphia occurs during the later stages of the CNP model, either at the level of allographic realisation or of graphic motor planning, and is caused by difficulties with translating these abstract representations into written forms [20].

There are three types of 'central' dysgraphia, known as surface, phonological and deep dysgraphia [21]. A fundamental issue when considering a differential diagnosis is whether an individual is forced to rely on knowledge governing the rules of phoneme to grapheme correspondence, or is unable to rely on this knowledge sufficiently. If they depend too heavily on this knowledge (suggesting that lexical spelling mechanisms are impaired), this is known as surface dysgraphia. If they are unable to translate phonology to orthography reliably (indicating impairment to the phoneme to grapheme conversion operations), this indicates either phonological or deep dysgraphia. In the former, real word writing is relatively intact, although there are typically errors with functors [22] and inflections [23]. In the latter, real word writing is also impaired,

and there is a pattern of performance whereby concrete, highly imageable words, for example 'table' tend to be more preserved than abstract, less imageable words such as 'trust.' Owing to this imageability effect, there tends to be a scale effect relating to word class, where noun production is least impaired, followed by verbs, then adjectives, with functors ('function' words such as prepositions and connectives) being the most difficult word class to produce accurately. These deficits are indicative of a level of semantic impairment, often further evidenced by substitutions with semantically related words, for example 'money' for 'coin.' There is some debate as to whether phonological dysgraphia (PD) and deep dysgraphia (DD) are two distinct conditions, or part of a continuum on which PD represents milder impairments and DD indicates greater deficit, owing to an underlying common 'primary system' problem rather than damage to discrete, task-specific mechanisms [24].

Cognitive neuropsychological theories contend that specific observable patterns of writing impairment depend firstly on the location of the impairment within the model, and further on whether alternative routes can be utilised. Causes of writing impairment may be rooted in the following stages of the CNP model: phoneme-grapheme conversion, the semantic system, accessing the orthographic output lexicon, within the orthographic output lexicon itself, at the graphemic buffer, or at the level of allographic realisation and graphic motor planning.

In surface dysgraphia, impaired access to the orthographic output lexicon [25] results in impaired writing to dictation via the semantic lexical route, besides impaired written naming and problems with spontaneous writing; words may still be written via phoneme to grapheme conversion, and comprehension of spoken and written words, and spoken word production, will be preserved. Phonological dysgraphia manifests as a phoneme to grapheme conversion [26] impairment, characterised by poor non-word writing, and sometimes rendering targets as similar real words (for example: bem/bed), known as a lexicalisation error. Deficits in the semantic system, seen in deep dysgraphia, [27] affect writing to convey

meaning and writing to dictation (at least via the semantically mediated route) and, typically, less imageable items are more difficult to spell. Impairment within the orthographic output lexicon itself [28] leads to disrupted writing via both the semantic lexical and the direct lexical route, so that only PGC may be relied upon, therefore spelling of more frequent words tends to be relatively well preserved. The graphemic buffer might be perceived as a component of short term memory, and usually stores the orthographic representation of a word long enough for it to be produced. An impairment at this level affects this storage [29] and results in difficulties with retrieval of written forms. Writing both real words and non-words, written naming, writing to dictation, copying (particularly if delayed), typing and oral spelling will be equally affected, As the buffer is post-lexical, performance is most likely to be affected by length, and less influenced by lexical or semantic variables such as grammatical class, frequency, imageability or concreteness, (though in a single case study, Sage and Ellis [30] argue these top-down influences on the graphemic buffer may be more widespread than has previously been acknowledged).

Difficulties in the final two stages of the model are known as 'peripheral' (rather than central) dysgraphias [31]. The allographic level is responsible for production of spatial representation of graphemes in their different forms (upper and lower cases). Allographic realisation problems [32] result in letter substitutions, or fused or incomplete forms, potentially in both words and non-words. Oral spelling is preserved, ability to describe the shape of a letter is retained, and copying is unaffected, as this not a motor disorder affecting the realisation of letters. Finally, graphic motor planning deficits are characterised by difficulties with the production of graphemes using writing tools. This is not a pure motor issue and is not related to hemiplegia, but to the planning stages of motor production. Copying may be easier than other forms of writing, and typing may be preserved.

### *1.2.2 A description of reading impairments with reference to the CNP model*

In the CNP model, reading for meaning involves three systems: visual orthographic analysis, which identifies letters, codes them for position and

may also parse them into graphemes (letters or groups of letters which represent corresponding sounds); the orthographic input lexicon, a store of visual word recognition units which recognises and accesses familiar written word forms; and the semantic system, whereby word meanings are activated in response to written word recognition. There are three routes for reading words aloud: the lexical semantic, the sub-lexical and the direct lexical route. Reading via the lexical semantic route requires access to meaning, and can only be used for real, familiar words; it should not be affected by spelling-to-sound regularity. The sub-lexical route is used for reading via grapheme to phoneme conversion, or sounding out letter-to-sound correspondences, permitting non-words and regular unfamiliar words, which do not have lexical representations, to be read successfully. Finally, the direct lexical route involves simply recognising a word in the orthographic input lexicon and retrieving its phonology from the phonological output lexicon, without depending on semantic knowledge, whereby real words may be accurately read regardless of irregularity (for example, 'hyena' [33]).

Deficits of reading correspond closely to their written counterparts in the model, and can also be categorised as either central or peripheral. Central impairments affect lexical and semantic operations, while peripheral impairments are confined to 'early' operations involved in visual analysis [10]. Again, there are three types of central dyslexia. Surface dyslexia typically arises from impairments in the orthographic input lexicon. As GPC is preserved there is [34] a marked advantage for reading regular spelling-sound correspondences, and difficulties with exception words. Errors in reading aloud are often regularisations, for example reading the irregular word 'pint' as rhyming with 'mint.' There may also be comprehension deficits owing to over-dependence on grapheme to phoneme reading. Deep dyslexia [35], [36] and phonological dyslexia [37], share a pattern of impaired ability to assign pronunciation to unfamiliar letter strings, because in both cases there is impairment to GPC. In phonological dyslexia, word recognition and comprehension are relatively intact so most real

words can be correctly read, though low-imageability word classes such as functors, and morphologically complex words, may be vulnerable [38]. By contrast, deep dyslexia additionally impairs the semantic system, resulting in frequent real-word errors, particularly with abstract targets [22].

The peripheral dyslexias include pure, neglect, attentional and visual dyslexia. Pure dyslexia [39] (sometimes known as dyslexia without dysgraphia), is characterised by dependence on letter-by-letter naming (that is, oral spelling) in order to read a word, coupled with retained auditory recognition of orally-spelled words and ability to spell to dictation. In neglect dyslexia [40], errors are spatially determined, occurring consistently at either the beginning or end of words, and attempts produced are typically of the same length as the target. This typically occurs as part of a wider neglect diagnosis, which affects the ability to process information in one area of space. In attentional dyslexia [41], graphemes 'interfere' with each other and may 'migrate.' Finally, in visual dyslexia [42], there is typically difficulty with identifying and recognising the visual form of a word, either at the level of visual orthographic analysis or subsequent access to the orthographic input lexicon.

As with deficits of written language production, the manifestation of reading errors depends both on location of the impairment within the model, and whether alternative routes through the model can be utilised. Locations of potential reading deficit are: visual orthographic analysis, access to the orthographic input lexicon, impairment within the lexicon, the semantic system and grapheme to phoneme conversion. Impairments to the first two stages result in peripheral dyslexia: damage to the visual orthographic analysis system results in visual reading errors (neglect, attentional or visual dyslexia), and may also cause letter-by-letter reading (pure dyslexia). As visual orthographic analysis is used in all aspects of reading, errors occur with both real words and non-words, and comprehension of real words is impaired. Impairment within the orthographic input lexicon, or in accessing the lexicon, leads to reduced comprehension and causes difficulties with lexically-mediated reading

aloud. If GPC operations are retained, patterns of surface dyslexia may be seen; i.e. regular words are read better than irregular ones, and lexical decisions occur via phonology, causing irregular words to be rejected but non-word pseudo-homophones to be accepted and understood. Semantic deficits result in reading comprehension impairments, which would also be reflected in poor auditory comprehension of the same targets, are indicative of deep dyslexia. Finally, orthographic to phonological conversion problems present as poor reading of non-words and novel words, which may be read as similar real/familiar words; if this is the only reading deficit it will manifest as phonological dyslexia.

### ***1.3 Conceptual models of disability***

#### ***1.3.1 The medical model of disability***

The cognitive neuropsychological model of language processing and other similar models focus on the nature of the aphasic impairment. They aim to identify the underlying cause of a demonstrable deficit in order to guide intervention to address this deficit. The CNP model fits within a medical model of impairment and disability. According to Haegele and Hodge [43], this model gained prominence when doctors and scientists replaced religious leaders as the cognitive authorities in society. They are somewhat critical of the pure medical model, stating that it takes a 'strongly normative' view (page 195) which leads to disability being regarded as a problem which must be medically cured. Many people with aphasia (PWA) and their families would not dispute this conceptualisation themselves: they experience aphasia, and the other physical, cognitive and psychological sequelae of stroke, as debilitating and unpleasant, and are keen to resolve them as effectively as possible. However, as with many chronic conditions, therapeutic and pharmaceutical interventions may only partially address the symptoms and long-term effects of stroke. Many individuals remain aphasic despite speech and language therapy, and have a degree of permanent impairment with which they must eventually reconcile themselves and accommodate in their day to day lives. The following section discusses an alternative theoretical conceptualisation of

impairment and disability, the social model, with reference to living with long-term conditions such as aphasia.

### *1.3.2 The social model of disability*

According to Oliver [44], the social model of disability originated from a 1976 document by the Union of the Physically Impaired Against Segregation (UPIAS) called *Fundamental Principles of Disability*, which stated:

‘It is society which disables physically impaired people. Disability is something imposed on top of our impairments by the way we are unnecessarily isolated and excluded from full participation in society. Disabled people are therefore an oppressed group in society. To understand this it is necessary to grasp the difference between the physical impairment and the social situation, called ‘disability,’ of people with such impairment. Thus we define impairment as lacking part or all of a limb, or having a defective limb, organ or mechanism of the body, and disability as the disadvantage or restriction of activity caused by a contemporary social organisation which takes no or little account of people who have physical impairments and thus excludes them from participation in the mainstream of social activities’ (cited in Oliver, page 40).

In the years since the UPIAS document was published, the social model of disability has gained currency as a result of sociological research and lobbying by disabled academics and activists, who reject what they regard as the medicalised, ‘individual’ model of disability, which they hold is accepted as the norm in Western industrialised societies. Barnes and Mercer [45] say that in our society, disability is:

‘Widely regarded as an individual failing and a personal tragedy. This is confirmed by its pre-eminent medical



diagnosis in terms of individual pathology, and associated deficits, abnormalities and functional limitations’ (page 1).

They go on to say that the crucial problem with this conceptualisation of disability is that:

‘These difficulties become both the *explanations* for the wide-ranging social disadvantages and dependence and the *justification* for routine intervention in disabled people’s lives by health and social welfare professionals’ (page 1, my emphases).

Put simply, while bodily impairments themselves are situated at the individual level, the limitations those impairments place on access to activities of daily living result chiefly from the unwillingness of society at large to accommodate them, and it is this which leads to disablement. Oliver illustrates the difference between the two models (in table 1.1, reproduced below). He notes that:

‘Like all tables, this one oversimplifies a complex reality and each item should be seen as the polar end of a continuum. Nevertheless, underpinning it is the fundamental distinction between impairment and disability as defined by UPIAS’ (page 45).

The nuances of the social model are hotly contested, even among its advocates. Some disagree with the stark separation of impairment and disability because they feel it directly contradicts the day to day experiences of disabled people [46], denying ‘the experience of our bodies, insisting our physical differences and restrictions are entirely socially created’ [47] (page 10). Others point out that separating impairment and disability has the potential to marginalise some specific impairment groups who may not self-identify as ‘disabled’ [48] - they use the examples of people with learning difficulties, deaf people and those with a mental

<b>The individual model</b>	<b>The social model</b>
Personal tragedy theory	Social oppression theory
Personal problem	Social problem
Individual treatment	Social action
Medicalization	Self-help
Professional dominance	Individual and collective responsibility
Expertise	Experience
Adjustment	Affirmation
Individual identity	Collective identity
Prejudice	Discrimination
Attitudes	Behaviour
Care	Rights
Control	Choice
Policy	Politics
Individual adaptation	Social change

**Table 1.1:** The individual model versus the social model of disability [44]

illness - and add that the social model also downplays the potential for considerable variation in experiences between different groups in terms of both impairment and disability, contrasting deafness with cerebral palsy by way of illustration. Furthermore, Corker [49] criticises the social model because she regards it as implicitly excluding groups for whom language and communication exert an additional effect on mediating social exclusion. While she writes about deafness, her remarks are highly pertinent to other language and communication impairments, including aphasia.

### *1.3.3 A social model approach to communication impairment*

Hewitt and Pound [50] seek to relate barriers to communication access to the social model of disability, stating:

‘Aphasia places the spotlight on language and communication both as the source of disablement and improved access. To have a voice within social and political discourse, to enjoy access to equality, citizenship and social belonging, reminds us of the central importance of language. With hidden impairments

affecting communication, cognition, mental health and energy, the experience of living with language difficulty challenges the social model of disability to grapple with discussions of access, inclusion, identity and impairment’ (page 181).

Elsewhere, Parr, Hewitt, Wimborne and Pound [51] also draw parallels between the visible, physical barriers to access which are most commonly described as disabling barriers in the social model literature, and the less tangible aspects of inclusion affecting PWA:

‘If you can’t get into a building physically you can’t participate in the discussions and activities that happen there. If you can’t get into a conversation or understand the papers for a meeting you can’t participate in the important decisions. You’re lost’ ([51], quoted verbatim from video-recorded material).

Parr argues speech and language therapists and other clinicians should adopt a social model of literacy [52], which ‘as an alternative to a professional discourse which construes language as a set of quantifiable, technical processes is one in which it is represented as a social practice’ (page 470).

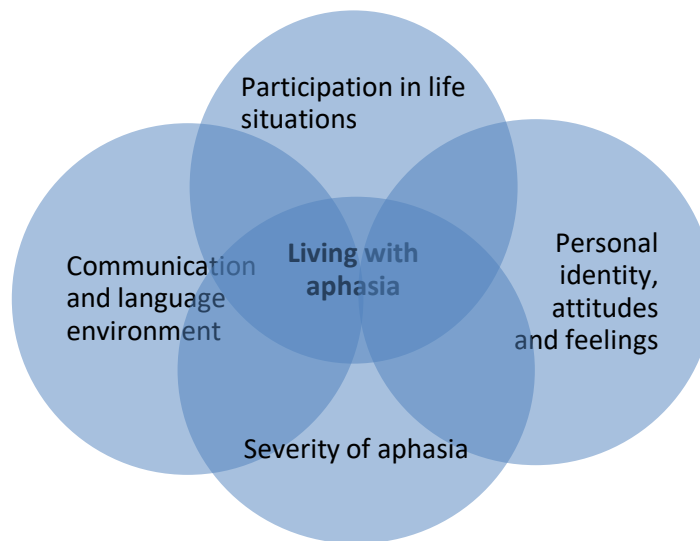
#### *1.3.4 The World Health Organisation International Classification of Functioning Disability and Health (ICF)*

The constitution statement of the World Health Organisation (WHO) principles defines health as: ‘a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity’ ([53] page 1). The ICF [54] is the WHO framework for measuring health and disability at both individual and population levels, using a checklist approach to quantify impairments of body function and body structures, and resulting activity limitations and participation restrictions. It also records environmental factors – physical, social and attitudinal – which impact on an individual’s health. The ICF was developed as an attempt to

integrate the medical model with social context, and the WHO claims to have made a 'radical shift' away 'from emphasising peoples' disabilities' and towards 'a focus on their level of health' (page 3).

### *1.3.5 The current study's approach*

The intervention study described in this thesis was intended to acknowledge the risk of creating a false disconnection between impairment and disability, and its design and ethos is intended to acknowledge the importance of clinical therapeutic input as well as holistic, patient-centred goals: in this respect it is informed by the integrated approach of the WHO ICF. The study was also heavily influenced by the social model of disability in general, and by the social model of literacy advocated by Parr in particular. These collective influences appeared to be a sound fit with the Living with Aphasia Framework for Outcome Measurement (A-FROM) developed by Kagan et al [55], which was designed as a simplified version of the ICF based around the social model perspective of the researchers' Life Participation Approach to Aphasia (LPAA) [56]. The A-FROM (Figure 1.7) was developed to take account of the impact of aphasia on life areas deemed important by PWA and their families when measuring outcomes, for example in functional tasks, participation and valued activities, in order to capture, document and track real-life, meaningful change. It consists of four domains: 1. participation in life situations, 2. severity of aphasia, 3. communication and language environment and 4. personal identity, attitude and feelings. At the intersection of these four domains is the individual's experience of living with aphasia. In the current study these would map onto outcome measures of 1. social participation, 2. dysgraphia and dyslexia, 3. Narrative writing with and without AT, and 4. Quality of life and mood, and the qualitative interview/observation data. Naturally, it is important to acknowledge the interrelatedness of these domains; for example, interviews also illuminate aspects of social participation and engagement with AT, degree of aphasia influences narrative writing and so on. The



**Figure 1.7:** The Living with Aphasia Framework for Outcome Measurement (A-FROM)

outcome measures used in the empirical study are discussed further in Chapter 3, 4 and 5.

The study described in this thesis designed, delivered and evaluated a compensatory training intervention program which provided individuals with aphasia with alternative means of meeting their individual every-day writing needs. The program explored the desired outcomes of each participant and then attempted to meet these using the assistive technology (AT) software packages described below. This personalised goal-setting approach was designed to circumvent potential difficulties with planning an activity which had grown to be neglected or feared, to encourage creativity and pleasure, and to promote motivation and engagement with the intervention. The challenges of generating ideas are discussed further in Chapter 4 in relation to the pilot study. Goal setting was also in keeping with the functional, social orientation of the study, and aimed to ensure that activities were of relevance to the individuals involved. As such, it was one of the active ingredients of the intervention, which is described in Chapter 6.

An increasingly significant issue to consider in relation to writing and aphasia is the influence of rapid technological development and its

implications for how the non-impaired population as a whole conducts everyday communication. Hewitt and Pound described technology as a double-edged sword whereby communication can be supported and facilitated, (they gave the example of ‘liking’ Facebook posts, an action which requires no writing but arguably enables PWA to participate in an online interaction), yet point out that technology can also reinforce a feeling of being side-lined if it is inaccessible; other studies have also noted that technology is not a panacea for disabled users generally [57] nor users with aphasia specifically [58], [59], [60]. With this in mind, a realistic prediction was that some individuals’ needs may not be wholly met by the training intervention program.

#### ***1.4 Writing and social inclusion***

In his examination of ‘everyday’ writing – that which occurs outside the educational or professional domains - Barton [61] argues that ‘literacy is embedded in the activities of ordinary life’ (page 2), and that writing is a fundamental aspect of our lives as social beings. Everyday literacy is described as not necessarily constituting a goal in itself, but rather as a means to achieving other domestic or social ends:

‘Cooking, eating, shopping, keeping records, celebrating all make use of literacy in some way. Literacy is not the aim of these activities, their aim is something else – to survive, to consume, to act in the world’ (page 6).

He also points out that besides being integral to some activities, literacy ‘can gate-keep activities and be a prerequisite for them’ (page 8). In other words, if one is unable to engage in the literacy practices of everyday life, access to other commonplace activities is also likely to be compromised. Barton and Padmore’s [62] qualitative interview study documents four aspects of the everyday writing activities of a group of adults: the social practices they engage in through writing, the social roles they play and how these are mediated through writing, the support networks to which they belong, and the value they place on writing. The participants were 20

adults with poor developmental reading and writing skills who attended basic literacy classes at an adult education college, yet there are some interesting parallels between this group and adults with acquired literacy impairments, such as expression of regret at not being able to maintain social contact with family and friends through writing, and concealment of difficulties owing to shame or embarrassment. More positively, some participants employed alternative strategies such as dictating poetry compositions to a daughter.

#### *1.4.1 First-hand written accounts of the psychosocial impact of stroke and aphasia*

Robert McCrum [63] and Jean-Dominique Bauby [64] are among those who have written powerfully about experiencing a stroke. While McCrum's stroke occurred in the right hemisphere of his brain, sparing language function, Bauby had a brainstem stroke, leaving him with locked-in syndrome, with spared cognitive function but with total paralysis and therefore unable to speak. His memoir was written painstakingly letter by letter, by blinking one eye towards an alphabet board, transcribed by his wife. Unsurprisingly, given the nature of their impairments, the body of literature by people for whom stroke resulted in aphasia is slender. A small group have written first-hand accounts of aphasia's impact on their everyday lives and their sense of self and identity [65] [66] [67] [68] [69], and as part of her research about her own condition, Newborn [70] also wrote case histories of two other women living with aphasia. The degree or type of assistance, technological or otherwise - if any - this latter group of writers with aphasia employed was not clear. What was obvious though is the tenacity required to produce them: in the introduction to his wife's paper [67], Austin H. Kutscher stated that the essay that followed had taken her 'two and a half months to put together. Under normal circumstances she probably could have written it in about an hour' (page 175). This was indicative of the determination felt by some PWA to express themselves and create a record of their experience, in these cases specifically through writing.

A further striking feature of these accounts was that, their affecting titles such as 'The Words I Lost' [69] notwithstanding, all are written in standard English, with no discernibly aphasic traits. In their electronic spellchecker intervention study, Beeson, Rewega, Vail and Rapsack [71] include an illuminating essay by their dysgraphic participant, describing her spelling strategies with great clarity; again, there is no evidence of impairment in this meta-examination of her skills, and she appears to have retained a good deal of linguistic knowledge:

'Is it ... *m* like mother, *n* like needle, *p* like purple, *t* like turkey etc? These sample words are usually nouns and usually concrete. When I find the first letter ... often the rest is easier. Sometimes it backfires. I have the word *agst* (with *g* – like giraffe). It takes a while to discover it should be *adjust* – so it's not *g* – like giraffe, but *J* – like Jupiter. Sometimes words that should be easy are difficult; sometimes words that should be difficult are easy' Participant SV, page 557.

Rare exceptions to the seeming invisibility of dysgraphia do appear in the literature however: first, in the poetry of Chris Ireland [72], who elects to leave her errors unedited in order to underscore and celebrate the expressive power of disordered language. Second, in the poetry and prose of Pinhasi-Vittorio's [73] single case study participant Ned, who had aphasia with dysgraphia following TBI, and found that creative writing allowed him to reveal communicative competence in a way that conversation, with the pressure of time and restrictions of turn-taking, no longer could. Finally, Moss, Parr, Byng and Petheram [74] reported on 13 individuals with a range of aphasia diagnoses after stroke, who constructed web pages describing their lives and experiences of chronic illness, as part of an aphasia-accessible website. Despite their criticisms of institutional discourses of language impairment in other websites, which were seen as eliminating aphasic traits and consequently marginalising them as readers, the majority of the group (eight of the 13 participants) replicated this style



when constructing their own accounts. They subsequently explained this was because they did not wish to be pitied, or thought stupid. Nevertheless, four individuals (the final participant ultimately did not produce a web page) chose not to edit evidence of aphasia from their writing. Describing her rationale for this when interviewed, one said:

‘Aphasia is not neat, and that’s the whole point .... in my head the words are jumbled up and I have to think of the way they come out and I get the grammar and everything wrong, but that’s aphasia and so I don’t think anyone should change that because that’s what we’re trying to show’ (page 764).

Parr [75] conducted qualitative in-depth, semi-structured interviews with 20 people with mild/moderate aphasia, and 13 of their partners, in order to establish which factors they felt had influenced the focus of the functional reading and writing therapy they had received. She compared pre-stroke and current writing with respect to four domains - domestic, work, leisure and social – and found that her participants, like those of Barton and Padmore, conceived of writing in relation to the social roles it fulfilled. She also noted that role gains as well as losses were described, and further that her participants did not always identify having aphasia as the main reason for their role change. Many had developed their own compensatory strategies to support their writing, which Parr categorised as either ‘operational,’ such as drafting, editing and proof-reading, or ‘technological,’ for example using word processors or Dictaphones. She advocated that goals for therapeutic writing interventions should be activities and strategies determined by PWA rather than clinicians.

### ***1.5 The impact of stroke and aphasia on relationships and social participation***

Parr, Byng and Gilpin [76] argue that aphasia does not simply affect a person with aphasia, but that its impact is felt across entire social

networks, and this impact can be deep and long-lasting. They say this is because:

‘Language is the currency of relationships. It is used to invite, to suggest, to question, to advise, to argue, to reprimand, to bargain, to joke and to reassure. The changing needs and attitudes of each person are expressed and responded to largely through the medium of language. As an obstacle to the sending and receiving of such messages, aphasia reduces the influence of one person in what was once a two-way process’ (page 44).

Pound also describes this loss of reciprocity as a factor in maintenance of relationships [77], and particularly friendships [78] after stroke. Dalemans, de Witt, Wade and van den Heuvel [79] noted that social participation is a theoretical term which PWA themselves do not tend to use. Their participants spoke instead of their level of engagement, involvement or a feeling of belonging, and the number and nature of the social activities they participated in were not perceived to be as important as their level of engagement. This level was influenced by both personal factors such as communication skills, physical and psychological health, and social factors such as the knowledge, skills and willingness of their main conversation partner. Northcott and Hilari [80] explored the reasons why friendships appear to be more vulnerable after stroke than family relationships. Interviewing a purposively selected group of 29 individuals after stroke, ten of whom had aphasia, they identified seven factors which influenced friendship loss. These were: physical disability, reduced energy levels, loss of shared activities, unhelpful responses from others, changing social desires, environmental barriers and aphasia. Echoing Parr et al, Northcott and Hilari found that PWA experienced more difficulty in maintaining their friendship network than those without aphasia. This was not to imply family relationships did not also experience considerable strain, however, as described in the systematic review by Northcott, Moss, Harrison & Hilari [81]. Cruice, Worrall and Hickson [82] quantified PWAs’ social lives in the

context of their non-aphasic peers, and found they engaged in less contact and fewer activities, and that friendship contact and leisure activities were particularly vulnerable.

### ***1.6 Research questions for this thesis***

1. What is the current evidence for the effectiveness of writing interventions for people with aphasia?
2. What is the evidence for using technology to deliver writing interventions for people with aphasia?
3. Can an effective voice recognition software technology intervention, to support narrative writing, be designed and delivered in a way which is acceptable to people with aphasia?
4. How can the intervention be customised and personalised to suit the functional and participatory goals of individual participants?
5. Can AT training compensate for writing and/or reading impairments and impact participation and/or mood, and can barriers to successful training be identified and overcome?
6. Does diagnostic assessment data, participant observation or any other measure offer insights as to candidacy for future intervention?

Questions 1 and 2 are addressed in Chapters 3 and 2 respectively, with a systematic review of the writing intervention literature and a descriptive review of assistive technology; question 3 is addressed in Chapter 4 through a pilot study; question 4 is addressed in Chapter 6, with a detailed description of the intervention and its customisation. Questions 5 and 6 are addressed by Chapters 6, 7 and 8, presenting and discussing the quantitative and qualitative results of the intervention. All six questions are returned to in the Discussion chapter. Question 5, summarising the overall aims of the empirical study, is discussed in further detail in section 1.7.2, where it is broken down into four separate Research Questions (RQs).

## ***1.7 Outline of the empirical study***

### ***1.7.1 Training intervention and participants***

The study described in this thesis designed, delivered and evaluated a compensatory writing training program, which used reading to support it. The training program was intended to enable participants with aphasia to produce and proofread their own written work, and to read, understand and respond to written material from others, whether friends, family and colleagues or global news media. It made extensive use of two AT packages, besides less sophisticated but practical supporting materials such as pictorial, 'screen grab' and written notes, to bypass the need for spelling and reading and capitalise on retained speaking and auditory comprehension skills. Owing to the demands of these technologies, the participants were people who were able to produce spoken sentences, and to understand the written word when it is read aloud; their pattern of impairment was very different from participants in some other therapeutic writing studies (see Chapter 3), in that they were relatively successful oral communicators. However, they were individuals who not only defined their own writing impairments as a main concern, but also felt this impairment as a keen loss. This is not to say that all were equally impaired diagnostically: they represented a broad spectrum, from a participant unable to spell single three-letter words, to an individual who continued to be able to touch type but produced only laborious single word approximations orthographically, to another with a doctorate degree and a best-selling book who had stroke-related motor impairments coupled with mild spelling difficulties, and an urge to write autobiographical stories. What united the group was a desire to re-engage with writing, either as a pleasurable activity in and of itself or as a means of corresponding with others, and the wish to participate more fully in the wider, social world.

### *1.7.2 Research questions for the empirical study*

The research questions addressed by the empirical study were:

Question 1: Does AT training compensate for writing and/or reading impairments and lead to improved performance in writing and/or reading activities?

Question 2: Does AT training have an impact on social participation and/or quality of life for PWA who have writing/reading deficits?

Question 3: What are the barriers to AT use by PWA?

Question 4: What strategies or supporting materials for using AT help overcome these barriers?

These questions will be returned to in more detail in Chapter 5: Methodology. In order to distinguish them from the five thesis questions (section 1.6) they are henceforth referred to as RQ1-4.

## **1.8 Summary**

Chapter 1 described stroke and aphasia, then introduced the cognitive neuropsychological model of language processing, and outlined how writing and reading impairments may be described with reference to this conceptual model. It then discussed an alternative conceptualisation of impairment and disability, the social model, and positioned the study described in this thesis as an attempt to bridge the divide between medical and social approaches to impairment, with specific reference to the four domains of the A-FROM. It explained how a social model of literacy has informed this study, in which writing can be used to achieve social goals, selected by participants rather than researchers, while also acknowledging the importance of clinical rehabilitation of language. An overview of the literature on writing and social inclusion was presented, including the written accounts of individuals with first-hand experience of stroke and aphasia, followed by an account of the impact of stroke and aphasia on social participation. Lastly, the current study's training approach and participants were outlined, and the research questions to be addressed were raised.



## **Chapter 2: Assistive technology (AT) software**

This chapter begins with a description of Augmentative and Alternative Communication (AAC), and distinguishes between no-tech AAC, and low-tech and hi-tech AAC devices. An overview of the hi-tech AAC devices available for users with communication impairments is given, followed by information on their use, acceptability and limitations. The specific needs of AAC users with aphasia are then explored, with reference to the barriers and facilitators to AAC use for this particular group. The chapter goes on to describe the findings of a small number of studies which have used mainstream AT packages to support writing, first for the non-impaired population, then for individuals with disabilities. It continues with an evaluation of the various speech-to-text and text-to-speech software packages which were available for public use when this study was designed. Finally, it describes the features of Dragon NaturallySpeaking™ and ClaroRead™, the two packages selected for use with participants in the current study.

### **2.1 What is AAC?**

The term AAC describes the various ways in which speech can be supplemented or replaced in order to communicate a message. No-tech AAC includes commonplace behaviours such as gesture, gaze, facial expression and body language [83], which occur as part of ordinary, everyday interaction. Low-tech AAC involves the use of props, often referred to in the aphasia literature as communication ramps [84], such as pen and paper, alphabet charts and picture boards. As part of their rehabilitation after stroke, the usefulness of self-cueing with a pen and paper to resolve word-finding difficulties may be demonstrated to PWA [85]. Likewise, drawing or writing keywords may be endorsed as alternative strategies to convey a message when speech is challenging [86]. Besides these standard tools, people with moderate to severe aphasia are frequently encouraged, often as part of their SLT, to devise personalised low-tech AAC such as communication books [87]. These typically contain words, pictures/photographs and other personal artefacts, and enable

PWA to convey key information about themselves, such as their preferences and habits, for example regarding dietary requirements or interests, and the names of people who are important to them. These serve foremost to support functional communication, but additionally provide conversation partners with more nuanced insight into an individual's personality, at a time when limited information can be given verbally, and relationship building may consequently be more difficult.

Hi-tech AAC is defined as any device requiring battery or mains power [83]. These are pieces of equipment specifically designed to support communication for individuals with a range of additional needs, including learning disabilities, paralysis and motor-speech impairments resulting from brain injury or degenerative conditions such as Motor Neurone Disease (MND). They produce digitised or synthesised spoken output, and may be operated with touchscreens/keyboards, or for those with more severe physical impairments, via eye-tracking or head pointing [88], or even respiratory input [89]. AAC devices are often portable and lightweight, and may ameliorate many communication impairments, yet learning to operate them may pose a cognitive burden for some users [90]. In the past they also tended to be prohibitively expensive and not widely available, however recent rapid developments of mainstream apps such as Siri for mobile phones mean they are beginning to be incorporated into some standard operating systems.

## ***2.2 Hi-tech AAC and aphasia***

Various hi-tech AAC devices have been used in writing therapy studies for PWA; these will be returned to in the systematic literature review conducted for this study, described in Chapter 3. However, despite its increasing availability, the literature suggests that specialist AAC technology may not always be acceptable to PWA.

Baxter, Enderby, Judge and Evans [91] conducted a systematic review and qualitative synthesis of the barriers and facilitators to hi-tech AAC use for people (including children) with communication impairments. They listed



ten factors which influenced the uptake of AAC: ease of use, particularly for users with physical impairments; reliability of devices; availability of technical support; the voice/language of the device; decision making regarding selection of an appropriate device; the time required to generate a message; family support for use of the device; other peoples' responses and attitudes; service provision such as accessing specialist evaluation; staff training. The findings relating specifically to users with aphasia indicated that responses of others to the device, along with the content of the message generated, had a particular impact on whether communication was more or less challenging. Further, wide variation in speech and language therapists' AAC knowledge and skills was reported.

Baxter et al's findings were echoed in the review of AAC devices for adults with acquired neurological conditions by Beukelman, Fager, Ball and Dietz [92] which discussed issues of use, acceptability and limitations of AAC, and described the needs of six user groups, including individuals with chronic aphasia and apraxia of speech. They found that while user groups with TBI, brainstem damage and amyotrophic lateral sclerosis (ALS, known as Motor Neurone Disease in the UK) showed high levels of uptake and acceptance of hi-tech AAC, users with chronic aphasia, and those with PPA or dementia, tended not to accept its use, favouring either low-tech AAC or attempting natural speech. The main barrier to AAC use by PWA in this review was concern, felt not only by individuals with aphasia but also their family and peers, that reliance on hi-tech strategies may impede recovery of natural speech and language. Lasker and Bedrosian [93] noted the same barrier, and concluded that without conversation partner acceptance of AAC, uptake by PWA is likely to be limited.

A further barrier identified in the literature was that owing to difficulties with either language planning and processing or with executive functioning, PWA often have difficulties with sequencing information to formulate messages, find AAC difficult to navigate, and struggle with using icons to symbolise meaning [94], [95]. Fried-Oken, Beukelman & Hux [96] highlighted the paucity of research evidence on the interplay between

cognitive and linguistic skills and deficits, and the intervention strategies used to encourage communication via AAC. They additionally noted that differences in layout and organisational frameworks can have a substantial effect on the transparency of AAC systems and therefore on the ease with which competence is attained.

Finally, Creer, Baxter, Enderby, Judge and John [97] identified 14 intervention studies using hi-tech AAC with PWA. 13 of these used computer software packages developed specifically for PWA, and only the remaining one used a voice output AAC: at the end of the intervention almost half of the 30 participants had no functional use of this device. And while seven interventions using SentenceShaper™ software described gains in narrative production, formal language assessments and grammatical structure, there was little evidence of carry-over to spontaneous functional use. Van der Sandt-Koederman [98] argued that computer applications developed specifically for aphasia rehabilitation have tended to focus on disorder-oriented treatment, rather than functional or social participation goals. She described how hi-tech AAC presents functional challenges because it cannot keep pace with normal conversation, and that novel utterances in particular take so long to construct that it is almost impossible to use AAC in most communicative settings (although one single-case study in the AAC literature [99] attempting to promote narrative constructions has reported promising results). Similarly, she pointed out that technology designed to support social participation is often designed without consulting PWA and emphasised the potential of accessible websites such as [www.aphasiahelp.org](http://www.aphasiahelp.org), designed with a team of advisors with aphasia, for increasing opportunities for social networking and accessing information.

In light of the range of barriers to AAC use by PWA identified above, the literature relating to the use of mainstream ATs to support written communication for the neuro-typical population, for those with other disabilities, and for PWA was also reviewed before the empirical study design was finalised. The ATs described below are considered in two

subcategories: those which convert the spoken word to written text (often known as voice recognition software or VRS), followed by those which read the written word aloud, thereby permitting auditory processing to bypass or support reading comprehension.

### ***2.3 Speech-to-text AT software***

A number of studies have highlighted the benefits of speech-to-text software both for the non-impaired population and for disabled users, besides describing their limitations.

#### ***2.3.1 Speech-to-text software and the non-impaired population***

Many of the studies described here were conducted when use of VRS first became more commonplace; as with all rapidly advancing technologies, it is noteworthy therefore that some of the limitations identified in these studies have been overcome in more recent iterations of the software packages. In 2000, Bertuca [100] noted that using the Dragon Dictate™ VRS package was not only helpful for colleagues with Repetitive Strain Injury (RSI) or physical impairments, but also supported extended and intensive data entry sessions - in this case, library cataloguing - for non-impaired staff, as it enabled users to focus on the content rather than the input of their work, thus improving accuracy. Further studies [101], [102] have found VRS to be a feasible way for qualitative researchers to reduce the onerousness of transcribing data, using the 'listen and repeat' method; the latter paper also suggests reading aloud for VRS can result in a deeper understanding of raw qualitative data, and permit the researcher to make fuller use of memo notes.

Others have sounded a note of caution however: Rae-Dupree [103] highlighted the need for up to date hardware to support VRS technology (Dragon NaturallySpeaking™ Preferred version 7.0 in her study), and noted the software's capacity for producing dictated text was superior to its ability to interpret spoken commands accurately. She also contended that adjusting from typing keyboard composition to dictating fully formed sentences is not straightforward. Hedberg [104] asserted that correcting

errors actually reduced her typing rate. Nevertheless, she conceded VRS would benefit less able typists. Zumalt [105] further pointed out that while rapid typists may produce a high number of words per minute (WPM), they are likely to be able to sustain this rate longer with voice than with a keyboard.

### *2.3.2 Speech-to-text software studies with impaired users from disabled populations other than PWA*

The population most obviously predicted to benefit from AT are those whose physical or motor impairments prevent them from using a keyboard and mouse conventionally. However, a small number of studies suggest AT may also be useful for other disabled users. Roberts [106] found all 12 of his learning disabled participants with chronological ages between 10 and 14 produced significantly fewer spelling errors with IBM's VoiceType 3.0 voice recognition software, and when permitted to dictate continuously, leaving errors to be corrected by the experimenters, all produced significantly longer and more fluent compositions than their handwritten samples. The six slower writers produced more text with the software in a paragraph copying task, while for the six faster the inverse was true, lending weight to Hedberg's position. Importantly, Roberts also found that irrespective of this objective measure, more of his participants expressed a preference for writing with software, suggesting 'computer dictation may make the task of composing more appealing to many struggling writers' (page 3).

Roberts and Stodden [107] conducted a mixed methods, though predominantly qualitative, study of VRS use (Dragon NaturallySpeaking™ Version 5.0 in their study) as a compensatory strategy for 15 postsecondary education students with learning disabilities, exploring whether their participants continued to use VRS independently to complete their academic coursework after training was complete, and whether they also used it for more general, non-academic purposes. They found that a subgroup of five participants did not attempt independent use, mainly owing to personal factors such as illness or lack of access to a

computer. However two of these individuals also expressed more fundamental reservations: one preferred a different compensatory strategy – asking his wife to proofread his work – while another explained she felt her disability was rooted in ‘organising her thoughts’ rather than in writing. A further five participants attempted to use the software independently but discontinued, citing poor accuracy levels and difficulty with making corrections - in part due to their reading impairments which made discerning whether text was accurate a challenge - and explaining they prioritised time spent meeting academic deadlines over learning to operate new software. Two of these participants also reported they were able to type faster than they could dictate. The authors noted that two speakers of non-Standard English dialects (Hawai’ian Creole or ‘Pidgin’) experienced a particularly high rate of word recognition error. Three further individuals described themselves as unsure whether they would continue to use the software, leaving only two participants who actively continued. Despite this low rate of uptake, the two software users reported positive outcomes: one used AT to dictate all her writing tasks, academic or otherwise, and also employed oral commands to circumvent use of the mouse; the other described her use primarily as ‘getting her thoughts on paper.’ Only the first participant showed significant gains on a writing assessment [108], and the authors suggest the profile of a user most likely to engage successfully with the software includes: motivation, disposition to tolerate high levels of ambiguity and frustration, limited alternative compensatory strategies and ability to speak Standard English.

To summarise, mainstream speech-to-text software appeared to have strengths and weaknesses for the neuro-typical users and users with intellectual impairments described above. It facilitated speed for slower typists, was acceptable to users, reduced typing burden and was a helpful compensatory strategy for those without alternative strategies in place. However, editing was more challenging than dictation, and faster typists wrote more slowly as a result of dictation. Speech-to-text software functionality depended on access to sufficiently powerful hardware, and it

did not appear to cope well with non-standard accents. Additionally, some users felt a different type of thinking and planning was required for dictation rather than traditional writing, which may pose an additional cognitive burden.

The speech-to-text interventions for PWA in the literature are described in the systematic review in Chapter 3. It is noteworthy at this point that all were conducted with compensatory, functional aims, and intended to promote social participation.

#### ***2.4 Text-to-speech AT software***

Text-to-speech software is most often used by individuals with developmental dyslexia [109] or visual impairment [110] and these groups appear to rate it favourably, though with some caveats. For example, Draffan, Evans and Blenkhorn [93] surveyed 455 students with dyslexia and found the majority were satisfied with the technological equipment they received, but noted that many elected not to receive additional training and therefore may not be using the software to its full capacity. Papadopoulos, Koutsoklenis, Katemidou and Okalidou [94] compared natural and synthetic speech perception in visually impaired adults, and found that although natural speech was more intelligible, there was no significant difference in comprehensibility in either condition.

There were few investigations of text-to-speech software use by individuals with brain injury in the literature, and those found reported mixed results. Harvey's [111] study of ten participants with TBI did not see a significant change in group reading comprehension when using 'reading while listening' (combining visual and auditory processing) compared with either reading alone or listening alone. However she observed that two participants within the group did appear to benefit more from the combined condition. One of these was an individual whose visual reading was very rapid but had poor comprehension scores, and she suggests the AT may have served to slow his rate and therefore improve his comprehension. Conversely, the other individual with improved

comprehension in the 'reading while listening' condition was a very slow reader, and Harvey suggested the AT may have served to reduce external distractions and accelerate his processing.

A small number of studies have used text-to-speech packages with PWA: Adams [112] had similar findings to Harvey with two PWA, though one participant did experience improvement in their reading rate. Harvey, Hux and Snell's [113] single case study replicated this finding and they conclude that text-to-speech software may be useful when there are time limitations. Caute et al [114] found that a short course of e-reader training improved reading confidence, enjoyment and participation, despite no significant improvement in comprehension. Finally, despite auditory comprehension difficulties, Caute and Woolf's [115] single case study participant was able to use a text-to-speech software package to support reading both his own dictated written output and online news. This study is described more fully in the systematic literature review chapter.

To summarise, mainstream text-to-speech software was broadly acceptable to users with visual impairments or dyslexia, while findings with brain-injured users were more equivocal. Of a small number of studies involving PWA, there were some promising implications for improving reading rate, and one study which suggested reading software had the potential to support a user with comprehension of their own written narrative output.

The results of this descriptive literature review strengthened the case for the main intervention study to use mainstream AT software rather than AAC packages designed specifically for PWA, for the following reasons: the low acceptability of, and large number of barriers to, AAC; the fact that AAC interventions have focused chiefly on disorder-oriented treatments rather than functional or social participation goals such as those addressed in the current compensatory study; the more promising findings from the small body of literature concerning mainstream AT interventions to compensate for writing impairments for PWA. The barriers to both speech-

to-text and text-to-speech software were nevertheless noted, and one of the aims of the main study was to investigate ways in which these could be reduced with appropriate strategies and support.



### ***2.5 Selection of speech-to-text and text-to-speech software packages***

Software packages designed to assist with writing and reading were evaluated in order to select the most appropriate packages for PWA. To be considered, the software needed to be compatible with a personal computer or laptop, as opposed to an app for a mobile phone or tablet device. Eligible packages were found through recommendations from colleagues and users with aphasia and by search engine (Google) using search terms 'writing software', 'voice recognition software', 'dictation software' and 'reading software.' This was not a systematic review, but rather an attempt to replicate what an informed user might do in order to identify readily available and widely accessible software. Three text to speech packages, five speech to text packages and two combined packages were found. They were evaluated on the criteria of cost, reliability, availability and accessibility, which were devised based on sample software acceptance criteria [116] and adapted for the specific user group in question: the results are shown in Table 2.1.

As a result of the evaluation, a number of software packages were rejected on the basis of poor availability of the software itself, such as Microsoft only platform, and of accompanying technical support services, for example location on another continent with consequently limited telephone support, or owing to poor reliability such as repeated freezing/crashing of programs and/or prohibitive cost, for example £795 for a single-user license. The remaining software packages were scrutinised in relation to their accessibility for PWA, for example the clarity and simplicity of their menus and navigation, their main features and their range of capabilities. As a result, the AT selected for use in the study were:

Name	Purpose	Cost, availability and reliability	Accessibility for PWA
Dragon Naturally Speaking <a href="http://www.nuance.com">www.nuance.com</a>	Speech to text	Home £60.50, Premium £107.79 (Amazon.co.uk) No free trial but reference section: <a href="http://www.nuance.com/for-individuals/by-product/dragon-for-pc/getting-started-version-12/index.htm">http://www.nuance.com/for-individuals/by-product/dragon-for-pc/getting-started-version-12/index.htm</a>	Good – interactive and standard tutorials, webinar membership for additional support, telephone support service Can be used in email and Internet applications Widely used in other studies for users with aphasia, users with other impairments and users without impairments
DictationPro <a href="http://www.deskshare.com">www.deskshare.com</a>	Speech to text	Free to download Easy to Install but froze repeatedly	Rejected on basis of unreliability therefore not assessed further
eSpeaking <a href="http://www.e-speaking.com/">http://www.e-speaking.com/</a>	Speech to text	Free to download Poor - part of Microsoft therefore unavailable to Apple users; limited to Word therefore no email /Internet use	Rejected on basis of availability therefore not assessed further
ClaroRead™ <a href="http://www.clarosoftware.com">www.clarosoftware.com</a>	Text to speech	Pro £199 + VAT, Plus £159 + VAT, Standard £129 + VAT 15 day trial: <a href="http://www.clarosoftware.com/info/trials-and-downloads/10">http://www.clarosoftware.com/info/trials-and-downloads/10</a>	Good – telephone support service Wide range of options for tailoring to personal use Accessible interface: menu bar can be simplified by removing any options not required
JAWS (Job Access with Speech) <a href="http://www.freedomscientific.com">www.freedomscientific.com</a>	Text to speech	£795, free trial available	Good, though designed for visually impaired users Rejected on basis of prohibitive cost
ReadWrite <a href="http://www.texthelp.com">www.texthelp.com</a>	Text to speech	Standard £140, Gold version £320 Free 30 day trial: <a href="http://www.texthelp.com/UK/support/request-information">http://www.texthelp.com/UK/support/request-information</a> Introductory videos: <a href="http://www.texthelp.com/uk/support/vid">http://www.texthelp.com/uk/support/vid</a>	Mostly accessible but complex menu bar

		<a href="#">eos/</a>	
Naturalreaders <a href="http://www.naturalreaders.com">www.naturalreaders.com</a>	Text to speech	Free to download Also for purchase: Personal \$49, Professional \$99, Ultimate \$199, Developer \$299 Based in Canada with no telephone support service	Accessible interface for users with aphasia; rejected on basis of poor support service
WriteOnline <a href="http://www.cricksoft.com">www.cricksoft.com</a>	Text to speech	Single user one year licence £100 – this would therefore cost £1000 per year of study duration	Marketed for secondary school pupils with dyslexia or other special needs Word bar feature useful for PWA Cognitively demanding interface Rejected on basis of prohibitive cost
Penfriend <a href="http://www.penfriend.ltd.uk">www.penfriend.ltd.uk</a>	Combined	Single user copy on CD £120, additional machine licence £30 each	Primarily for users with motor impairments, to reduce the number of keystrokes needed Useful word prediction tool but complex interface owing to on screen keyboard likely to be distracting and confusing for users with aphasia
Speak and See Suite <a href="http://www.clarosoftware.com">www.clarosoftware.com</a>	Combined	Education version £102.12 Available to schools for academic purposes only	Rejected on basis of poor availability

**Table 2.1:** Evaluation of AT software packages (conducted November 2012)

- Dragon NaturallySpeaking™ Professional Version 12, voice-to-text voice recognition software produced by Nuance Communications Inc.,
- ClaroRead™ Pro Version 6, a reading support text-to-speech package produced by Claro Software Ltd.

Dragon NaturallySpeaking™ has been used in three single case writing therapy studies with individuals with aphasia [117], [118], [115], therefore adopting its use would allow direct comparison with their results.

#### *2.5.1 An overview of speech-to-text AT used in this study: Dragon NaturallySpeaking™*

Dragon NaturallySpeaking™ is a speech-to-text software package; this type of software is also commonly referred to as voice recognition software (VRS). Users speak at a normal rate using a microphone, in this study worn as a headset, and the speech they produce is encoded as writing and appears on the screen before them. The microphone may be operated either by clicking with the mouse, or by voice command, and uses a clear traffic light colouring system to indicate whether it is off (red), paused (yellow) or on (green). The menu bar is visually simple and unobtrusive, with a number of drop-down boxes.

In order for Dragon NaturallySpeaking™ to perform accurately, users are required to set up a voice profile. This is typically done by reading aloud a passage of text, provided integrally with the software, using the microphone, though more creative methods are possible with the most recent version, as described in Chapter 9. It is also possible for Dragon to scan stored emails and documents to learn from frequently used vocabulary. Dragon can be operated in a range of different ‘modes.’ In ‘normal mode’ a user can dictate and use commands interchangeably. There are also settings purely for dictation and purely for commands (where both macro commands such as ‘open a new email’ and micro commands such as punctuation symbols can be given). Finally, there is a

'numbers' mode, useful for applications such as spreadsheets, and a 'spell' mode, for the insertion of alphanumeric characters.

### *2.5.2 An overview of text-to-speech AT used in this study: ClaroRead™*

ClaroRead™ is a text-to-speech software package which decodes written language by reading it aloud for auditory processing. It is compatible with Microsoft Word, Internet browsers and PDF files. A male or female voice with a range of international accents can be selected, and modified for rate, volume and tone. Users can choose whether paragraphs are read with pauses after each word or each sentence. Text can be highlighted as it is read aloud either word by word, sentence by sentence, paragraph by paragraph, or as an advancing word trail. ClaroRead™ also has a number of optional features such as a screen ruler, which promotes visual focus by brightening a scrolling section of screen and darkening the remaining portion, and text reformatting to reduce visual/cognitive load. The ClaroRead™ menu bar is simple and iconic, and can be further streamlined by users since buttons which are not useful to them may be removed.

Neither software package operates in isolation; rather they bolt on to existing packages such as Microsoft Office, web browsers and email systems, adjusting the ways in which these are engaged with and operated.

## **2.6 Summary**

Chapter 2 described no-tech, low-tech and hi-tech AAC. It noted that acceptance of specialist hi-tech AAC devices by PWA has been low, and described the barriers to its use. It moved on to review the literature concerning the use of mainstream speech-to-text AT, first in the non-impaired population, then with impaired users from other disabled populations, and finally with PWA. A small number of studies using text-to-speech AT with participants after stroke or TBI were also briefly discussed. The chapter justified the selection of mainstream AT software rather than AAC designed specifically for PWA. It then presented the range of AT available at the outset of the study, and ended with an overview of the

features included in the two AT selected for use: VRS Dragon NaturallySpeaking™ and reading support AT ClaroRead.

### **Chapter 3: A systematic literature review of studies aimed at improving writing for people with aphasia**

This chapter systematically reviews the current literature on writing treatment studies for people with aphasia. Both traditional pen and paper treatments, and those delivered with any form of technology, either mainstream or specialist, are included; a total of 53 papers are reviewed. The chapter begins with the methods of the literature review, comprising: an outline of inclusion criteria for eligibility, the data sources, the search strategy adopted, the screening procedure, the strategies used for data extraction and the tools for critical appraisal. Tables of extracted data used to inform the results of the review can be found in Appendix 3.1 and quality ratings appear in Appendix 3.2. The methods are followed by the results of the literature review, in the form of a narrative synthesis and critical appraisal of data from the 53 reviewed papers. First the design and participants are presented, then the papers' findings are discussed with reference to the following four questions:

1. How was writing gain following treatment assessed?
2. What aspects of writing did treatment target? (Including whether the focus was on single word, sentence or narrative output, which writing activities were pursued and whether these had functional purposes, and whether the treatment aim was compensatory or remedial);
3. Did the treatment result in gains? (Including whether these generalised beyond treated items, and whether they were maintained at follow up assessment);
4. Were participants' reading requirements addressed?

Findings from these questions were used to inform the study reported in this thesis, particularly with reference to gaps in the existing literature.

#### ***3.1 Literature review methods***

##### ***3.1.1 Eligibility criteria***

For a study to be eligible for inclusion in the systematic review, it had to report research data on using any form of treatment designed to improve

writing for PWA following stroke. Only publications which reported the use of an alphabetic script were included. Owing to the constraints of time and financial resource associated with translation of papers, only English language publications were included. Participants in the reported studies had to be at least 18 years old; no other exclusion criteria such as severity or type of aphasia, comorbidities, age, sex or setting were applied, nor was there any restriction on publication date, geographical location or study design.

### *3.1.2. Sources of information*

Electronic searches of the following databases were conducted in April 2017, using the EBSCOHOST platform: Academic Search Complete, CINAHL Plus with Full Text, Communication Source, eBook Collection, E-Journals, MEDLINE Complete, PsycARTICLES, PsycINFO and SocINDEX with Full Text.

### *3.1.3 Search strategy*

Search terms were:

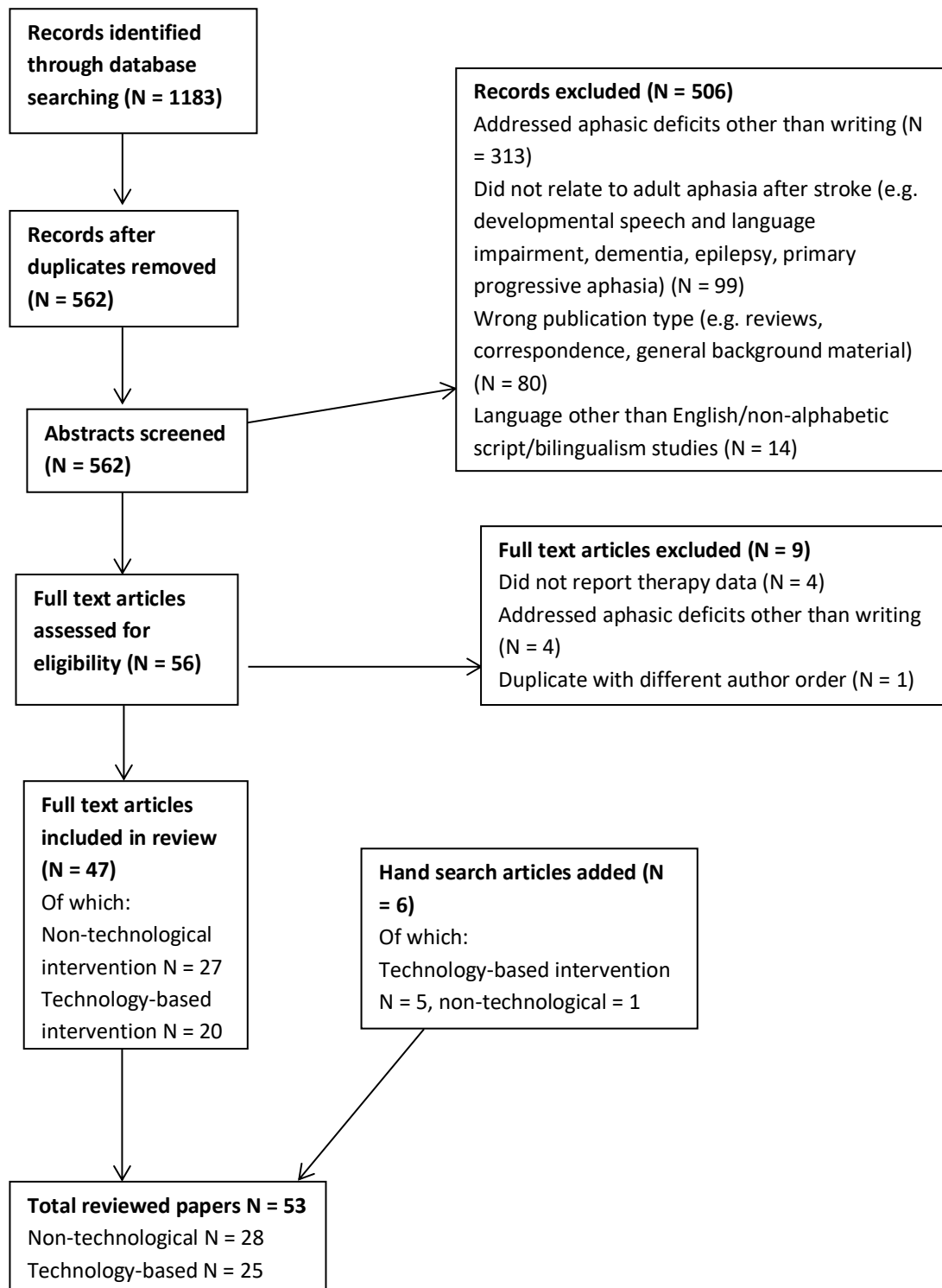
- 1 Dysgraph\* or writ\* or spell\*
- 2 Treat\* or intervention or therap\* or train\*
- 3 1 and 2
- 4 Aphas\* or dysphas\*
- 5 3 and 4

All searches were at abstract level. 1183 references were found; after automatic deduplication 631 remained, and after manual deduplication there were 562 references.

### *3.1.4 Screening*

The abstracts of these 562 references were screened against the exclusion criteria. 506 papers were excluded because: they addressed aphasic deficits other than writing (N = 313), they did not report treatment data (N = 80), they did not relate to adult aphasia resulting from stroke (N = 99) or they were not written in English/concerned a non-alphabetic script (N = 14).





**Figure 3.1:** The review process flow diagram

The remaining 56 papers were read in full. Nine of these were eliminated because: they did not report treatment data (N = 4), their primary focus was not writing (N = 4), or they reported duplicated results (N = 1). The

flowchart in Figure 3.1 illustrates the study selection process and reasons for exclusion; only one reason is given for each study, although in many cases studies could have been excluded for more than one reason. Some of the papers excluded at either the abstract scanning phase or the full-text reading phase were nevertheless referred to in the introductory and discussion chapters of this thesis. The remaining 47 papers were critically appraised and systematically reviewed following the PRISMA [119] guidelines. An additional six papers relating to writing interventions were found by hand searching the reference sections of the 47 papers; these were also included in the systematic review. Therefore a total of 53 papers were reviewed.

### *3.1.5 Data extraction*

Appendix 3.1 shows the data extracted from the 53 reviewed papers, subdivided into non-technology based (N = 28) and technological (N = 25) interventions. Data extracted included author(s), year of publication, participants, setting, design, intervention, outcome measures and main findings. The papers were alphabetically ordered by first author surname and a sample of approximately 25% of the papers (N = 15) was randomly selected using the online number generator [www.calculatorsoup.com](http://www.calculatorsoup.com). Papers in this sample were divided between four reviewers for independent data extraction (and critical appraisal, see below), and were allocated to ensure none of the reviewers would be rating papers they had co-authored. Data were extracted by the independent reviewers, then discrepancies between the reviewers and the author were discussed and consensus reached; differences were minor and related to volume of information rather than content.

### *3.1.6 Critical appraisal*

Following data extraction, each of the 53 papers was critically appraised. There were a range of study designs. Just under half were single case studies (N = 25). Of these, 13 were pen and paper writing treatments (eight single word level [120], [121], [122], [123], [124], [125], [30], [126] and five sentence/phrase level [127], [128], [129], [29], [130]), and 12 were

technological writing treatments (three at single word level [131] [132] [133], two at sentence/phrase level [134], [135] and seven at narrative level [117], [136], [137], [138], [115], [139], [71]). There were also 20 case series studies, twelve of which were single word pen and paper treatments [140], [141], [142], [143], [144], [145], [146], [147] [148], [149], [150], [151], while eight were technological treatments (five single word level treatments [152], [153], [154], [155], [156] and three narrative level treatments [157], [158], [159]).

A small number of studies adopted other designs. There were five group studies: two pen and paper single word treatments [160], [161] and three technological treatments, two at single word level [162], [163], one at narrative level [164]. There were also two single word level studies which adopted a randomised controlled trial (RCT) design [165], [166] and one narrative level qualitative interview and iterative design study [167].

To reflect this range of study designs, a number of critical appraisal tools were used to examine the quality of the 53 papers reviewed: the Single Case Experimental Design (SCED) Scale [168] for both single case and case series studies, the Critical Appraisal Skills Programme (CASP) Cohort Study Checklist [169] for the group outcome measure studies, the CASP RCT Checklist [170] and the CASP Qualitative Checklist [171]. As with data extraction, each of the four independent reviewers also critically appraised the four papers allocated to them; again, discrepancies between these and the original ratings were discussed and consensus reached. One group study had been mis-rated as a case series; when this rectified, the level of rater agreement was around 95%. Results of the critical appraisal are shown in Appendix 3.2, with second rater results also clearly indicated where appropriate.

## **3.2 Literature review results**

### ***3.2.1 Study design***

Evidence in the literature came from small scale studies, predominantly from single case studies, or from case series studies with a maximum of ten

[147] participants but frequently with only two; besides the two RCTs described below, there were only five studies which considered group outcomes, with a maximum of 18 participants [163].

Most of the studies used assessments that were selected or designed to investigate their treatment hypotheses, presented detailed results, and contextualised the nature of participants' deficits within the spectrum of possible impairments described by commonly used models of language production. In two older studies, design was of poor quality and participant descriptions vague. In the first of these, Schwartz, Nemerov and Reiss' 1974 study [165] attempted to adopt an RCT design, matching experimental and control participants for age, months post-stroke, education and Porch Index of Communicative Ability (PICA) [172] score, and testing whether PICA scores were improved by writing treatment for the experimental group, versus multimodal treatment for the control group. However, there were fewer participants in the control group (N = 6) than in the experimental group (N = 8), and critically there was no untreated control group. The potential for confounding variables was high, and no information regarding individuals' baseline writing impairments or speaking impairments was presented. No significant difference between the outcomes of the two treatments was observed.

In the second, Pizzamiglo and Roberts' 1967 study [166] also attempted to adopt an RCT design. In this study, matching of individual participants was not attempted and 'the 20 cases were arbitrarily divided into two equal groups' (page 251); furthermore, baseline language assessments were not uniform since the participants were being treated in three different hospitals, and the two groups are merely described as 'quite similar' based on 'clinical observation.' No detailed descriptions of participants' writing deficits were given, only those of spoken production. The authors hypothesised that treatment dosage would impact gains in written object naming and single word sentence completion, with one group receiving treatment each day and the other group every other day; their hypothesis was correct and the more intensive treatment was more effective, but this

is arguably a generic, common sense finding. Nevertheless, their Language Retrieval Unit was an innovative development at the time of the study.

### *3.2.2 Participants*

A total of 217 participants' treatment progress was reported. 115 individuals took part in non-technological treatment studies and 102 in technology-based treatments. The maximum number of participants in any study was 20 [166]. As far as could be ascertained, each paper reported a discrete study with different individuals or groups of participants, with two stated exceptions: one male participant in Raymer et al's 2009 case series study [151] was the same individual who participated in their earlier single case study [124]; and the eight individuals reported in the functional outcomes of spelling therapies paper by Thiel et al [149] were also described in their uni-modal versus bi-modal treatment paper [146]. There were a small number of further possible exceptions: the four individuals in Clausen and Beeson's 2003 study [143] appeared – based on their initials and genders - to have possibly also participated in two other studies conducted by their team: DR, SL and WD in Beeson, Rising and Volk 2003 [173] and AD in Beeson, Hirsch and Rewega 2002 [141]. In two later papers [162], [174] by this research team, participants were assigned numbers rather than initials, so it is possible there was further repeated participation.

The control group from Schwartz et al's study were not included in the total since they did not receive writing treatment. Three papers, besides reporting data from PWA, included a total of four participants with other conditions: one with PPA [126], two participants with TBI and brain tumour [153], and one with TBI [166]. In the first of these papers, only data relating to the participant with aphasia following stroke were extracted for inclusion in this review; the individual with PPA was not included in the total participant count presented here and the study was reviewed as a single case rather than a case series. In the other two papers this distinction was not possible, as individual outcomes were not linked to diagnosis when reported.

The age range of participants was very wide, from 22 years [163] to 86 years [147], as was their time post onset, from 2 months [151] to 24 years [144]. Most papers clearly stated the ages and time post onset of individual participants. There were a small number of exceptions: three studies described only the age range rather than individual ages [166], [153], [164], and one gave only the range of time post onset without individual information [164]. Furthermore, Carlomagno, Colombo, Casadio, Emanuelli & Razzano [160] reported neither ages nor time post onset and simply stated all participants were at least 8 months post stroke; Pizzamiglio and Roberts [166] offered no information on time post onset, and Seron, Deloche, Moullard and Rochelle [153] stated that one participant was three months post onset while the remaining four were at least 16 months post onset (no indication was given as to whether the most recently affected individual had a CVA, TBI or tumour).

Participants were notably younger than the typical stroke population. As described, not all of the papers gave individual ages, but of those that did, a total of 106 participants – almost half of all participants in the treatment studies - were below 65 years of age, while as described in Chapter 1, the average age of first stroke is 71 for men and 77 for women [6]. The 106 participants under 65 years of age were relatively evenly spread between pen and paper (N = 50) and technological (N = 56) treatments.

Around 80% of the papers reviewed (N = 41) gave either participants' number of years in education or described their former employment; some provided both. In these papers the range of years in education was wide, from 7 years [152] to 22 years [144]; one paper simply referred to their participants as 'highly educated' [160]. 12 papers gave no information on education or profession of their participants; all but two of these papers [147], [126] were technological studies [167], [139], [163], [175], [166], [132], [134], [137], [153], [164]. Participants' professions or former professions were reported with varying degrees of specificity. A descriptive analysis indicated that the population of these treatment studies – both in conventional and technological treatments - was skewed towards higher

levels of education, career choice and progression than might be expected in a typical stroke population [6]. This will be returned to in Chapter 9.

### *3.2.3 How was writing gain following treatment assessed?*

Across the 53 studies, a total of 14 standardised aphasia assessment batteries were used: the Western Aphasia Battery (WAB) [176], the Johns Hopkins University Dysgraphia Battery (JHU) [177], the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) [17], Communicative Abilities in Daily Living (CADL) [178], Boston Naming Test (BNT) [179], Verb And Sentence Test (VAST) [180], Porch Index of Communicative Ability (PICA) [172], Test Of Word Knowledge (TOWK) [181], Arizona Battery for Reading and Spelling (ABRS) [182], the Comprehensive Aphasia Test (CAT) [183], Boston Diagnostic Aphasia Examination (BDAE) [184], Quality of Communication Life scale (QCL) [185], the Functional Assessment of Communication Skills for Adults (ASHA FACs) [186], and the Communicative Effectiveness Index (CETI) [187]. In addition, three assessments in languages other than English were used in four studies: Carlomagno et al [160], [161] used the Batteria per l'analisi dei deficit afasici (BADA) [188], to assess their Italian-speaking participants, Lavoie et al [133] used the Batterie d'Evaluation Cognitive du Langage chez l'Adulte (BECLA) [189] with their French-speaking participants, and Murray and Karcher [135] used the Test of Adult and Adolescent Word Finding (TAWK) [190] with their German-speaking participants.

Some studies used more than one of these assessments, selecting subtests most relevant to their treatment aims and measuring participants' deficits using tests from two or more batteries. Two assessment batteries, the WAB and the PALPA, were widely used: the WAB in 10 studies [140], [191], [173], [144], [192], [124], [139], [131], [155], [193], [126] and the PALPA in 12 [194], [173], [127], [144], [29], [130], [139], [152], [137], [149], [159], [150].

The remaining batteries were used in fewer studies: the JHU in six studies [140], [191], [71], [126], [151], [148], the CAT in five [118], [115] [149],

[159], [150], the BDAE in four ([149], [159], [150], [108]) and the rest in one study each: CADL [161], BNT [144], VAST [130], PICA [165], TOWK [139], ABRS [162], QCL [117], ASHA FACS [117], CETI [135], TAWF [135]. One study [128] cited the assessments they used as in preparation and another did not specify which assessments were used, referring simply to 'language evaluation, reading and writing probes' [134] (page 47).

A small number of the studies supplemented their measures of writing gains with other assessments. These included semantic assessments: Pyramids and Palm Trees [140], [173], [143] [174], [155] [149], [159], [150] and Kissing and Dancing [155], cognitive assessments: the Cognitive Linguistic Quick Test (CLQT) [140, 155] the Coloured Progressive Matrices [173] and the Weschler Memory Scale [173], [148], a reading assessment in Orjada and Beeson's [192] concurrent reading and spelling treatment, the Gray Oral Reading Test 3<sup>rd</sup> version (GORT-3), and two psychosocial assessments, the Recovery Locus of Control Scale and the Rosenberg Self-Esteem Scale, both used by Lustig and Tompkins [122].

Eleven studies devised novel assessments which specifically tested 'authentic' writing use before and after treatment, rather than writing to dictation or written picture naming, to measure their participants' functional gains. These included:

- Written and spoken procedural and descriptive discourse samples [129];
- An email skills assessment, keyboard skills assessment and written email assessment [159];
- A questionnaire with which to quantify writing strategy use and number of targets abandoned [122];
- A measure of informative items in written notes made pre- and post-treatment, for blind independent rating [29];
- Keystroke logging to measure message length, proportion of correct spellings, WPM, and successful edits with and without a technological device [157];



- A record of number of prompts required for a participant to perform VRS commands and error corrections, supplemented with a functional questionnaire and a written narrative account of progress by the participant [118];
- Total token counts of email composition with and without VRS with two levels of constraint [115];
- Comparisons of dictated picture/video descriptions constructed with and without technological support [158];
- Comparisons of spontaneous writing with and without technical support to test remediation [136];
- Pre- and post-treatment video recording of conversation using a questionnaire designed to simulate natural information exchange in three settings [132];
- Quantification of VRS accuracy pre- and post-voice training, using pre-recorded speech files of aphasic and non-aphasic speech [164].

All but three of these [122], [29], [129] were technological studies.

Seven studies did not repeat formal aphasia battery assessment following treatment, using them for diagnostic purposes only. Two gave transparent rationales for this decision. Robson et al [125], [147] used PALPA subtests and Pyramids and Palm Trees to conduct background assessments in order to inform treatment targets. They explained that owing to the profound nature of their participants' jargon aphasia, repeated assessments would have been onerous and distressing, and also risked introducing a learning effect, therefore they used control sets of untreated items to measure gains at each stage of their treatments. The remaining five studies [30], [163], [175], [145], [146] reported multi-stage treatments, all of which were directly contrasting different types of writing therapy within participants, such as errorless versus errorful spelling to test effects on speed besides accuracy [145], or unimodal versus multimodal treatment [146]. All measured progress on treated items against control items and indicated the degree and type of generalisation where appropriate.

Some analysis methods and measures used feature less commonly in the writing treatment literature. However, these are routinely used in other types of social and linguistic research, and were appropriate to the aims and methodologies of the studies described here. They included: Conversation Analysis (CA) [195] of an aphasic participant and his partner to quantify behaviours, and semi-structured interviewing to explore impact of treatment [120], Social Network Analysis (SNA) [196] to examine a participant's social participation after VRS therapy [115], qualitative interviewing [197] and iterative design in an email software design project [167] and Social Validity Judgements (SVJ) [198] of participants' writing performance before and after treatment by independent blind raters [115], [122].

#### *3.2.4 What aspects of writing did treatments target?*

This section describes whether the writing treatments targeted the single word, sentence or narrative output level, the mode of treatment delivery (pen and paper or technological), the extent to which functional writing activities were targeted, and whether treatment aimed to be compensatory or remedial. Numerical information and references from this section are also summarised in Table 3.1.

##### *3.2.4.a Single word level treatments*

Almost two thirds of the 53 writing treatments reviewed focused on single word production (N = 34). Of these, 23 were delivered with pen and paper. 11 of these aimed to provide individuals with severely impaired spoken output with a means of making meaningful written contributions in its place, while 12 specifically aimed to remediate spelling. The remaining 11 single word treatments were delivered with technology. Of these, five were adapted from previous pen and paper treatments, while six were designed solely for technological delivery.

	Mode of delivery		Treatment aim	
	Pen and paper (N = 28)	Technological (N = 25)	Remediatory (N = 33)	Compensatory (N = 20)
<b>Single word (N = 34)</b>	23  [191], [194], [173], [143], [192], [152], [124], [125], [147], [122], [120], [30], [144], [126], [145], [151], [146], [149], [160], [199], [150], [148], [165]	11  [152], [162], [156], [131], [132], [166], [153], [163], [175], [133], [155]	23  [152], [162], [156], [131], [132], [166], [153], [163], [175], [133], [155], [30], [144], [126], [145], [151], [146], [149], [160], [199], [150], [148], [165]	11  [191], [194], [173], [143], [192], [152], [124], [125], [147], [122], [120]
<b>Phrase/ sentence (N = 7)</b>	5  [29], [200], [129], [127], [130]	2  [193], [134]	6  [200], [129], [127], [130], [193], [134]	1  [29]
<b>Narrative (N = 12)</b>	0	12  [71], [136], [201], [157], [137], [158], [202], [159], [164], [118], [117], [115]	4  [71], [136], [201], [157]	8  [137], [158], [202], [159], [164], [118], [117], [115]

**Table 3.1:** Aspects of writing targeted by treatment in the 53 reviewed studies

#### *3.2.4.a.i Pen and paper single word treatments using writing to supplement speech (N = 11)*

Beeson and colleagues [191], [194], [173], [143], [192] conducted a set of studies designed to promote use of personally relevant single word vocabularies to support functional day to day communication, using Anagram and Copy Treatment (ACT) and Copy And Recall Treatment (CART). Ball, de Riesthal, Breeding and Mendoza [140] delivered a non-technological version of Beeson and Egnor's [152] (see section 3.2.3.a.iii) modified CART plus Oral Repetition Treatment (ORT) protocol, testing whether spelling gains generalised to spoken naming. Raymer, Cudworth and Haley [124] also used CART, in a study specifically designed to test generalisation to untrained written words.

Robson and colleagues conducted a single case study [125], followed by a case series study [147] of ten participants with undifferentiated and neologistic jargon aphasia, who had poor monitoring of their spoken output despite good auditory comprehension, and retained ability to perceive written errors despite otherwise poor visual word recognition skills. Their three stage 'message therapy' ([125] page 320) was devised to improve writing of trained single words then encourage their functional use in conversation, which they later tested in the case series. Lustig and Tompkins [122] trained a participant with aphasia and dyspraxia of speech to substitute a self-initiated written word for protracted articulatory struggle, testing functional use in three conversational settings (private, public, unfamiliar partner). Finally, Beeke, Johnson, Beckley, Heilemann, Edwards, Maxim and Best [120] used conversation analysis to create and assess a training program to promote written self-cuing in conversation for a participant with non-fluent aphasia.

#### *3.2.4.a.ii Pen and paper single word treatments to remediate spelling (N = 12)*

Sage and Ellis [30] treated a participant with graphemic buffer disorder, training a set of words and testing whether spelling improvements generalised to orthographic neighbours and to untrained words. Kiran

[144] also conducted phoneme to grapheme training and tested writing to dictation for trained words, untrained words and untrained tasks, while Tsapkini and Hillis [126] used the method to investigate untrained word spelling. Thiel and Conroy [145] compared errorless and errorful learning to evaluate their comparative influence on spelling accuracy and speed; Raymer, Strobel, Prokup, Thomason and Reff [151] also examined errorless versus errorful single word spelling. Thiel, Sage and Conroy [146] then used a crossover design to compare unimodal (either CART or writing to dictation) with multimodal treatment, which trained both procedures, and further to explore whether this single word therapy had any impact on functional narrative writing [149]. Carlomagno, Colombo, Casadio, Emmanuelli and Razzano [160] conducted a small group study delivering two rehabilitation treatments based on dual route theory, where phonological treatment stimulated phoneme-grapheme conversion and visual-semantic treatment stimulated whole word retrieval; this was followed by a larger group study by Carlomagno, Pandolfi, Labruna, Colombo and Razzano [199]. Krajenbrink, Nickels & Kohnen [150] delivered a dual phase CART designed to strengthen graphemic buffer and test whether orthographic neighbourhood size impacted treatment effects and generalisation, while Rapp [148] examined generalisation of a spell-study-spell protocol for three individuals with either orthographic output lexicon or graphemic buffer deficits. Finally, Schwartz, Nemerov and Reiss [165] conducted a RCT to test whether type of treatment influenced writing and other remediatory outcomes.

#### *3.2.4.a.iii Technological single word treatments adapted from pen and paper (N = 5)*

All five of the technological studies described here were remediatory in aim; four of the five were conducted by Beeson and colleagues. Beeson and Egnor [152] incorporated spoken repetition into CART, and compared this to spoken repetition without spelling, using an augmentative and alternative communication (AAC) device to allow participants to listen to the target words. In both a case series and a group study, Beeson, Rising,

Kim and Rapsack [162], [156] created a multiple regression model aiming to predict the relative contribution of the lexical and sub-lexical spelling routes for regular words. Beeson, Higginson and Rising [131] made further use of the modified CART plus ORT, contrasting their established handwriting approach, which relied on allographic knowledge, with the texting facility on a standard mobile phone, testing both spatio-motor knowledge and ability to hold information in the graphemic buffer. Finally, Jackson-Waite, Robson and Pring [132] focused on functional outcomes, testing a Lightwriter with a participant with jargon aphasia to investigate whether she could type single words in order to contribute to conversation.

#### *3.2.4.a.iv Single word treatments designed solely for technological delivery (N = 6)*

All six technological treatments described here were also remedial in aim. Pizzamiglio and Roberts [166] used a 'Language Retrieval Unit' (page 252): a typewriter for input, connected to another external keyboard for display, which lit up as participants supplied the final word in eight written sentences or the written name of ten single pictured objects. This device was designed to avoid reinforcement of error: when an incorrect key was activated, the correct letter was nevertheless illuminated. A similar procedure was used by Seron, Deloche, Moulard and Rouselle [153], whereby single words written to dictation appeared on a screen letter by letter if the correct target was selected, while for an incorrect attempt the screen remained blank, in order to avoid visual reinforcement. This was intended to ameliorate the challenge of intervening sufficiently quickly to indicate each error, and the illegibility involved when errors are repeatedly corrected on paper. Deloche and colleagues used a microcomputer to conduct a typed written naming treatment group study [163] and a case series study [175], investigating whether online feedback, in the form of a beeping sound when an incorrect key was activated, could influence error rate. Lavoie [133] tested a self-administered single word verb naming treatment, delivered via an iPad for pen and paper written picture naming.

Finally, Furnas and Edmond [155] conducted remote verb network strengthening treatment (VNeST) via the Internet, testing typewritten responses to cues and exploring whether these generalised to untrained words and spoken retrieval.

#### *3.2.4.b Phrase and sentence level treatments (N =7)*

Only seven of the 53 writing treatments reviewed focused on the production of short phrases or sentences; all were single case studies. Five were delivered with pen and paper, two with technology.

Panton and Marshall's [29] study aimed to facilitate note taking skills, a functional requirement of their participant's role as a political councillor. Mitchum, Haendiges and Berndt [128] trained their participant to write 16 transitive verbs in response to line drawings, and use them to construct a subject-verb-object sentence, then tested whether improvements generalised to spoken sentences. Murray, Timberlake and Eberle [129] used Treatment of Underlying Forms (TUF), a treatment based on the premise that training complex sentence structures can improve written production of untrained, syntactically related but simpler structures. They also tested whether TUF would generalise to improved performance in spoken sentence production. Bowes and Martin [127] investigated the impact of bigraph-biphone segment blending, firstly focusing on improving awareness of grapheme-phoneme correspondences and sound blending abilities for non-words, then extending these abilities to writing (and reading) two syllable words and, eventually, sentences. Finally, one sentence level study had similar aims to the 11 single word treatments for individuals with limited spoken output described in section 3.2.2.a.i: Salis and Edwards' [130] treatment targeted single word transitive and intransitive verb spelling alongside simple sentence (subject-verb and subject-verb-object) production for their participant with severe apraxia of speech, in order that she could convey brief written messages.

In the two technological sentence level treatments, which - in common with all of the single word technological treatments - had remediatary

goals, Murray and Karcher [135] used Cowriter™ software to support verb retrieval at word and sentence levels, while Lee and Cherney's [134] high-intensity sentence repetition from memory treatment used a virtual therapist and daily submission of homework exercises via a Smartpen and microdot paper.

#### *3.2.4.c Narrative level treatments*

There were more narrative level than sentence level treatments in the literature, though fewer than single word treatments: 12 narrative level writing treatment studies were reviewed. All of the narrative level treatments were delivered using technology; four for remediatary purposes, eight with compensatory aims.

##### *3.2.4.c.i Remediatary narrative treatments (N = 4)*

Beeson, Rewega, Vail and Rapcsak [71] conducted a homework based treatment with repeated assessment of narrative typing with spellchecker support. King and Hux's [203] participant continued to work voluntarily as a copywriter and wished to improve his functional skills, specifically editing; the researchers transcribed stories dictated by the participant and inserted written errors, which he then attempted to correct using the spellcheck and auditory playback facilities of Write:OutLoud™, a text-to-speech software package. Armstrong and MacDonald [139] also used Write:OutLoud™, combined with the grammatical prediction programme Co:Writer™. They tested whether using a splint and a Mousepen to write directly onto the computer screen with his formerly dominant (now hemiplegic) hand affected their participant's writing performance. The computerised writing aid model tested by Behrns, Hartelius and Wengelin [157] used either predictive text or a spellchecking facility to support written production of diary entries and picture descriptions; their three participants were encouraged to choose which one they felt would be most appropriate for their needs.



#### *3.2.4.c.ii Compensatory narrative treatments (N = 8)*

Mortley, Enderby and Petheram [137] used a word predictive software named INTACT, developed specifically for PWA, to train an individual with severe dysgraphia to use his preserved speech to compensate for spelling impairments. Dahl, Linebarger and Berndt [158] used VRS plus SentenceShaper™ to decouple speech production from real time, allowing users to dictate fragments of text then build them into longer structures. Al Mahmud and Martens [167] designed an adapted email programme (known as 'Amail') in collaboration with a group of PWA, their family members and clinicians, based on qualitative interviews with PWA regarding barriers to conventional email use. Thiel, Sage and Conroy [159] used CoWriter™ software to facilitate narrative texts of increasing complexity, using predictive text, word banks and text to speech.

Finally, four studies investigating the use of Dragon NaturallySpeaking™ VRS with PWA appeared in the literature. Wade, Petheram and Cain [164] conducted a scoping study testing whether an early version of the software could be trained to recognise aphasic speech, focusing on initial voice profile set up and training rather than on the potential for narrative writing production. As in the group study reported in this thesis, three single case studies [118], [117], [115] tested whether Dragon NaturallySpeaking™ could compensate for writing impairments at narrative level; the last of these also used a text-to-speech package, Read&Write Gold, to support their participant's reading.

#### *3.2.5 What gains were made, did they generalise beyond treated items, and were they maintained?*

##### *3.2.5.a Single word level treatment*

Of the 34 single word writing treatment studies, 27 studies included a single word spelling task in the outcome measures, involving spelling words to dictation (N = 20) [191], [194], [173], [160], [161], [144], [192], [124], [30], [145], [146], [126], [152], [162], [174], [153], [148], [150], [151], [149] or writing picture names (N = 13) [191], [194], [173], [160], [161], [125], [147], [152], [163], [175], [155], [140], [133]; as shown by the overlap in

these lists, five studies used both tasks. In all of these studies, both trained and untrained words were assessed. Thiel et al's eight participants were counted only once, owing to their repeat participation in two of their papers ([146], [149]), therefore 26 studies, with a total of 109 participants, were examined. 25 (96.2%) studies reported significant gains in spelling trained words, and the remaining (case series) study [173] reported significant gains in 4 of the 8 participants, meaning 105 of 109 (96.3%) participants made gains. In the study where only half of the participants benefitted, severity of aphasia was not predictive of success, rather this was influenced by degree of semantic impairment, ability to discern words from non-words, preserved non-verbal visual problem solving skills, and adherence to homework tasks. All but five studies [191], [162], [163], [124], [147] measured maintenance of gains; a total of 71 participants were assessed at follow up. Gains were maintained for 64 of these participants (90.1%).

19 (70.4%) of the 27 studies reported wider gains than trained spelling words for at least some participants. These were mostly significant spelling gains on untrained words [140], [160], [161], [144], [192], [124], [30], [145], [126], [174], [155], [153], [149], [148] with more rare instances of generalisation to functional writing activities such as beginning to write emails [194] or letters [161], and to spoken picture naming [163], [175] or spoken verb production [133]. Of the 109 participants described across the 27 studies, the number for whom treatment effects generalised was 66 (60.6%).

The remaining seven of the 34 single word treatment studies assessed gains with different outcome measures. These included the two flawed single word RCT studies [165], [166] described above; little weight can be lent to their results owing both to their poor design and to the lack of information regarding whether the participants had dysgraphia diagnoses. The remaining five studies reported on a total of nine participants.

In the conversation analysis single case study [120], there was a significant functional increase in written self-cuing in conversation, and this was maintained at follow up. In the other written self-cuing study [134] the taught strategy was used in all three conversational settings; this too was maintained at follow up, and there was also improvement on one of the psychosocial measures. However, social validity judgements by independent raters indicated improvement in communicative success in shorter rather than longer conversational segments only. Clausen and Beeson [204] gave four individuals with severe aphasia individual ACT and CART treatment then facilitated group, single word level functional information exchange. Gains were made and maintained in the treated set of words, and they were successfully used in the conversational setting. Beeson, Higginson and Rising's [205] participant made gains in both written and texted discourse samples. This generalised to spoken use of trained items, and to functional use of remote texting, which was maintained at two year follow up. Furthermore, his wife reported that an estimated 40% of her husband's successful face to face communication attempts with herself and others were now mediated by text.

Finally, Jackson-Waite, Robson and Pring's [132] participant disliked the synthesised speech output of the portable keyboard provided, and eventually used only the text output option. She made significant gains in written word typing, but there was no evidence of functional use; the authors concluded that the Lightwriter may have in fact constituted a barrier, since she was unwilling to initiate its use and her family, like many relatives of PWA [92], [93], were equally reluctant to prompt her to do so.

To summarise, of the nine participants described here, all made gains in treated items, and all but one maintained these gains, generalised them to untreated items and made functional use of them.

#### *3.2.5.b Phrase and sentence level treatments (N = 7)*

All of the sentence level treatments in the literature were single case studies, therefore their participants represent a very small proportion

(3.2%) of the 217 individuals reported. Four studies included formal sentence writing assessments from aphasia testing batteries: the WAB, [135], PALPA [127], VAST [130] and BNT [128]. The fifth, technological, study used unspecified 'language evaluation, reading and writing probes' [134], and the final two [29], [129] devised novel assessments, as described in section 3.2.2.

All found significant gains in treated items, and in all but one [135] gains generalised to untrained items. Two studies [134], [200] did not examine maintenance; of the remaining five, all gains were maintained in three [127], [135], [129] treated but not untreated item gains were maintained in one study [29], and two of three improved items were maintained at follow up in one [130]. Notably, in Mitchum, Haendiges and Berndt's [200] study, the participant's reading was so impaired that he was unable to make sense of his own compositions, therefore the functional usefulness of his gains were limited.

#### *3.2.5.c Narrative level treatments (N = 12)*

The narrative level studies treated a total of 36 participants, representing 16.6% of the participants in the literature. Two studies [164], [167], with six and eight participants respectively, worked with their participants in a somewhat different way to the rest of the studies reported in this review: both used compensatory software with their groups primarily to test software, either its capacity to understand aphasic speech [164] or its acceptability and usability for the wider population [167]. Nevertheless, positive gains were made by their participants: Wade, Petheram and Cain [164] found that VRS could process aphasic speech as well as standard speech. They also reported that PWA with a range of speaking impairments were able to teach the software a set vocabulary, bypassing the standard narrative reading task. While flexibility in this function is now a standard feature of Dragon NaturallySpeaking™, this was an innovative study at the time of its publication. Al Mahmud and Martens [167] found their prototype email software was acceptable to users with aphasia, and that

they could successfully compose emails, particularly when using pre-programmed phrases.

Of the remaining 10 narrative level studies, all but three, with three [157] four [158] and six [159] participants, were single case studies. Four studies used written picture description measures from the CAT [118], [115], the BDAE [117] or the WAB [139] to test whether technology compensated for writing difficulty; all showed significant positive gains. These did not generalise to the handwritten versions of the tasks, suggesting treatment did not have a remediatory effect. One of these studies [118] also measured the number of command and error prompts issued by the researchers and saw significant reduction as treatment progressed, suggesting increased independence. One observed a significant increase in the size of their participant's social network [115], and his dictated writing in their novel email composition was judged by independent raters to be significantly better than his handwritten attempts. One of these studies [139] did not test generalisation; another [117] indicated this was very limited based on their participant's inability to use VRS for any task other than trained written picture description. In the other two studies [118], [115] there was significant functional generalisation to a number of writing tasks including shopping lists, letters and diary entries, which was maintained at follow up for both participants.

Four studies compared dictated writing samples produced with and without spellchecker support [158], [136], with either spellchecker or predictive text [157], or with a blend of both [159], using keystroke logging [157], independent rating [136], spelling accuracy assessments [159] or VRS voice files [158] to obtain an objective picture of their relative accuracy levels. In one [158], three of their four participants showed significant gains, while the fourth showed no effect. In the second [136], the single case study participant showed significant gains and his supported sentences were judged more accurate by blind independent raters. Neither study tested generalisation or maintenance. One of the three participants in the third study [157] made significant gains, and these were maintained

at follow up; some generalisation to unsupported writing was observed. In the fourth, half of the eight participants made statistically significant spelling improvements, with a trend towards wider word class use, and group level changes in word length.

Finally, two narrative studies [137], [71] used single word spelling to dictation to measure outcomes; one of them [137] also used written picture naming. Both reported significant gains, and both saw functional generalisation, to independent creative writing [71], where maintenance was not measured but positive self-reports were offered by the participant, and to email, where benefits were maintained at eight week follow up.

### *3.2.6 Were participants' reading requirements addressed?*

Evidence of reading support in the writing treatment studies was scant. Only two pen and paper writing treatment studies examined the influence of reading on written outcomes: Bowes and Martin's [127] pen and paper sentence level study, and Orjada and Beeson's [192] single word pen and paper writing treatment. In one technological narrative treatment study, Caute and Woolf [115] supported their participant's impaired reading with an additional AT package alongside the VRS they tested for writing.

Five studies [162], [174], [194], [173], [161] measured reading but did not appear to address it with treatment. Three further studies observed that a consideration of reading deficit may have been useful: in their pen and paper sentence level study, Mitchum, Haendiges and Berndt [200] acknowledged that their participant was unable to read his compositions, and two narrative level technological studies discussed reading. Behrns, Hartelius and Wengelin [157] reflected that reading difficulties may have influenced their participant's performances and considered whether the introduction of an auditory component to their protocol may have been beneficial, and Al Mahmud and Martens [167] reported that when they tested their 'Amail' (aphasia-accessible email) product with end users with aphasia, the introduction of auditory feedback to assist with processing was recommended.

### ***3.3 Gaps in the existing literature and implications for this study***

The body of research on writing treatment for people with aphasia was relatively small, yet it offered some strong evidence of treatment effectiveness: other than the 28 participants receiving treatment via the two flawed RCT studies, only four (1.8%) of 217 individuals did not make significant gains on treated items. The degree of generalisation and maintenance of gains was not always tested or reported, but where it was indications were also encouraging.

Of note however, was the fact that generalisation more commonly extended to untrained words, and less often to other functional writing activities. This finding may be a by-product of the way in which outcomes were measured, whereby formal spelling assessment batteries rather than functional tasks were used in all but ten of the studies. While such impairment-based batteries are an effective means of measuring and reporting gain in a transparent way, they arguably lack the authenticity of functional, every-day tasks.

The studies in the literature may have been hampered by the lack of a standard measure of functional writing specifically designed for PWA, as noted in Thiel et al's systematic review [206], which has sometimes resulted in the use of informal or novel tasks such as those listed in section 3.2.3 above. These have limitations, since the psychometric properties of the tests have not been tested, and studies used a range of tasks, making between study comparisons difficult.

The current study made use of both formal assessment batteries and functional tasks. Standardised writing assessments are used for diagnostic and monitoring purposes, in traditional pen and paper format. These also permit any potential remediatory effects of the writing treatment to be examined. Additionally, a novel functional email composition task is undertaken, using both pen and paper and keyboard. This allows observation of whether the training package supports independent production of spontaneously generated material, such that participants

may wish to produce in real world circumstances beyond the clinic. The compensatory potential of assistive technology to support narrative writing via dictation will also be revealed through this assessment, if writing is significantly improved by the use of AT rather than typing alone once the training is complete. A variant of this assessment was used in a previous AT narrative writing study [115] and is continuing to be employed in the CommuniCATE project (in preparation), so further comparisons across participants will be possible. Linked normative data are also being collected, so some psychometric data for this task will eventually become available.

Finally, a picture description task is also undertaken in both of these formats, in order to explore whether a more scaffolded narrative task may be easier to perform than a free composition task.

The literature suggested a number of other areas in which further investigation is also warranted. Firstly, many more participants received single word level treatment than sentence/phrase or narrative level treatments. This may reflect the fact that treating writing at the level of narrative discourse is regarded as precarious, yet the findings from the small number of studies undertaken were promising. One striking finding was that the studies which made use of technology were considerably more balanced with respect to single word versus narrative goals (as shown in Table 3.1): this may reflect a more functional focus in these studies. Since the technological studies are relatively recent, they are perhaps indicative of a growing awareness that therapy needs to address targets that extend beyond the single word, as real world writing tasks are so often at the narrative level. Therefore, the current study will focus on narrative production, in line with its underpinnings in the social model of writing described in Chapter 1, and to add to the burgeoning literature as this area receives more attention.

Additionally, of particular interest was that all of the existing narrative studies were delivered via technology, suggesting this is an area especially



ripe with potential as advances in this area continue. In the light of this, the seven narrative level compensatory studies were scrutinised with reference to the following criteria: software, treatment, dosage, frequency, participant profiles, assessments used and gains reported. This revealed four instances of success with mainstream voice recognition software Dragon NaturallySpeaking™, as described in Chapter 2, in treatments ranging from a single voice training session [149] to 17 sessions [109], besides one using Windows Voice Recognition [144]. Written picture description tests indicated that the software resulted in improved writing performance, and two studies [109, 107] also described generalisation to every-day functional writing; in the latter study this was explicitly measured with a novel composition task. The participant also increased social participation, and the size of his social network grew. Furthermore, two studies [107, 152] found that text to speech software can effectively promote auditory comprehension to support writing. Other useful background information for the current study was also gleaned from the seven studies which used technology to compensate for narrative writing difficulties, and was considered when designing the training intervention program described in this thesis. These included the usefulness of pasting together fragments of dictated written text to form longer compositions [152, 144] and the recommendation to reduce visual steps and navigation where possible [144]. The findings from the narrative compensatory studies using technology are summarised in Table 3.2.

Single case - or small case series - studies were conducted much more frequently than group studies; besides the two weak RCT studies there were only five group studies in the literature, and one qualitative interview group study. With particular reference to VRS studies, with the exception of Wade et al's voice training program there are not yet any group studies. Of the three single case studies, two reported promising levels of generalisation to a range of independent functional writing tasks. More research examining group outcome measures is therefore warranted, in

	Software	Treatment	Dosage and frequency	Assessments used	Gains reported
Al Mahmud & Martens 2013 [152]	Modified email tool for PWA: 'Amail'	12 PWA interviewed regarding writing emails and barriers to use, testing of design and feedback	Three visits	Experimental use of modified software	End users recommended text to speech to assist with reading, pasting function to support composition, reduced visual steps and navigation
Bruce, Edmundson & Coleman 2003 [109]	Dragon NaturallySpeaking	Single case training program	17 one hour sessions over 8 months	CAT written picture description with and without software, PALPA subtests, Reading Comprehension Battery for Aphasia, WAB, pen and paper and dictated writing samples	Number of recognition errors reduced over training time Generalised to using writing as a main form of communication, began keeping a diary and writing emails
Caute & Woolf 2016 [107]	Dragon NaturallySpeaking and Read+Write Gold	Single case	16 one hour treatment sessions	CAT picture description, constrained writing task (novel task devised by authors and independently rated for social validity), social network analysis, social activities checklist	Significant improvements in efficiency and communicative effectiveness ratings, gains generalised to functional writing and were maintained, social participation increased, social network grew
Dahl, Linebarger & Berndt 2008 [144]	Windows Voice Recognition, Sentence Shaper, CoolEdit 2000 and two bespoke programs	Recording fragments of speech and assembling them into longer structures to make written sentences	One session	None stated	Three of four participants produced more accurate text with the software (descriptive only)

Estes & Bloom 2011 [108]	Dragon NaturallySpeaking	Single case	10 one hour training sessions over four weeks plus email exercises	BDAE including written picture description, BNT, ASHA FACS, Quality of Communication Life Scales	Dictation accuracy and error recognition increased; no generalisation to functional writing – picture description remained superior to spontaneous writing
Mortley, Enderby & Petheram 2011 [127]	INTACT (designed for people with aphasia)	Single case 3 stage intervention to develop writing/ typing skills, train compensatory strategy (operating predictive text) and promote functional generalisation (correspondence with daughter)	6 month therapy plus homework; intensity of dose not stated	PALPA subtests (pen and paper) and informal spelling assessment	Spelling improved (from 3/51 to 50/51 on informal assessment), and significant PALPA gains; generalisation to correspondence, maintained at 8 week follow up
Thiel, Sage & Conroy 2017 [159]	CoWriter™	Case series with eight individuals with aphasia	10 one-hour sessions of therapy over five weeks	Email skills assessment, keyboard skills assessment, email composition, hand-written picture description, CAT disability questionnaire	Four of eight participants showed statistically improved spelling accuracy within emails; group level significant increase in word length
Wade, Petheram & Cain 2001 [149]	Dragon NaturallySpeaking	Six individuals with aphasia (and five controls) - tested whether VRS is useful for spoken language therapy but findings relevant to compensatory writing	Single session	PALPA naming, word repetition, oral reading	Software successfully trained by PWA as well as controls, bypassing need for reading with use of a set vocabulary

**Table 3.2:** Features of narrative compensatory studies using technology

order to strengthen the evidence base for the use of AT in writing therapy, and to gather further information on which individuals may benefit most.

Most writing treatment studies in the literature had remedial goals. Only eight studies focused specifically on compensating for writing impairments (the remaining compensatory treatments sought to compensate for severely impaired speaking via the use of single word writing). The usefulness of writing remediation is not disputed in this thesis; rather, it reports a study designed specifically to extend the functional writing capabilities of individuals with chronic dysgraphia for whom remedial therapy may have reached the limits of its usefulness. Of the eight writing compensation treatments in the literature, seven were delivered using AT, again suggesting an area rich in potential as technology continues to progress.

The literature rarely considered the role of reading in functional writing. In the small number of studies which featured it, there were indications that reading support may be beneficial: Coute and Woolf's positive findings were particularly encouraging for the current study, since both the reading and writing software they made use of was similar to that employed here. Neglecting the role of reading in writing is problematic, since writing production and reading comprehension need to work in tandem for any writing attempts to be truly functional. This training intervention program will therefore feature reading support software as an integral aspect of three elements of participant training: checking and editing their own writing; accessing written text received from others, as part of the reciprocal, social aspect of writing; accessing existing written texts such as information on the Internet.

Finally, only two treatment studies in the literature used qualitative methodologies. This study uses a mixed methods design, gathering and analysing statistical data, then illuminating this with detailed descriptions from training observations and in depth interviews. Qualitative data is particularly useful for gaining insight into the perspectives and priorities of

participants themselves, and as such is well suited to a social model approach to dysgraphia. Further, participant views, for example regarding acceptability of treatment, are particularly important for early stage intervention treatments in which the therapy is still being developed and refined.

To summarise, the current study was intended to make a contribution to the existing literature in the following ways. It examined group narrative writing outcomes, using both standardised assessments and a novel functional narrative task. It had compensatory treatment aims, and endeavoured to support reading in an attempt to ensure that participants could fully access their own writing and that of others. Finally, it used both quantitative measures and qualitative methods, and examined the wider impact of dysgraphia on the emotional and social well-being of people with aphasia.



## **Chapter 4: A pilot study to test the acceptability of an AT training intervention, inform its design and delivery and select outcome measures**

This chapter describes a pilot study undertaken with two participants, Ella and Claire. The three main aims of the pilot study are outlined, followed by the procedure and the methods including the inclusion criteria, demographic and language information about the participants, and case histories of their prior computer use. The chapter moves on to briefly describe the features of quantitative and qualitative outcome measures tested in the pilot study, including measures of language, writing and reading, measures of cognition, quality of life, mood and social participation, and methods of qualitative data collection. The results of the pilot study are then discussed, with reference to the each of its main aims: testing the acceptability of the training intervention program, design and development of the training schedule and materials, and selection of appropriate outcome measures. Finally, the implications of the pilot for the main intervention are summarised.

### **4.1 Aims**

The 10 week pilot training program took place before recruitment of ten participants for the main intervention study, and had three overarching aims: to test the acceptability of the AT training intervention to participants, to design and develop the training schedule and materials for the main study, and to test quantitative assessments and qualitative data collection methods for measuring outcomes in the main study and select the most appropriate tools. These aims are each described in more detail below.

1. Testing the acceptability of the AT training intervention to participants: this included examining the accessibility of AT, in order that the software companies could be approached for additional trainer support if necessary, which would in turn allow appropriate materials for the intervention to be prepared before delivering the training to people with aphasia. It also involved testing whether adequate time had been allocated to the main intervention study in

order to deliver a sufficiently broad and appropriately paced training program, such that independent software use was possible by its end.

2. Designing and developing the training schedule and materials for the main study: this included testing the training materials which are integral to the software packages or provided as supplementary documentation, consulting with the pilot participants regarding their effectiveness and accessibility, and seeking participant advice regarding what additional material would be useful. It also involved exploring what types of writing activities participants wished to engage in, and the type and degree of support required for each of these.
3. Testing quantitative assessments and qualitative data collection methods for measuring outcomes in the main study and selecting the most appropriate tools. At the outset of the pilot study, a number of decisions about assessment had already been reached, based a) on the theoretical perspective of the social model of writing and the domains of the A-FROM (Chapter 1), b) consulting the literature on assistive technology (Chapter 2) and c) reflecting on the results of the systematic literature review of writing interventions (Chapter 3). To briefly summarise these decisions: it appeared clear that there needed to be assessments of mood and/or quality of life to tap into the A-FROM domain of personal identity, attitude and feelings, and of social participation, to tap the domain of participation in life situations. A comprehensive aphasia battery was also required, in order to diagnose deficits and exclude those whose speaking was more severely impaired than their writing, since they would be unlikely to benefit from dictation software; these would correspond to the A-FROM domain of severity of aphasia, and overlap also with communication and language environment. Owing to the processing demands of complex software, an assessment of cognition would also be required, with a specified cut off below which individuals would be



excluded; cognition was furthermore to be monitored at each time point in case of deterioration. Tests of single word writing and reading would be required, in order to gather more specific information regarding the exact type and severity of individual participants' dysgraphia and dyslexia. These would be both diagnostically informative and may additionally offer insights into whether differential diagnoses had an effect on intervention effectiveness. Tests of cognition and single word writing and reading would speak to the A-FROM domains of severity of aphasia, and of communication and language environment.

Outcome measures of narrative writing production and narrative reading comprehension were also clearly required. Those in which changes in writing/reading performance could reasonably be expected post-intervention, owing to the compensatory effects of AT, were to be administered both with pen and paper and via keyboard, on separate occasions, prior to the training program at repeated baseline, in order to observe broad differences in individuals' keyboard versus orthographic skills, and to provide a control dataset for individuals' computer use without software. After training, at T3 and T4, the assessments were to be administered both with pen and paper and via computer *with both AT packages enabled* – again, in separate assessment sessions and with keyboard and handwriting assessments counterbalanced to prevent order effects. This would highlight any areas where AT was able to perform a compensatory role and facilitate a meaningful change in participants' functional narrative writing and reading comprehension abilities. Lastly, there would be in-depth qualitative interviews before and after training, to explore participants' perspectives on writing, reading, technology, employment and social activities prior to and since stroke.

At the outset of the pilot study, an assessment protocol (Figure 4.1) had been designed, with the aim of measuring all of the outcomes

described above. The pilot study was an opportunity to test the acceptability of these assessments to participants, in terms of compliance, time taken to complete assessments, and any evidence of participant burden. It was also intended to finalise decisions where more than one outcome assessment was under consideration. Consequently, it was anticipated that the assessment protocol may need to be further refined prior to the main intervention study; the rationale for each assessment selected for the main study is given in the Methodology chapter. Assessments were conducted at T1 (first baseline), T2 (repeated baseline six weeks later), T3 (at the end of the 10 week training intervention) and T4 (follow up, three months later).

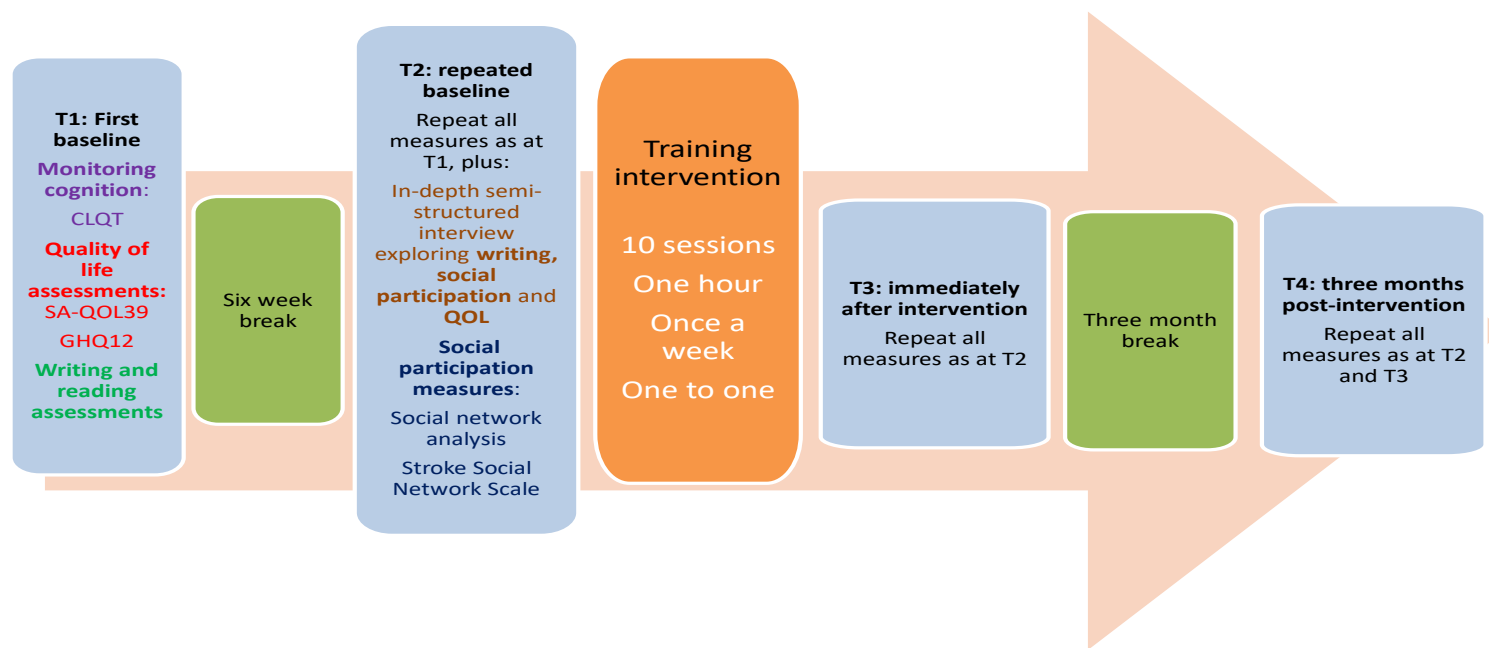
A training protocol had also been designed (Table 4.1), and a proposed training dose and frequency of ten hour-long sessions, once a week had been set. Both participants chose to undertake the training intervention in their own homes; Ella also completed all pre- and post-intervention assessments at home, while Claire undertook some pre-intervention assessments in a private room within a community setting, with the remaining assessments completed at her home.

## **4.2 Methods**

### *4.2.1 Pilot study participants*

#### *4.2.1a Inclusion criteria*

Ella and Claire had been informed of the project via the City, University of London aphasia team recruitment drive, and were selected from the wider pool of candidates based on their availability and their willingness to enter the pilot study rather than the main intervention. They satisfied the inclusion criteria for the main project (Chapter 5) except for the fact that Ella was receiving SLT, which would have excluded her since it may have interfered with the effects of the AT training intervention. As the pilot study focused on the three aims above rather than on results of treatment outcome measures, she was able to take part. Ethical clearance had



**Figure 4.1:** Pilot assessment protocol

Session	Activities
1	Installation of the two AT packages Familiarisation with headset microphone Reading aloud exercise to enable Dragon software to recognise participant voice
2	Begin Dragon NaturallySpeaking™ Interactive tutorial Welcome, Basics, Dictation, Correction menu, Spelling window, Editing, Learning more
3	Complete Dragon NaturallySpeaking™ Interactive tutorial ClaroRead™ software overview and settings adjustment
4	Practising using the two software programs in tandem and correcting errors
5	Composing emails
6-10	Work of own choosing, supported and observed by the student researcher

**Table 4.1:** Pilot training protocol

already been granted to the study (Appendix 5.1), and Ella and Claire both gave informed consent to participate.

#### *4.2.1b Demographic and language information*

Claire was aged 65 and was 13 years post-stroke at the time of her first assessments, while Ella was aged 23 and was four years post-stroke. Ella was a student and lived with her mother, while Claire was retired owing to ill-health and lived alone.

Both candidates presented with mild to moderate non-fluent aphasia, with relatively intact auditory comprehension and some spoken word finding difficulties. Both identified writing and reading deficits as being particularly troublesome to them. Their responses to the spoken and written picture description task in the Comprehensive Aphasia Test [161] (see Chapter 5 for a detailed description of this language battery) are shown in Table 4.2.

#### *4.2.1c Prior computer use*

Case histories were taken from pilot participants regarding their prior experience of using computer technology, and their access to and familiarity with up to date software and hardware. Both had routinely used

	Spoken picture description	Written picture description
<b>Ella</b>	<p>The man is sleeping on the erm the armchair and erm the books and erm no and erm the cat is erm seems to be playing on erm the water bowl and the baby is playing on erm a toy car erm and the table on on erm on the the cup of tea and erm the man is erm resting under the book er the sheet of table</p> <p><i>Student researcher: what about the little boy, what's he doing?</i></p> <p>Playing? Playing yeah. And the shelf on is erm on erm no the erm</p>	<p>The bald man is sleeping on the armchair, seating the feet of the table. ¢</p>
<b>Claire</b>	<p>The cat erm the cat is erm swim no the cat is fish and the cat and the fish erm the baby looking at the car and the man is sleeping, the cup is on the table and the book is half a point, the newspapers the sock not the feet</p>	<p>THE CAT IS <del>DR</del> FISHING HIM FISH THE BOY IS TOY CAR THE MAN IS SLIPPE</p>

**Table 4.2** Pilot participant CAT spoken and written picture description

computers for work or study prior to stroke, and both were experienced Microsoft Office (particularly Word), email and Internet users. Post-stroke, both continued to use computers for a range of activities including email, shopping, personal and practical writing, information-seeking, playing games and social media, though their satisfaction with these activities varied, and had reduced since onset of aphasia. It was anticipated that by recruiting relatively experienced computer users, the focus of the pilot could be the specific aphasia-related challenges they encountered when learning to use the novel AT packages, rather than challenges arising from the computer interface more generally. Claire had a desktop Mac which she preferred to use, though she also owned a PC. She was therefore offered the equivalent AT for Mac (Dragon Dictate™ and ClaroRead™ Mac) so that she could continue to use her favoured hardware. Ella had a laptop at home on which Dragon NaturallySpeaking™ and ClaroRead™ for PC were installed.

#### *4.2.2 Measures*

##### *4.2.2a Quantitative assessments*

The assessments that were retained for the main intervention are described briefly below, and more fully in Chapter 5: Methodology.

##### *4.2.2.a.i Measures of language, writing and reading*

Two assessments were administered pre- and post-pilot training: the CAT Language Battery [183] (full version pre-training, written picture description with and without AT post-training) and the Wide Range Achievement Test 4 (WRAT4) [207]. In addition to these two assessments, a novel constrained writing task was created and administered at all four time points, with pen and paper and via keyboard (AT enabled at T3 and T4). In the pilot study, this required participants to spend five minutes composing an email to the student, outlining a recent writing activity they had undertaken.

##### *4.2.2.a.ii Measures of cognition, quality of life, mood and social participation*

The Cognitive Linguistic Quick Test (CLQT) [208], the Stroke and Aphasia Quality of Life 39 generic (SAQOL-39g) scale [209] and the General Health Questionnaire (GHQ) 12 [210] were administered in the pilot study. Additionally, two quantitative measures of social participation, the Stroke Social Network Scale (SSNS) [211] and Social Network Analysis, were tested in order to establish which was more informative and which the pilot participants found most acceptable.

##### *4.2.2b Qualitative data collection*

##### *4.2.2.b.i In-depth semi-structured interviews*

Tentative topic guides had been designed for the pre- and post-intervention interviews for the main study (Appendices 4.1 and 4.2), based on the research questions it was intended to address, yet designed to be used flexibly according to issues raised by participants, with additions to be made where appropriate. These topic guides were tested for acceptability and comprehensiveness in the pilot study. Additionally, the pilot post-

intervention interviews were used as a scoping exercise to explore participants' experiences of the training program, therefore they were also asked to what extent their expectations had been met, what they had enjoyed and what their recommendations for improvement would be during their post-intervention interviews. All interviews were audio-recorded and transcribed by the student researcher. Claire was interviewed alone at both T2 and T3, while Ella's mother Jackie was at home when her T2 interview took place and offered additional insights. At T3 Ella was interviewed alone.

The in-depth semi-structured interview data were to be managed in the pilot and main study and analysed using the Framework Analysis method [212], an approach designed in the 1980s at the National Centre for Social Research in the UK, and regarded as particularly useful for semi-structured data such as that gathered in this study. The name Framework is derived from 'thematic framework', and refers to the way in which the method uses a matrix-based format to organise and synthesise qualitative data and then classify it according to key themes, concepts and emergent categories; using a six stage process of: 1) initial theme identification through familiarisation with the data, 2) construction of a thematic index such that all issues raised are comprehensively included, 3) coding of all data according to themes and sub-themes, 4) creation of thematic charts/matrices, 5) sorting and synthesising of coded data, and 6) development of descriptive and explanatory accounts. All but the last stages of Framework are organisational rather than analytical in intent. An important feature of the method is that it stipulates that all the gathered data must be coded, in order to ensure that "cherry picking" of evidence is minimised. A further advantage is that the method retains original content - rather than simply conducting counts of specific behaviours - which facilitates rich description and first person quotes from participants. Framework has been successfully used in other qualitative studies in the speech and language therapy field by other researchers with a social model

approach such as Parr [213] and Northcott [80] and in the student researcher's own previous work [74].

#### *4.2.2.b.ii Video recording*

Pilot training sessions were video-recorded using a compact camera and tripod focused on the computer screen, in order to capture writing and reading attempts in detail, including any editing that occurred. Dialogue was also captured by this recording, and salient exchanges were transcribed. Additional notes on procedural successes and challenges, and on participant comments, demeanour and engagement were made during the sessions and written up afterwards. These provided information as to participants' skills and aspects of the training that they found difficult, in order that training content and supporting materials could be created and refined. At the time of the pilot, these recordings were primarily intended to serve as a progress record, a task which was anticipated to be particularly important for record keeping and monitoring of barriers and facilitators to AT software use with the larger number of participants in the main intervention. Recording was also intended to address the fact that PWA may find it challenging to verbally report the nature of any difficulties they were experiencing in the moment, owing both to word finding difficulties and to the burden of cognitive processing required by using the AT. The pilot study therefore aimed to check that being recorded was acceptable to participants, and did not inhibit their behaviour.

### ***4.3 Results and implications for the main intervention study***

#### *4.3.1 Acceptability of the training intervention*

Both participants successfully learnt how to use both AT packages in the ten, hour-long weekly time slots allocated to them, and additional support or training from the software companies was not required. However, there were individual differences between Claire and Ella both in relation to the two AT packages, and in terms of their learning skills and preferences. These differences were illustrated by comments made during training sessions and in the post-training interviews, besides training observation notes made by the student researcher. They are briefly described below,



firstly with reference to each of the AT software packages in turn, then with reference to their approaches to learning.

#### *4.3.1.a Dragon NaturallySpeaking™*

Claire described using Dragon Dictate™ as ‘easy but difficult.’ She said that owing to her difficulties with speaking, writing was ‘a long process’ (Claire, T3 interview). She reflected on how the software could be frustrating to use at first because its word recognition capability appeared to be inconsistent, sometimes immediately reproducing a word accurately, other times failing to recognise a word after numerous repetitions. Claire’s pragmatic solution to this was to orally attempt a word three or four times, and if it was still not produced correctly she would simply, if laboriously, type it. Mistakes rarely deterred her or slowed her down, and her standard response to these setbacks was one of amused acceptance. Over time, outlandish errors of reproduction were markedly reduced, and Claire frequently made positive remarks about the software’s capacity to recognise even proper nouns such as ‘Guggenheim’, ‘Staten Island’ and ‘Niagara Falls’. She soon discovered that using an authoritative, crisp tone of voice facilitated recognition, and consistently made use of this. It may have been of relevance that prior to her stroke, Claire had been a lawyer and an accomplished and confident public speaker.

By contrast, Ella found Dragon NaturallySpeaking™ ‘a lot more harder’ to use than she had expected; she recollected specific examples of errors (such as ‘bald’ for ‘bold’) and said that the software ‘misrepresented my work’ (Ella, T3 interview). In her training sessions, she often became disheartened by the burden of editing and correcting these errors, and in an early session remarked in frustration: ‘It would be easier to just write it!’ (Ella, training session 3). This lowering of morale in turn introduced a greater rate of error as Ella’s speaking voice became softer and more hesitant. Ella also struggled with feeling that the work she produced was not perfect and deliberated over every word, which seemed to impede her pleasure and satisfaction. Claire was more inclined than Ella to accept her

own work as broadly satisfactory and continue to move forward with the task she had set herself.

Ella said she was unlikely to continue using Dragon NaturallySpeaking™ independently once training was completed. She was satisfied with the arrangement she had with her support worker at college, and preferred to continue writing collaborative emails with her mother, providing an idea and asking Jackie to refine it. Claire, however, intended to continue using Dragon Dictate™ independently, and was considering writing a story or a document related to her legal experience. She reported she may also be contributing to a journal paper written by a student in whose recently completed PhD study she participated.

#### *4.3.1.b ClaroRead™*

Since her reading impairments were relatively mild, Claire did not feel she needed to rely on ClaroRead™ software to check her written work. In the early stages of training, she used it to listen back to what she had written, but found its prosodic features unnatural and jarring. She soon became confident with combining rehearsing her spoken output with the microphone off, then dictating it, and finally checking it by reading directly from the screen. Ella, however, used ClaroRead™ throughout the training period, and described it as ‘good, really good.’ Though like Claire she criticised its prosody, deeming it ‘completely not realistic at all,’ she found this ‘funny’ rather than problematic, and indeed had selected ‘Australian male’ as an accent choice to heighten her amusement (Ella, T3 interview). At the end of the training intervention Ella expressed her intention to continue using ClaroRead™ to support her independent reading.

#### *4.3.1.c Learning skills and preferences*

It was evident from working with Ella and Claire that individual learning styles at a macro level were likely to influence participants’ approaches to training: for example, adopting an appropriate oral dictation style came more naturally to Claire than Ella, as did tolerance of errors. Conversely, Ella found it easier than Claire to cope with the distraction and additional

burden of auditory processing. This was noted as a consideration for the main intervention study sessions, with the intention that these should be personalised to suit each individual; this will be returned to in detail in the intervention chapter (sections 6.4 and 6.5). Adopting a 'coaching' role was felt to be the most appropriate way to scaffold participants' successful communication strategies and to tailor support to individual requirements. Participant observation was already planned, and could readily be extended to scrutiny of specific communicative behaviours such as oral dictation traits. Further, immediate written evidence of success would exist owing to the use of dictation software, which could serve to reinforce the usefulness of the strategy employed. Finally, the influence of trainer behaviour may also be captured by this approach, in a similar way to a primary conversation partner in every day conversation. This would be useful in terms of recording replicable training strategies.

These methods are somewhat analogous to those used in conversational coaching (CC) ([214], [215]) and conversation analysis (CA), ([216], [217]), though both these latter involve working with dyads rather than individuals. CC and CA offer a means of providing individuals with additional or alternative strategies for conveying information, in order to maximise their chances of being understood and to reduce frustration. The strategies suggested in these approaches are suggested based on observation of participants' current communicative behaviours, and the outcomes of these behaviours. Practitioners engage in close scrutiny both of unhelpful habits and of areas of strength which could be further exploited, with a theoretical underpinning that by bringing unconscious behaviours to participants' attention they can be eliminated if unhelpful, or refined and extended if they are beneficial. The current study takes a broadly similar approach.

#### *4.3.2 Design and development of the training intervention and materials*

In their post-intervention interviews, Claire and Ella made three recommendations pertaining to the second aim of the pilot study. These

are described below, along with actions undertaken to implement them for the main intervention study.

#### *4.3.2.a More detailed goal setting*

Both participants suggested more time should be spent at the outset of the training program on exploring what activities future participants would like to undertake. Claire described how for her, while the initial intervention sessions were structured, the later ones ‘flowed’ as her travelogue took shape; often on arrival at Claire’s home during those weeks she was already working on the document and observation and note-taking were all that were required. Nevertheless, Claire felt a list of ‘options’ for writing activities would support future participants who may find it more challenging to come up with ideas (Claire, T3 interview). This was borne out by Ella’s experiences: she explained that the hardest thing for her had been coming up with ‘a concept’ and found that using Dragon NaturallySpeaking™ was difficult not only because she had to ‘re-work what I’m saying’ [when there were errors of reproduction] but also because it is even more difficult ‘thinking of the idea in my head.’ She suggested it would have been preferable to undertake a ‘project.’ (Ella, T3 interview). She initially found it difficult to describe what type of project she may have liked, but eventually thought perhaps something related to describing or reviewing television programmes she had watched.

In order to implement this recommendation, a power-point presentation was prepared for participants in the main study (Appendix 4.3), containing suggestions for both short and in depth projects. This was intended to support participants who found it challenging to conceptualise and formulate what they wanted to write about, by alleviating the burden of coming up with an idea and encouraging participants to focus on the act of writing itself, at least in the early stages of the intervention. Plans were also made to provide each participant in the main study with a folder containing a simple progress record (Appendix 4.4) in which they could indicate from a checklist, supported with pictures: tasks undertaken independently, time spent on each task, level of ease/difficulty and level of

enjoyment. Each participant's folder would also be updated weekly with materials from their most recent training session, recapping the main learning points in an accessible format (Appendix 4.5 contains a sample from the folder of Sarah, a participant in the main study). Finally, in the main study there would be an opportunity at the end of each session for participants to print out a record of what they have written, to enable them to monitor their weekly progress and foster a sense of achievement.

It was noted that Ella's greater preference for structure at a more micro level in the training sessions, such as needing more support not only to formulate an abstract concept but then to express it verbally in words, may also be a factor for some participants in the main intervention study. For example, they may respond more favourably to step by step procedural guidance, while those with a more loosely structured approach like Claire may prefer to learn through experimentation or trial and error, with less explicit instruction-giving from the trainer. Therefore, this too was to be considered when the sessions were personalised to suit each individual, again with broad parallels to the conversational coaching and CA literature, and will also be returned to in the intervention chapter.

#### *4.3.2.b Extending Dragon NaturallySpeaking™ initial voice training*

Ella recommended that more initial training time should be spent on improving voice recognition, in order to reduce dictation errors. In practice, the most effective way to overcome this issue is simply continued usage of Dragon NaturallySpeaking™, as Claire's more intensive use demonstrated. Nevertheless, as a result of Ella's comments, more care was taken to explain this explicitly to participants in the main intervention study. It was also noted that additional reading aloud tasks could be provided to supplement those in the Dragon NaturallySpeaking™ tutorial if main study participants felt this would be useful.

#### *4.3.2.c Mode switching between Dragon NaturallySpeaking™ editing and dictation*

Despite the mechanical ease with which this can be done, Ella and Claire both found editing by voice command a challenging task, and both favoured amending their text with the keyboard. With time, they were able when encouraged to locate an error with the cursor and then delete it and correct it using voice commands, but given the choice both preferred to type. It is possible that while AT was useful for locating and deciphering the nature of an error, rectifying it conventionally felt more natural for Claire and Ella. However, this would not be a realistic option for participants with severely impaired writing and/or reading. Training in the main intervention was therefore planned to accommodate this preference where viable, and to provide more focus on mastering both modes and effectively switching between them for those unable to type either owing to physical impairment or the severity of their spelling deficits.

#### *4.3.3 Selection of assessments to measure outcomes*

The two pilot participants were compliant with the assessments, which took approximately two hours to complete at each time point. The assessments tested were acceptable to participants and most yielded appropriate data. There was no evidence of undue participant burden, which was assessed by monitoring for signs of fatigue or distress, offers of taking breaks or resuming another time which were declined in favour of continuing, and explicit enquiries as to whether levels of fatigue were acceptable for participants. Some changes to the assessment battery were made, however; these are described below, along with a brief outline of assessments which remained unchanged, which are described more fully in Chapter 5: Methodology.

##### *4.3.3.a Language, writing and reading*

The CAT was acceptable to participants and was retained for the main intervention; it is described in Chapter 5.

Two substantive changes to the battery of writing and reading assessments were made. Firstly, the use of the WRAT4 was discontinued because there were factors which made it an ineffective measure of the skills targeted by the training intervention. The WRAT was not created specifically for an aphasic population, but designed to assess reading comprehension and single word spelling in both children and adults in order to identify specific learning disabilities; the original assessment also tests numeracy but that sub-test was not used.

The three WRAT4 tasks which pilot participants were originally required to complete were single word reading, single word written spelling to dictation, and written sentence comprehension (where comprehension was deemed successful if the participant could successfully provide a missing word orally). The last task was particularly problematic for the pilot participants, and it was concluded it could not offer a true measure of sentence comprehension for participants with aphasia owing to the potentially confounding effect of their word-finding difficulties. The WRAT4 was therefore replaced by selected subtests of the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) [17], as described in more detail in Chapter 5. Most of these were to be used diagnostically, while a small subset was to be administered at all time points, in conventional pen and paper format only. This subset would monitor for potential remedial effects of the intervention, for example as a result of improved confidence, or intensive practice with/increased exposure to the written word. Secondly, as a result of deciding not to use the WRAT, the Gray Oral Reading Test 4 (GORT-4) [218] was introduced to ensure that narrative reading comprehension was sufficiently assessed and monitored in the main study.

In addition to these two changes, a minor adjustment was made to the constrained writing task in order to ensure that it was truly reflective of functional writing skills. The instructions regarding the topic of this task were amended to emailing a friend inviting them to meet, arguably a more natural task than writing to the student researcher. Further, the pilot

participants indicated that the original topic would not be easy to fulfil for those who had not engaged in any recent writing activity. Nevertheless, the constrained writing task appeared to be sensitive to change, with both participants able to produce more written narrative with AT than with pen and paper.

#### *4.3.3.b Cognition, quality of life, mood and social participation*

The CLQT, the SAQOL-39g, the GHQ-12 and the SNA were all found to be acceptable to participants and were retained in the main intervention; they are described in Chapter 5. Use of the SSNS was discontinued owing to the high degree of overlap with SNA. The SSNS is a questionnaire-based measure which captures the number of people from five subgroups - children, friends, relatives, neighbours, interest groups - with whom the interviewee is in contact, the frequency of this contact, and a rating scale for satisfaction with frequency (though not quality) of contact for each group, from which an overall rating can be obtained. Scores range from 0 to 100, with higher scores indicating a stronger social network. The pilot participants expressed a preference for SNA owing to the pictorial accessibility of the diagram and instructions, and the way in which each individual member of their social network, rather than simply subgroups such as friends, relatives or neighbours, could be discussed, thereby capturing change in participants' social relationships in finer detail. Furthermore, Claire pointed out that any dissatisfaction she felt with regards to her social network tended to stem not from frequency of contact, but the *quality* of that contact, which she felt was impeded by her aphasia. However, there were useful elements of SSNS which were missing from SNA, namely satisfaction levels with frequency and type of contact with members of the network, membership of groups, and experience of loneliness. In the main study, the first aspect could readily be incorporated into SNA, and the latter two were to be covered with more specific probing in the in-depth, semi-structured interviews.



#### *4.3.3.c Qualitative data*

The topic guides created for pre- and post-training intervention yielded rich information relating to functional reading/writing, social participation and engagement with technology pre- and post-stroke, and as a result were not amended before the main study, though as with all semi-structured interview guides they were not an exhaustive question battery; rather, they were to be treated flexibly throughout the main study and adapted as appropriate whenever novel and relevant topics were introduced by participants.

A highly useful finding of the pilot study was that the combined use of video-recording and observation note taking for participant training sessions was more illuminating than was anticipated at the design stage. Not only was it acceptable to participants, but - besides fulfilling its original purpose of recording and monitoring progress – the video recordings and observation notes additionally captured numerous instances of participants discussing many of the phenomena covered in the in-depth interviews. Sometimes this occurred when participants cited a training experience as representing a specific example of something they had described in general terms during interview, whether procedural, such as struggling to find a word or forgetting the steps required to start a computer programme, or psychological, such as feeling frustrated or mourning the loss of their employment. At other times, additional disclosures were made which related to interview topics but which participants had not previously mentioned, perhaps owing to the intimacy of one-to-one training and increased trust as the weeks passed. Furthermore, as noted above, observation data would be very useful for scrutiny of specific communicative behaviours and recommendation of successful strategies, as described in the conversational coaching literature.

As a result of this finding, the emphasis on observation in the main intervention was increased, and the literature on participant observation (PO) in interventions was therefore consulted at the end of the pilot study; this literature is briefly summarised below. It revealed that the additional

insights yielded by observation described above were indeed a justification for its continued use: observation data is often used for interview triangulation, to 'provide a check on what one is told for reasons of impression management' [219] (page 532). In other words, in interviews participants may, consciously or otherwise, give responses they believe interviewers may find favourable; however, they are less likely to be able to sustain a stance they do not genuinely hold over longer periods of observation during which they are concentrating on an additional activity besides creating a positive impression.

PO as a methodology is a form of field research, frequently used in sociological disciplines such as anthropology in which the researcher is regarded not as an outsider but at least nominally as a member of the group being studied. Fine [219] argues that the advantages of PO include its potential for gathering rich and detailed descriptive data, high levels of analytical validity owing to its in situ findings (typically backed up with recorded evidence) and relatively low economic expense – though one might argue this is counterbalanced to a degree by its labour intensiveness. There are several types of PO, and these are largely distinguished by the level to which the observer is actively involved in the situation they describe. Mulhall [220] sets out Gold's [221] original classifications of observers as the following:

- The complete observer, who maintains some distance, does not interact and whose role is concealed;
- The complete participant, who interacts within the social situation but again whose role is concealed;
- The observer as participant, who undertakes intermittent observation but whose role is known;
- The participant as observer, who undertakes prolonged observation, is involved in all the central activities of the organisation and whose role is known ([220], page 308).

In the current study, the form of observation used most closely corresponded to the final type listed, since the student researcher was also responsible for both delivering the AT training intervention and conducting all of the assessments. Reflections on the challenges encountered by performing a multi-faceted role, besides its advantages, will be given in the intervention and discussion chapters.

A further distinction in the PO literature is between structured and unstructured PO [222], distinguishable by use or non-use of a systematic observational checklist. In the current study, unstructured PO was employed, for two reasons. Firstly, Mulhall indicates that in unstructured observation the observer may play a number of different roles, while in structured observation the intention is always to adopt a distance from the action under observation – something the role of trainer and assessor would have made impossible in the intervention described here. Secondly, the paradigm of unstructured observation appeared to fit the exploratory and participant-led principles of the AT training program, in that unstructured observers do not approach with fixed or predetermined ideas of what behaviours they might see, but gather data inductively and then subsequently code it for analysis. Similarly, the intention of this study was to gain detailed insight into individual writing deficits, technology use and personal writing goals, and then to support participants in achieving these. Nevertheless, the importance of creating a replicable intervention was recognised. For this reason a range of behaviours observed are described in chapter 6, where personalisation of the training program is set out.

#### ***4.4 Summary***

Chapter 4 began by describing the three main aims of the pilot study. It covered the procedure and methods used, including participant inclusion criteria, demographic and language information and computer use case histories, before moving on to describe outcome measures tested in the study. It then discussed pilot study results, with reference to its three main aims: testing the acceptability of an AT intervention, designing and developing training materials for the main study, and selecting appropriate

outcome measures. Finally, for each of the three main pilot study aims, the implications of the findings for the main intervention study are discussed.

## **Chapter 5: Methodology**

This chapter lists the research questions addressed by the AT training intervention. It describes the design, participants and procedure of the training intervention, the measures used to address each of the research questions, and the way in which data relating to each research question were analysed.

### ***5.1 Research questions***

The research questions addressed by the main intervention study were:

RQ1: Does AT training compensate for writing and reading impairments and lead to improved performance in writing and/or reading activities?

RQ2: Does AT training have an impact on social participation and/or quality of life for PWA who have writing/reading deficits?

RQ3: What are the barriers to the use of AT by PWA?

RQ4: What strategies or supporting materials for using AT help overcome these barriers?

### ***5.2 Design***

A mixed methods, repeated measures design was adopted to answer the four research questions, whereby both quantitative assessments and qualitative data collection and analysis were utilised to investigate outcomes for writing, reading, social participation, mood and quality of life. Assessments were conducted at four time points. As there was no control group of participants, a double baseline design (T1 and T2) was employed to monitor potential variability in outcome variables without any input. Baseline assessments were conducted six weeks apart, and there was no contact in the interim other than for administrative purposes. AT was not installed on participants' computers until T2 assessments had been completed.

At T3, the end of training, participants were tested again. It was predicted that participants would be competent and confident enough to continue using AT independently. To test this, and explore factors influencing independent use of AT beyond training, a final set of assessments and

interviews were conducted at T4, three months later. Again, during this final three month period contact was purely administrative. Figure 5.1 shows a detailed protocol of all the assessments administered at each time point.

### **5.3 Participants**

#### *5.3.1 Inclusion criteria*

Eligibility to participate was dependent on the following criteria:

- A diagnosis of aphasia due to a stroke, identified by the CAT;
- Minimum of 6 months since most recent stroke and medically stable;
- Not currently receiving SLT, nor participating in another research project with therapeutic goals;
- No significant cognitive impairment, as this may limit ability to engage with AT, as defined by a score below cut off point for four or more of the ten CLQT tasks;
- Presenting with acquired dysgraphia, as evidenced by PALPA scores, where writing is more impaired than speech, as evidenced by superior spoken than written picture description raw score on the CAT;
- Self-reported ability to speak, read and write fluent English prior to stroke, and retained ability to participate in assessments and training activities delivered in English;
- Access to a computer, with an Internet connection if training was to include email and/or Internet use, in order that self-directed practice on training tasks could be completed;
- Over 18 years old when consent given to participate in the research project;
- No marked evidence of neuromuscular or motor-speech impairments such as dysarthria or dyspraxia, nor structural abnormalities such as cleft palate which would preclude successful use of VRS;
- No self-reported history of developmental dyslexia;

- No visual/auditory impairments, unless corrected with the use of spectacles or hearing aids.

The aim was to recruit ten individuals for a small group study, in order that detailed qualitative data could be gathered and intensive training and assessment sessions could be conducted, while still broadening the literature beyond the single case studies with PWA which have been reported up to now.

### *5.3.2 Recruitment*

As participants were required to be a minimum of 6 months post-onset of aphasia/most recent stroke, they were recruited from community settings such as Stroke Association communication support groups and Connect – the communication disability network. There were many aphasia-related research and doctoral projects being undertaken in the Division of Language and Communication Science at City, University of London, and a joint, systematic recruitment program in London and surrounding areas was devised. Former non-NHS employers and University colleagues were approached by the recruitment team, and new community contacts were targeted. A power-point presentation, project information booklet and contact form were created. Each community group was given a short presentation then an opportunity for one to one conversations with researchers. Besides the community group recruitment drive, this project had been described, at the early stages of its inception, to PWA who were participating in other research projects with colleagues in the Division, and individuals who expressed an interest in hearing more about the project were approached. Individuals with aphasia who self-referred to the City Aphasia Research Clinic team and described difficulties with writing and/or reading were also referred to the project. Finally, participants who had joined the study recommended it to friends with aphasia.

### *5.3.3 Ethical considerations*

The study was granted ethics permission by the Division of Language and Communication Science Proportionate Review Committee of the City,

University of London School of Health Sciences Research Ethics Committee on 16 January 2013 (Appendix 5.1). The ethics application considered informed consent, data protection, participant expectations and frustration/fatigue/distress. Consent to participate was sought using carefully designed materials in order to ensure the study was transparent to people with communication disabilities; these included a flyer (Appendix 5.2), a detailed information sheet (Appendix 5.3) and a consent form (Appendix 5.4), all of which were given to participants to keep. Participants were assigned number codes used in lieu of names on paper assessments. These were kept in a locked filing cabinet accessed only by the student; computer files were password-protected. Video- and audio-recorded material could only be accessed by the student unless explicit permission was given by individual participants for recordings to be used for teaching and/or conference presentation. Printed material used in this thesis and in any future publications has been de-identified through the use of pseudonyms and alteration of any other features which could identify participants. At times, both assessments and training necessarily focused on participants' specific language and communication difficulties, potentially causing fatigue or distress. Participants were supported by the student, who had experience of working with PWA and facilitating communication and technology access. Participants were invited to take breaks during training sessions if they were experiencing frustration, and were able to terminate and reschedule sessions if they wished. Participants were given information about how to access further therapy and/or counselling if they sought it, and were informed this would be given regardless of on-going participation or withdrawal. Naturally, participants entered the training program hoping for functional writing and/or reading improvements, and/or improvements in their level of social participation. The project information sheet indicated that while such benefits were possible, they could not be guaranteed, and this was reinforced verbally when informed consent was gained.



## **5.4 Procedure**

### *5.4.1 The assessment protocol*

Assessments at T1 were conducted over two to three visits, each of approximately two hours duration, depending on participants' levels of fatigue and the speed with which they could comfortably complete each test. Screening assessments (CLQT and CAT) were administered during the first session to limit the period of uncertainty for participants. At all sessions, testing order was structured to ensure measures of writing and reading were distributed across them in order to reduce fatigue, and tests using the same stimuli were presented in separate sessions in order to avoid priming effects. Likewise, assessments which were delivered in two different formats (pen and paper/keyboard) were administered at separate sessions and were counterbalanced to ensure electronic versions were delivered first 50% of the time, at all test points. At T2, T3 and T4, assessments were conducted over two visits of approximately two hours duration. Social Network Analysis was undertaken before the in-depth interview in order that any discussions of social participation raised by SNA could be addressed in more detail in the interview.

### *5.4.2 The training protocol*

Training was delivered in a series of weekly one-to-one sessions, each lasting approximately one hour, for 7-10 weeks per participant (see Table 6.1). Criteria for terminating training were either reaching ten sessions, or successful mastery of AT to a level permitting independent use, or for individuals who experienced more difficulty, maximum benefit having been reached by mutual agreement. Breaks for holidays or illness were accommodated. Whether in participants' own homes or at City, University of London, training took place in a quiet, private space. Detailed activities during the sessions were tailored in order to address individuals' training goals and learning preferences, and the way in which the intervention was personalised will be described in detail in Chapter 6. For all participants core training included:

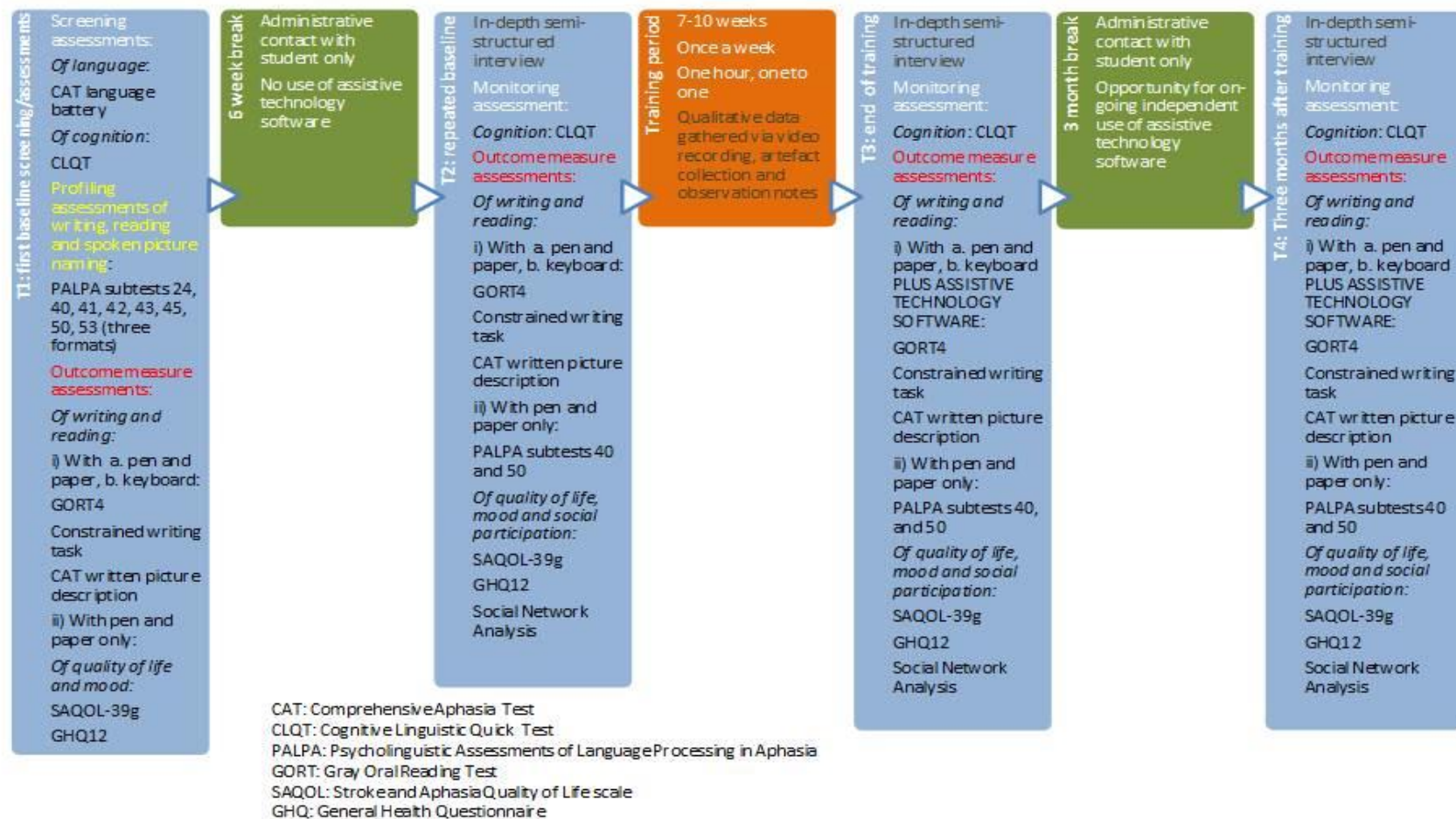


Figure 5.1: The assessment protocol

- An initial consultation to identify written communication goals, for example using email, accessing the Internet for information or social contact, writing shopping lists, autobiographical writing;
- Support with computer set up, installation of the two AT packages and familiarisation with equipment and software, including specific functions such as error correction;
- Training and support in use of AT in relation to identified goals, for example teaching Dragon NaturallySpeaking™ to recognise a list of high frequency words and phrases, planning and composing correspondence, and using prompt sheets to help select content and topic;
- Troubleshooting challenges that arose;
- Revisiting goals to check they continued to be relevant and appropriate, and revising them where necessary;
- Completing practice exercises at home to encourage independent AT use and promote the long-term efficacy of the training - this included provision of an aphasia-friendly work log for participants to document time spent and activities undertaken;
- Ongoing communication support: accessibly-written, step-by-step prompt sheets were presented in an aphasia-friendly format in which short, simple sentences were supported by the use of pictures, large plain font, colour contrast and ample space. These were provided as memory aids for new procedures, and each training session began with a brief progress review.

## **5.5. Measures**

### *5.5.1 Screening assessments*

#### *5.5.1.a Of language: Comprehensive Aphasia Test (CAT) language battery [183]*

The CAT is a battery of assessments designed to investigate language production and comprehension across all four domains (speaking, listening, writing and reading) in order to create an impairment-based treatment plan. The language battery takes approximately 45 minutes to administer

and yields summary scores, which are then converted to standard T-scores (25-75), for comprehension of spoken language, comprehension of written language, repetition, spoken picture description, reading, writing and written picture description, where higher scores indicate better language functioning. The CAT was selected as it has test-retest reliability of 95% and inter-rater reliability is described as 'excellent' for almost all tests with the exception of reading non-words and functors (90% and 80% respectively) [183] (page 111). Furthermore, the written picture description from the CAT was used in the Dragon NaturallySpeaking™ single case studies conducted by both Bruce et al [118] and Caute and Woolf [115], so use here would allow for direct comparison with these studies. The CAT also includes a cognitive screen and a disability questionnaire, but those sections of the assessment were not used in this study, nor are T-scores for spoken naming given since these require scores from a sub-test from the cognitive screen.

#### *5.5.1.b Of cognition: Cognitive Linguistic Quick Test (CLQT)*

The CLQT [208] is a 10 item assessment designed for use with adults with acquired neurological impairments in order to gain information about cognitive and linguistic functioning, which takes 15 to 30 minutes to administer. It assesses five domains: attention, memory, executive functions, language and visuospatial skills. Scores yield severity ratings for each domain and a total composite severity rating, range = 0 – 4, where lower scores indicate greater impairment (0 - 1 = severe, 1 - 2 = moderate, 2 - 3 = mild, 3 – 4 = within normal limits). The CLQT has test-retest reliability of between 61% and 90% for the cognitive domains, and inter-rater reliability of 86%. In this study, the CLQT was used as a screening assessment at T1, at which point participants with a severe impairment in any domain were excluded. Participants with more than two scores indicating moderate impairment were also excluded; for both groups it was predicted that learning to operate two complex software packages would be too demanding. The CLQT was selected because it allows for comparison between impairment in linguistic versus non-linguistic

domains. It was felt to be particularly appropriate for this study since although the intervention is mediated by language, other non-linguistic domains may also play a role in progress, for example visuospatial impairments leading to neglect of certain parts of the computer screen. The CLQT was recommended by Cauter and Woolf as a potentially more insightful measure of cognition for this type of intervention than the Wisconsin Card Sorting Test used in their single case study.

#### *5.5.2 Profiling assessments: Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) subtests 24, 40, 41, 42, 43, 45, 50, 53 (three formats)*

The PALPA [17] assesses single word level language processing in adults with acquired aphasia and consists of a resource set of 60 language tasks from which assessments can be selected to create a tailored protocol. Ten tasks were used to establish diagnostic information about the nature and severity of participants' single word spelling and reading deficits and their ability to name pictures aloud; see Table 5.1. Moreover, this information would be useful for replication purposes and/or if a particular subgroup of individuals made markedly more or fewer gains as a result of the software training intervention. Two of the PALPA subtests, 40: imageability spelling and 50: written synonym judgements, were also used as outcome measures to examine whether participants' single word spelling and reading deficits were remediated by the training program, and were therefore repeated at all four time points. The PALPA was selected for its capacity to offer fine-grained, differential diagnostic information at the single word level, for example regarding real word versus non-word processing and production. This was felt to be particularly appropriate when considering issues such as the ability to proofread text for accuracy. Furthermore, as described in Chapter 3, the PALPA was the most widely used single word assessment in the writing treatment literature.

#### *5.5.3 Monitoring assessments: Cognition*

Cognitive function is not an outcome measure of this study; nevertheless, besides its use as a screening tool at T1 the CLQT was further used at T2, T3

Spelling	PALPA assessment	Procedure
	<b>40 – Imageability and frequency spelling</b>	<b>Participants are presented with 40 spoken words (10 high imageability high frequency, 10 HI LF, 10 LI HF, 10 LI LF) by the examiner and are required to write them to dictation</b>
	41 – Grammatical class spelling	20 items (in order of imageability from high to low: 5 nouns, 5 adjectives, 5 verbs, 5 functors) are presented orally and must be written to dictation
	42 – Grammatical class spelling (controlling for imageability)	20 items (10 highly imageable nouns and 10 low imageability functors) are presented orally and must be written to dictation
	45 – Non-word spelling	24 monosyllabic items (6 x 3 letter, 6 x 4, 6 x 5, 6 x 6 letter) are presented orally to be written to dictation
	53 - Picture naming: written spelling	Participants are shown 40 line-drawn objects and are required to write down their names. Note that the items are regular/exception for reading therefore some ‘regular’ items may be irregular for spelling
Reading	24 – Visual lexical decision with ‘illegal’ non-words	Participants look at 30 words and 30 non-words and judge whether they are real, marking them with a tick or cross. The non-words are made of letter pairings which do not occur in written English, hence ‘illegal’
	43 – Lexical morphology and reading	A 60 item assessment of 10 regular, 10 irregular and 10 derived inflection with 30 matched for length controls which participants are required to read aloud [In the PALPA this test is named Lexical morphology and spelling, but in this study the assessment was delivered as a test of reading]
	<b>50 – Written synonym judgments</b>	<b>60 pairs of words (30 high imageability, 30 low imageability, matched for frequency) are presented for participants to judge whether each pair is close in meaning, marking them with a tick or cross</b>
	53 – Picture naming: reading aloud picture names	Participants read 40 items (20 regular, 20 exception words) aloud; note that pictures are not provided as stimuli. The stimuli set is the same as the items in the <i>Picture naming: reading aloud picture names</i> described above
Spoken naming	53 – spoken picture naming	Participants are shown 40 line-drawn objects and are required to name them aloud. The stimuli set is the same as the items in the <i>Picture naming: reading aloud picture names</i> and <i>Picture naming: written spelling assessments</i> described above

Bold = outcome measure assessments delivered at all four time points.

**Table 5.1:** PALPA diagnostic subtests

and T4 to monitor for signs of cognitive decline, in case this was a factor affecting training progress for individual participants.

#### *5.5.4 Outcome measure assessments testing compensation*

The three measures in this section were chosen to explore whether AT training compensates for writing and reading impairments and leads to improved performance in writing and/or reading activities (research question 1). They were delivered in both pen and paper and keyboard formats at T1 and T2, and in both pen and paper and keyboard with AT enabled at T3 and T4.

##### *5.5.4.a Writing*

###### *5.5.4.a.i Constrained writing task*

The rationale for use of this task is given in Chapter 3, section 3.3. The task was adapted from a similar assessment devised by Cauter and Woolf [115] for use in their single case study of emailing therapy using voice recognition software. The participant is given five minutes to compose an email to a friend, including a greeting and an ending and as much information as they can; they are warned when there is one minute remaining. If they have difficulty thinking of a topic, it is suggested that their email should arrange a meeting with the friend. Picture prompts are also available for this assessment but were not used in this study. At T1 and T2 participants completed this task once on paper and once with a keyboard; at T3 and T4 they completed the task once on paper and once with a keyboard with the two AT packages enabled.

Counts of tokens (total words) and types (total words minus repetitions) were then made, and the type-token ratio calculated in order to calculate lexical variety:  $\text{type divided by token multiplied by 100} = \text{percentage lexical variety}$ , where higher score indicates greater variety. Besides these calculations, five PhD students from the Division of Language and Communication Science at City University London conducted social validity judgements (SVJ), scoring each email for effectiveness, informativeness, grammaticality and comfort, each with a range = 1 – 10, where lower

scores indicate poorer performance. Where no writing was produced, zero scores were given. Any handwritten attempts made by the participants were first converted to typewritten format by the PhD candidate, with errors and strike-throughs included, before being given to the SVJ raters, in order to blind them to writing method (pen and paper/conventional keyboard/keyboard with AT); they were also blinded to time point. As in Caute and Woolf's study, scores were averaged across the raters before being analysed. The inter-rater reliability of such a scoring system, at least for informativeness and efficiency, has previously been demonstrated to be as high as 98% [223].

#### *5.5.4.a.ii CAT written picture description*

As described above, the whole language battery section of the CAT was administered at T1 as a screening assessment. In addition, the written picture description subtest was delivered at all four assessment time points as an outcome measure. In this task, the participant is given three minutes to write an account of what is happening in a picture, in as complete sentences as they are able. As above, at T1 and T2 participants completed this task once on paper and once with a keyboard; at T3 and T4 they completed the task once on paper and once with a keyboard with the two AT packages enabled.

#### *5.5.4b Reading*

##### *5.5.4.b.i Gray Oral Reading Test 4 (GORT-4)*

The GORT-4 [218] is a test of oral reading rate, accuracy, fluency and comprehension. It was selected owing to its reliability scores of greater than 90% for content sampling, test-retest and inter-rater testing, and further because it focuses purely on reading aloud rather than silent reading (unlike for example the Reading Comprehension Battery for Aphasia); this was felt to be important since it would offer a more transparent insight into the pace of participants' processing speed and accuracy. The GORT-4 is composed of two sets of 14 passages of text which become progressively longer and more complex, each passage followed by five comprehension questions. For each passage, the tester reads aloud a



brief summary, for example: 'This story is about a family. Read the story to find out what happens to them', then participants are required to read the text aloud as quickly and accurately as they can, and to answer five multiple choice questions about the text which result in a comprehension score of 0-5, where a higher score indicates superior performance. These questions are read aloud by the test administrator and may also be read from the page by the participant, who is not permitted to turn back to the original text. In the full version of the GORT-4, the tester also times how long each passage takes to read, converting this to a rate score ranging 0-10, where a higher number indicates a superior performance, and notes how many production errors occur, converting this to an accuracy score ranging 0-10, where a higher number indicates superior performance. The rate and accuracy scores are combined to achieve a fluency score, and testing continues until the participant has a fluency score of two out of 10 or less, and a comprehension score of two out of five or less, or until the end of the assessment is reached. Fluency scores were not measured for this study, since in the AT condition at T3 and T4 texts were read aloud by the software rather than participants. Therefore, testing continued until scores fell below comprehension cut off or the end of the assessment was reached.

The GORT-4 was originally designed for use with children and young adults aged between six years and 18 years 11 months. Reading tasks begin at a sufficiently simple level that individuals with relatively severe reading impairments can obtain a score. To facilitate repeated administration there are two sets of stories, A and B, each with a set of comprehension questions. For the purposes of this study, both sets of stories and both sets of multiple choice comprehension questions were typed into a Microsoft Word document in order that they could be delivered either on paper or on a laptop, with (at T3 and T4) or without (at T1 and T2) AT enabled. The A and B sets were alternated, whereby for example if a participant received set A as the paper version and set B as the computer version at T1, the opposite would be the case at T2.



### *5.5.5 Outcome measure assessments testing remediation*

*5.5.5.a. Writing: PALPA subtest 40 – imageability and frequency spelling;*

*Reading: PALPA subtest 50 – written synonym judgments*

One single word writing and one single word reading task from the PALPA were used as outcome measures to explore whether the software training had a remediatory effect. These were completed with pen and paper at all time points (see Table 5.1, page 88).

### *5.5.6 Group outcome measure assessments of social participation, quality of life and mood*

#### *5.5.6.a Social Network Analysis (SNA)*

Antonucci & Akiyama's [196] SNA diagram was designed to quantify the number of individuals in participants' networks, in three strata: innermost circle representing people to whom the subject is so close they find it hard to imagine life without them; middle circle for people whom the subject regards as not quite that close but still very important; outermost circle for people not yet mentioned but whom the subject feels sufficiently close to place them in their network. SNA gives a descriptive account of which sub-groups (friends, family, neighbours, work colleagues) are well or poorly represented and the frequency and nature of contact with each individual or sub-group in the network, and tracks whether this pattern changes over time (either individuals appearing in or vanishing from the network entirely, or moving from one circle to another). Overall scores can then be calculated to monitor significant change in the size of an individual's social network. An accessible version of the SNA diagram was developed for this study (Figure 5.2), and presented to participants with a written and verbal explanation of what the assessment entailed. Responses were written down by the student and diagrams of participants' social networks were subsequently created using pseudonyms for each of their contacts. The rationale for selection of this measure is given in section 4.3.3.b.

## Your Social Network

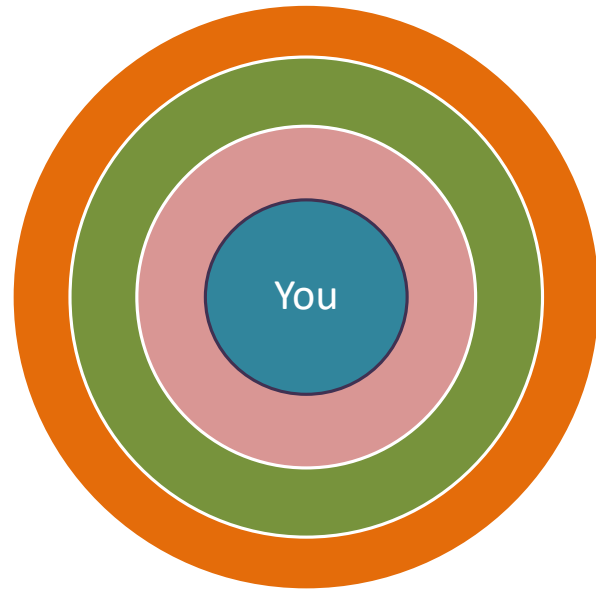
So close to it is **hard to imagine life without them**

Not quite that close but **still very important** to you

Not already mentioned but **close enough** to be in your network

For **each person**:

- Their **relationship** to you
- **How long** you have known them
- How **nearby** they live
- How **often** you see them or contact them
- How satisfied you are with frequency and nature of contact



**Figure 5.2:** Accessible social network diagram

### 5.5.6.b Stroke & Aphasia Quality of Life – 39 item version (SAQOL-39g)

The SAQOL-39g [224] was designed to assess health-related quality of life for people who have had a stroke and have aphasia. It is an interviewer-administered self-report measure with 39 items covering three domains: physical, psychosocial and communication. Participants rate their responses to 39 questions covering aspects of their quality of life over the past week on a five-point scale, such as ‘During the past week how much trouble did you have finding the word you wanted to say?’ where responses range from 1 = couldn’t do it at all to 5 = no trouble at all, or ‘During the past week did you go out less often than you would like?’, where responses range from 1 = definitely yes to 5 = definitely no. The SAQOL-39g takes approximately 15 minutes to administer and yields both domain scores and a total quality of life score, all of which range 1 - 5 and higher scores indicate greater quality of life. The instrument has good internal consistency ( $\alpha=.95$  overall score, .92-.95 domains), test-retest reliability (ICC=.96 overall, .92-.98 domains), convergent ( $r=.36-.70$  overall,

.47-.78 domains) and discriminant validity ( $r=.26$  overall,  $.03-.40$  domains). It also has good sensitivity to change ( $d=.35-.49$ ;  $SRM=.29-.53$  from two-weeks to six-months post-stroke). The SAQOL-39g was chosen for this project as it has excellent psychometric properties with people with aphasia and it seems to be the most commonly used quality of life measure with people with aphasia [225].

#### *5.5.6.c General Health Questionnaire 12 item version (GHQ-12)*

The GHQ-12 [210] is an abbreviated version of the complete GHQ which contains 60 items and is a self-administered screening instrument designed to detect high emotional distress. The GHQ was developed for use in general population surveys, in primary care settings or among general medical outpatients, and uses a time frame of 'the past few weeks.' As in the GHQ-60, the 12 item abbreviated version features four responses per question (better than usual/same as usual/less than usual/much less than usual) and is scored with a two point score which rates problems as absent or present (0-0-1-1). The cut off score for diagnosis of psychological ill-health using the GHQ-12 is 2-3 [226]. For this study, an aphasia-accessible version of the GHQ-12 was used, with enlarged font size, bold typeface, increased spacing and the inclusion of thumb up/down picture symbols. The questions were read aloud to participants by the student besides being presented in written form. The GHQ-12 takes approximately five minutes to administer. Score range = 0 – 12, with higher scores indicative of greater distress. The GHQ has test-retest reliability of 90%, inter-rater reliability of 96%, validity ranging between 76% and 81%, sensitivity of 93.5% and specificity of 78.5% [227], and is widely used with individuals are stroke and other populations with impairments [228], owing to the ease and speed with which it can be administered, hence its selection in the current study.

#### *5.5.7 Qualitative data*

To explore the barriers to AT use by PWA (RQ3) and investigate what strategies or supporting materials for using the software help overcome these barriers (RQ4), the following data were gathered. These data were

also used to augment and illustrate the outcome measure assessment data used to answer RQ1 and RQ2 above.

#### *5.5.7.a In-depth semi-structured interviews*

An interview topic guide was designed to ensure unbiased questioning for depth and breadth of information [197], [229], [230], [231]. Participants were interviewed immediately before the training program (T2), at the end of the program (T3), and at three month follow up (T4). Topic guides were based on outcome variables, covering computer use, writing, reading and social participation pre- and post-stroke (as described in the pilot study chapter above, and Appendices 4.1 and 4.2). The topic guide for T3 and T4 also included questions about the AT packages and the training program. Order of topics was flexible and topics were treated as guidelines rather than rigidly followed. Additional topics raised by participants were pursued if relevant, and incorporated into subsequent interviews with both that participant and others if appropriate. Interviews were audio-recorded and transcribed in full by the student.

#### *5.5.7.b Participant observation*

Detailed observation notes were made by the student researcher immediately following 80 of the 90 training sessions, including information on procedural successes and challenges, and on participant comments, demeanour and engagement. 58 of the sessions were also video-recorded using a compact camera and tripod focused on the computer screen, in order to capture writing and reading attempts in detail and in real time, including any editing that occurred. Dialogue was also captured by these recordings, which was reviewed as part of observation note-taking; salient exchanges were transcribed verbatim. Approximately 58 hours of observation video data was captured, and roughly one hour of note-taking and review occurred for each hour recorded.

### **5.6 Data analysis**

Descriptive statistics were used to summarise participant scores on the measures used. For RQ1 and RQ2 (RQ1. Does AT training compensate for

writing and reading impairments and lead to improved performance in writing and/or reading activities? Measured with the CAT written picture description, the constrained writing task and the GORT-4 reading comprehension test, and RQ2. Does training have an impact on social participation, mood or quality of life? Measured with SNA, GHQ-12 and SAQOL-39g respectively) Friedman's repeated measures non-parametric test was used owing to the small number of participants in the study. A beneficial effect of AT training would be demonstrated by improved scores on measures after training (T3 and T4) compared to baseline (T1 and T2). For assessments delivered in both pen and paper and keyboard formats (CAT, constrained writing, GORT-4), gains in keyboard format would point to a compensatory effect of AT. Two tests of single word writing and reading (PALPA subtests 40: imageability and frequency spelling, and 50: written synonym judgements), were also analysed using Friedman's test to check for evidence of gain over time, which would suggest that AT training had remediated, as well as compensated for, writing and reading impairments at the single word level. All quantitative analyses were performed with SPSS version 22.

For RQ3 and RQ4 (RQ3 What are the barriers to the use of AT by PWA?, and RQ4 What strategies or supporting materials for using AT help overcome these barriers?), qualitative analysis of video recording and observation notes during training sessions, and in-depth interview transcripts at T2, T3 and T4, was undertaken using Framework Analysis [212], as described in Chapter 4. Written and verbal comments pertaining to participants' own experiences of writing and reading impairment, and their perceptions of their social participation and quality of life, along with samples of completed writing tasks and examples of challenges faced during their production, were also used to complement and illustrate the quantitative analysis used to address RQ1 and RQ2. Qualitative data was organised and managed using NVivo 10 software package for Microsoft Windows. Case notes for two of the ten participants were independently reviewed by a speech and language therapist with expertise in qualitative

data analysis to check for agreement, completeness and unbiased reporting. These notes included transcripts of all three interviews, observation notes from all training sessions, the thematic index, completed matrices and a draft narrative synthesis of qualitative data.

### ***5.7 Summary***

Chapter 5 began by revisiting the research questions to be addressed by the study. The study design was then described, and inclusion criteria, recruitment procedure and information on ethics were given. The assessment and training protocols were described, before presenting detailed information on the screening, profiling, monitoring and outcome measures to be used in the study. Outcome measures were sub-categorised into those testing compensation for writing and reading deficits, those testing remediation of writing and reading skills, and those investigating social participation, quality of life and mood. This was followed by an overview of how qualitative data were to be gathered. The chapter ended with a breakdown of how the data collected for each of the research questions would be analysed.



## **Chapter 6: Participant characteristics and diagnostic profiles, the training intervention and individual training plans**

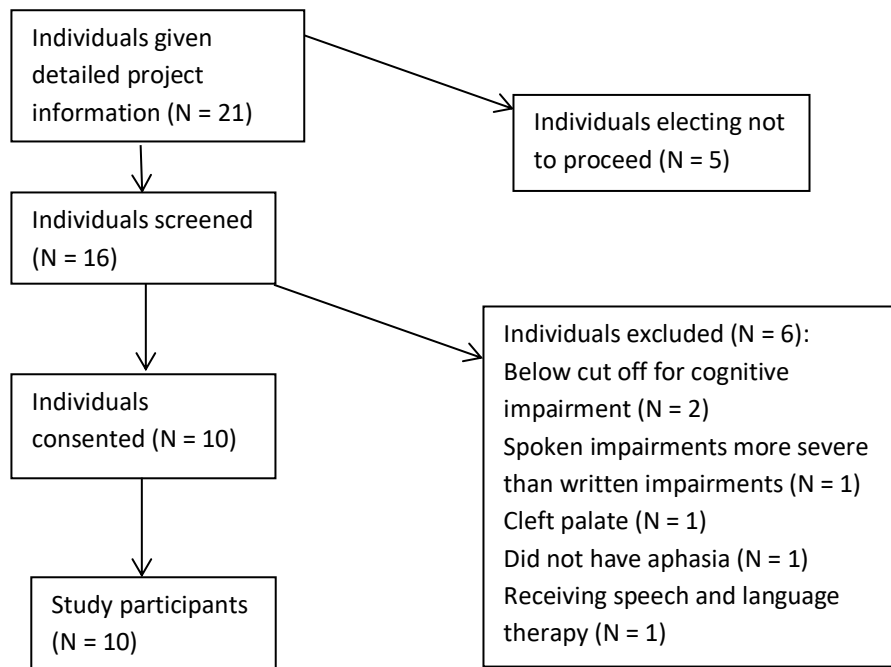
This chapter begins by describing the study participants, presenting a profile of the groups' collective pattern of skills and deficits, followed by a more in depth diagnostic case by case outline of each individual's impairments. These outlines include PALPA test scores, examples of errors made, and an account of conclusions drawn regarding each participant's dysgraphia and dyslexia diagnoses. A summary of each participant's prior employment, computer use and individual writing goals for the training sessions is then presented, based on information from the in-depth, semi structured interviews conducted at T2. The chapter moves on to give a detailed description of the training intervention, with reference to the TIDieR checklist [232]. Finally, some examples and training strategies are given to illustrate how the training program was customised according to individual participant requirements.

### ***6.1 Participants***

The aphasia team group recruitment slides were presented to 27 community groups for PWA after stroke; a total of 189 individuals were added to a potential participant database. Of these, 21 individuals discussed the current project further, either in person or by telephone. Five decided it would not suit their requirements; the remaining 16 were screened to take part. Six did not meet the inclusion criteria for the following reasons: two fell below the cut off for cognitive impairment, one had more severe spoken than written impairments, one showed no evidence of aphasia, one had a cleft palate and one was continuing to receive SLT. The remaining ten participated in the study (Figure 6.1).

#### ***6.1.1. Participant characteristics***

Table 6.1 displays participant characteristics. Four female and six male participants were recruited, with an age range of 44 - 75 years old at T1 (mean = 58.2 years, SD = 10.5 years). All were substantially beyond the inclusion criteria of six months post-onset (range = 23 months to 14 years,



**Figure 6.1:** Participant recruitment flowchart

mean = six years and two months, SD = three years and seven months). Eight had ischaemic strokes, two had haemorrhagic strokes; half of the group had hemiplegia. Three left education after GCSE/O levels, the remaining seven were university graduates (three with Bachelor degrees, two with Master degrees and two participants with PhDs). Three participants were already retired at the time of their stroke; a further two retired owing to ill-health. The remaining five had also left their former employment but two were working freelance/retraining and three volunteering.

## **6.2 Diagnostic assessment results**

### **6.2.1 Rationale for individual diagnostic assessment and reporting**

The empirical study adopted a group rather than case series design, and outcome measures were selected accordingly. Further, the study tested a compensatory rather than remedatory intervention. While these factors would usually preclude detailed individual diagnostic assessment, in the current study this was nevertheless merited, for three reasons. Firstly, in the event that differential diagnoses, for example surface versus deep dysgraphia, could account for degrees of change/no change in

performance, thus allowing candidacy criteria to be specified more accurately for a future study. Secondly, to examine whether any incidental remediation of spelling and/or narrative writing occurred as a result of compensatory training, and if so whether this was influenced by specific diagnoses or severity of deficit. Finally, diagnostic profiling would enable personalisation of the training intervention, for example by calling upon the processing strengths of certain individuals, and bypassing their known deficits.

The assessments used and procedures required are shown in Table 5.1 in the Methods chapter, and participant overall scores are given in Table 6.2. Participants are presented in the order that they were recruited, rather than according to any particular stroke-related variable. A total of 10 PALPA diagnostic assessments were conducted at T1: five of writing/spelling, four of reading, and one of spoken naming. Eight of these were only to be used diagnostically, while the remaining two were conducted at all four time points in order to monitor for any single word level remediatory effects of the software training.

### *6.2.2 A brief picture of diagnostic results across the group*

#### *6.2.2a Spoken naming*

This was the version of subtest 53 on which the highest scores were achieved: range = 77.5% - 100%. A superior performance here was predictable, owing to the stipulation in the inclusion criteria that participants should have fewer spoken than written deficits.

#### *6.2.2b Spelling*

Written naming scores ranged from 7.5% to 95%, indicating a very widely differentiated group with regard to writing impairment. It was clear from the full spelling test battery that Peter was the most severely impaired by a considerable margin, while Albert had the fewest deficits. Figure 6.2 shows individual participant baseline scores on the single word spelling to dictation measure, PALPA subtest 40.

	Gender	Age at T1	Project start date	Months post-onset at T1	Stroke type	Hemiplegia	Highest educational qualification	Occupation pre-onset	Employment status	Training site	Training sessions received
1 'Peter'	M	74	3/14	10 years 3 months	Ischaemic	N	Master degree	Lecturer/trainer specialising in dyslexia	Retired pre-onset	University	10
2 'Rohan'	M	64	2/14	3 years 0 months (approximately)	Ischaemic	Y	Doctorate	Computer Science lecturer	Retired ill health	Home	8
3 'Sarah'	F	61	3/14	14 years 0 months	Ischaemic	Y	Master degree	Secondary school English and history teacher	Retired; full-time parent for ten years pre-onset	Home	10
4 'Karen'	F	49	3/14	5 years 0 months	Ischaemic	N	GCE 'O' levels	Secondary school secretary and Personal Assistant	Retired ill health; retraining	University	8
5 'Albert'	M	75	3/14	4 years 10 months	Ischaemic	N	Doctorate	Marketing for banking (co-authored retail banking textbook), pharmacology background	Retired pre-onset	University	9

6 'Dean'	M	44	7/14	1 year 11 months	Ischaemic	Y	GCE 'O' levels	Hotel locksmith	Retired ill health, volunteering	University	10
7 'William'	M	52	9/14	7 years 2 months	Ischaemic	N	Bachelor degree	Journalist for international news agency	Retired ill health; volunteering	University	9
8 'Janet'	F	55	12/14	6 years 0 months (approx)	Ischaemic	N	Bachelor degree	Fashion designer	Retired ill health; freelance	Home	9
9 'Doreen'	F	49	1/15	3 years 2 months	Haemorrhagic	Y	Bachelor degree	Substance misuse worker on Youth Offending Team	Retired ill health	Home	10
10 'Simon'	M	59	3/15	3 years 8 months	Haemorrhagic	Y	GCE 'O' levels	Quantity surveyor, co-owner of own business	Retired ill health, volunteering	Home	7

**Table 6.1:** Participant characteristics

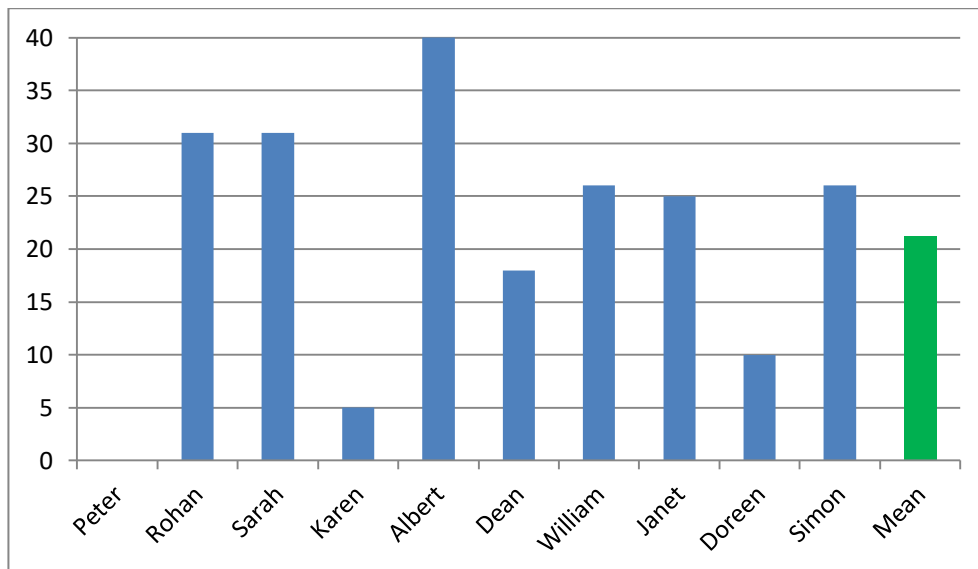
	Assessment	Number of items	Peter	Rohan	Sarah	Karen	Albert	Dean	William	Janet	Doreen	Simon
Spelling	<b>40 Imageability and frequency spelling</b>	<b>40</b>	<b>0 (0%)</b>	<b>31 (77.5%)</b>	<b>31 (77.5%)</b>	<b>5* (12.5%)</b>	<b>40 (100%)</b>	<b>18* (45%)</b>	<b>26 (65%)</b>	<b>25 (62.5%)</b>	<b>10 (25%)</b>	<b>26 (65%)</b>
	41 Grammatical class spelling	20	0 (0%)	17 (85%)	17 (85%)	9 (45%)	18 (90%)	10 (50%)	13 (65%)	Declined	7 (35%)	17 (85%)
	42 Grammatical class spelling (controlling for imageability)	20	0 (0%)	16 (80%)	16 (80%)	7 (35%)	20 (100%)	7 (35%)	12 (60%)	14 (70%)	0 (0%)	14 (70%)
	45 Nonword spelling	24	1 (2.2%)	6 (25%)	5 (20.8%)	5 (20.8%)	18 (75%)	3 (12.5%)	3 (12.5%)	0** (0%)	0 (0%)	13 (54.2%)
	53 Picture naming: written spelling	40	3 (7.5%)	30 (75%)	37 (92.5%)	14 (35%)	38 (95%)	29 (68.9%)	37 (92.5%)	35 (87.5%)	19 (47.5%)	36 (90%)
Reading	24 Visual lexical decision with 'illegal' nonwords	60	56 (91.7%)	60 (100%)	60 (100%)	60 (100%)	60 (100%)	57 (95%)	60 (100%)	60 (100%)	60 (100%)	60 (100%)
	43 Lexical morphology and reading	60	16 (26.7%)	57 (95%)	59 (98.3%)	60 (100%)	60 (100%)	59 (98.3%)	48 (80%)	57 (95%)	17 (28.3%)	60 (100%)
	<b>50 Written synonym judgments</b>	<b>60</b>	<b>49 (81.7%)</b>	<b>52 (86.7%)</b>	<b>56 (93.3%)</b>	<b>57 (95%)</b>	<b>60 (100%)</b>	<b>41* (68.3%)</b>	<b>57 (95%)</b>	<b>56 (93.3%)</b>	<b>41 (68.3%)</b>	<b>59 (98.3%)</b>
	53 Picture naming: reading aloud picture names	40	33 (82.5%)	40 (100%)	40 (100%)	40 (100%)	40 (100%)	39 (97.5%)	40 (100%)	39 (97.5%)	27 (67.5%)	39 (97.5%)
Spoken naming	53 spoken picture naming	40	37 (92.5%)	34 (85%)	39 (97.5%)	40 (100%)	40 (100%)	40 (100%)	38 (95%)	40 (100%)	31 (77.5%)	39 (97.5%)

**Table 6.2:** Participant PALPA scores

\*Declined at T1 therefore score at T2 (repeated baseline) reported here

\*\*First four items attempted inaccurately; test discontinued owing to distress

Bold: outcome measures, administered at all four time points



**Figure 6.2:** Individual single word total correct spellings on PALPA subtest 40 at baseline

Notably, two participants, Albert and Simon, performed markedly better than the rest of the group for non-word spelling, achieving 90% and 65% respectively, while the range for the other eight = 0% to 30%. A more detailed examination of each individual's patterns of spelling deficit is given in section 6.2.3, in each case making reference to the cognitive neuropsychological model of language processing described in Chapter 1 (Figure 1.1, page 26). In this study, phonological dysgraphia and deep dysgraphia are conceptualised as part of a spectrum rather than as two discrete disorders, after Jefferies, Sage & Lambon Ralph [24].

### 6.2.2c Reading

As a group, the participants' single word reading was comparatively less impaired than their writing, with five showing either no sign of deficit or only slight, non-specific indications. None of the group found it difficult to distinguish between real and non-words, and only two (Peter: 91.7% and Dean: 95%) did not achieve a ceiling score on this test. Most also scored highly on the lexical morphology reading task, achieving scores of 95% or more, with the exceptions of William (80%) and, more dramatically, Peter (26.7%) and Doreen (28.3%). Peter and Doreen also found reading object names aloud more challenging than the rest of the group, scoring 82.5% and 67.5% respectively (while the other eight scored either 97.5% or 100%).

The range of scores on the synonym judgement task was = 68.3% to 100%; here the lowest scores were again recorded by Doreen and Dean. Doreen had more severely impaired reading than the rest of the group, with Peter, William and Dean also experiencing difficulties in some areas, and Rohan showing some mild semantic impairments. Individual baseline scores on the single word reading outcome measure, PALPA subtest 50, are shown in Figure 6.3.

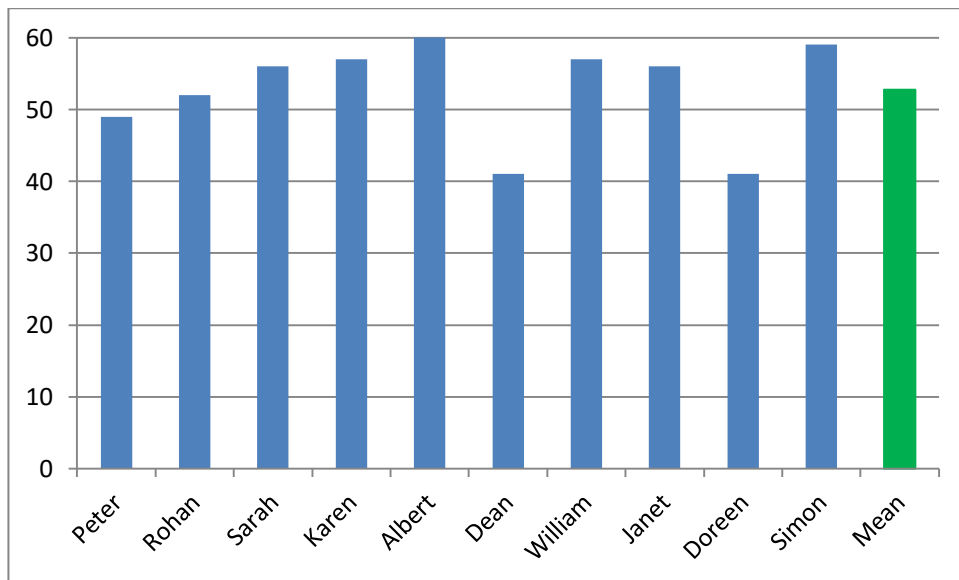
As with spelling, a more detailed examination of each individual's patterns of reading deficit is given below, again with reference to the cognitive neuropsychological model of language processing (Chapter 1).

### *6.2.3 Case by case diagnostic information*

#### *6.2.3a Participant 1: Peter*

Subtest 53 indicated a very marked discrepancy between Peter's spoken and written picture naming ability (92.5% versus 7.5%). In the former, of the three errors he made, two were lexically related to the targets ('ancient' for 'anchor' and 'lady' for 'ladder') while the third was phonologically related ('chew' for 'shoe'). In the written version he could spell only 'glove', 'eye' and 'dog' correctly. Since the first two of these items are irregular, he was likely to have been spelling via the lexical rather than the phonological route for at least two of these items. Peter's single word spelling to dictation was even more impaired than his written object naming: he was able to produce one correct three letter non-word on subtest 45, and no correct targets in any assessment of real word spelling, indicating he was unable to spell to dictation via the lexical route. Peter often attempted to use phoneme to grapheme conversion by sounding out segments orally. Unfortunately this routine was also unsound, as he usually either produced an incorrect phoneme, or mistranslated a correct one orthographically. He occasionally demonstrated some awareness of missing phonemes, inserting question marks to indicate these, for example 'wh?m' for 'whom', 'id?' for 'idea.' His errors were sometimes recognisable attempts at the target with minor omissions ('otside' for 'outside', 'blef' for





**Figure 6.3:** Individual single word total correct judgements on PALPA subtest 50 at baseline

‘belief’) but were more often unrecognisable, such as ‘thacn’ for ‘situation’ or ‘kth’ for feather.’

Peter effectively had no functional spelling mechanism available to him even at single word level, since all of his spelling routes were severely impaired, consistent with a diagnosis of deep dysgraphia.

Peter obtained the lowest score of all the participants on reading subtest 24 (discerning non words from real ones) and was one of only two participants (with Dean) who did not perform at ceiling on this task. Nevertheless, he scored 93.3%; his errors were four false negatives (‘sieve’, ‘clip’, ‘dread’ and ‘prune’). Peter was able to correctly read 82.5% of subtest 53 picture names correctly, with no significant regularity effect. However he showed a significant imageability effect:  $\chi^2 (1) = 5.46, p = .021$  on synonym judgement subtest 50, suggesting access to his semantic knowledge of more abstract lexical items may be impaired. His poor score (26.7%) on subtest 43, where targets with morphological endings were significantly more difficult for him than control words that were not inflected:  $\chi^2 (1) = 6.65, p = .010$ , and were simply not attempted, was further suggestive of a degree of semantic impairment. Despite this,

	Assessment	Total score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	0/40 (0%)	HIHF HILF LIHF LILF	0 0 0 0
	41 Grammatical class spelling	0/20 (0%)	Nouns Adjectives Verbs Functors	0 0 0 0
	42 Grammatical class spelling (controlling for imageability)	0/20 (0%)	Nouns Functors	0 0
	45 Non-word spelling	1/24 (2.2%)	3 letter 4 letter 5 letter 6 letter	1 0 0 0
	53 Picture naming: written spelling	3/40 (7.5%)	Regular Exception	1 2
Reading	24 Visual lexical decision with 'illegal' non-words	55/60 (91.7%)	N/A	55 (4 false negative, 1 false positive)
	43 Lexical morphology and reading	16/60 (26.7%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	1 1 1 5 3 5
	50 Written synonym judgments	49/60 (81.7%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	14 12 13 10
	53 Picture naming: reading aloud picture names	33/40 (82.5%)	Regular Exception	18 15
Spoken naming	53 spoken picture naming	37/40 (92.5%)		

**Table 6.3:** PALPA scores: Peter

Peter's reading was clearly relatively spared by comparison with his severe dysgraphia.

#### 6.2.3b Participant 2: Rohan

Rohan was able to name more objects correctly in the spoken version of subtest 53 (85%) than in the written version (75%); there was no significant effect of regularity in the written version of the test. His non-word spelling

	Assessment	Total score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	31/40 (77.5%)	HIHF HILF LIHF LILF	9 8 8 7
	41 Grammatical class spelling	17/20 (85%)	Nouns Adjectives Verbs Functors	5 3 5 4
	42 Grammatical class spelling (controlling for imageability)	16/20 (80%)	Nouns Functors	7 9
	45 Non-word spelling	6/24 (25%)	3 letter 4 letter 5 letter 6 letter	3 1 1 1
	53 Picture naming: written spelling	30/40 (75%)	Regular Exception	15 15
Reading	24 Visual lexical decision with 'illegal' non-words	60/60 (100%)	N/A	60
	43 Lexical morphology and reading	57/60 (95%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	9 10 10 9 9 9
	50 Written synonym judgments	52/60 (86.7%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	14 14 13 11
	53 Picture naming: reading aloud picture names	40/40 (100%)	Regular Exception	20 20
Spoken naming	53 spoken picture naming	34/40 (85%)		

**Table 6.4:** PALPA scores: Rohan

was poor (25%), particularly of longer items (Chi Square test was not performed on the scores of this subtest owing to the small number of items). Since there are no lexical representations for non-word items, plausible attempts to spell these can only be produced via phoneme to grapheme conversion; Rohan's performance therefore suggested that this

mechanism was impaired. His real word spelling was much more intact, with scores of 77.5%, 85% and 80% respectively on subtests 40, 41 and 42, suggesting he was able to access these items by the lexical route. He sometimes made letter substitutions or omissions, such as writing 'weet' for 'wheat' and 'moun-ton' for 'mountain'; he also sometimes struggled with double consonants ('sattire' for 'satire', 'tobbco' for 'tobacco', 'vallour' for 'valour'). These errors were consistently recognisable attempts at the targets, and there were no significant frequency/imageability effects on subtest 40, and no observable word class effects on subtests 41 and 42 (item count insufficient to perform Chi Square tests). The pattern of preserved spelling skills and deficits Rohan exhibited was suggestive of a relatively pure form of phonological dysgraphia.

Turning to reading, Rohan was able to discern all 60 word/non-word items accurately in lexical decision, and read all picture names in subtest 53 aloud with 100% accuracy. His performance in subtest 43 was also largely intact, with 95% correct and three minor lexical errors (two control items: 'buffet' for 'butter' and 'prawn' for 'pram', one regularly inflected: 'pale' for 'pays'). His synonym judgement was slightly more impaired, with a score of 86.7% reflecting three high imageability and five low imageability errors. His reading assessments indicated Rohan's single word reading was largely intact, perhaps with some mild semantic impairment.

#### *6.2.3c Participant 3: Sarah*

Sarah performed well on both written and spoken versions of subtest 53, scoring 97.5% for spoken and 92% for written naming, with no significant regularity effect in the written version. Her non-word spelling was notably poorer (20.8%) than her real word writing to dictation (77.5%, 85% and 80%). Real word errors were not significantly affected by imageability/word class and were typically recognisable attempts at the target, such as 'youself' for 'yourself', 'therey' for 'theory' (although 'befeth' for 'belief'). This pattern suggested that like Rohan, Sarah had relatively spared access to spelling via the lexical route, with mild phonological dysgraphia.

	Assessment	Total score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	31 (77.5%)	HIHF HILF LIHF LILF	8 8 8 7
	41 Grammatical class spelling	17 (85%)	Nouns Adjectives Verbs Functors	3 5 4 5
	42 Grammatical class spelling (controlling for imageability)	16 (80%)	Nouns Functors	8 8
	45 Non-word spelling	5 (20.8%)	3 letter 4 letter 5 letter 6 letter	2 0 3 0
	53 Picture naming: written spelling	37 (92.5%)	Regular Exception	19 18
Reading	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	59 (98.3%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	10 10 10 9 10 10
	50 Written synonym judgments	56 (93.3%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	14 12 15 15
	53 Picture naming: reading aloud picture names	40 (100%)	Regular Exception	20 20
Spoken naming	53 spoken picture naming	39 (97.5%)		

**Table 6.5:** PALPA scores: Sarah

In the reading assessments, Sarah had no difficulty distinguishing between real and non- words, scoring 100% on subtest 24, and achieved the maximum score for reading object names aloud (subtest 53). In subtest 43 Sarah mispronounced only one control item, and in her subtest 50 results

there were four false negatives (one highly imageable, three low). She had only slightly impaired reading at the single word level.

#### *6.2.3d Participant 4: Karen*

On subtest 53, Karen achieved 100% spoken picture naming accuracy compared to only 35% of written targets; there was no observable regularity effect. She found non-word spelling to dictation challenging, with a score of 20.8% and diminishing accuracy with greater word length. She also found real word writing to dictation difficult, with scores of 12.5%, 45% and 35% on subtests 40, 41 and 42 respectively. Though not specifically examined by these subtests, a length effect was also evident in the real word assessments. Notably, Karen's difficulties with spelling and writing appeared to be qualitatively different to those of the rest of the group. She often traced the shape of a grapheme in the air, and replicating it on the page required great concentration and effort. Her attempts at targets appeared to be made easier when she had already used a grapheme elsewhere, and could therefore copy it. The length effect in her written spelling appeared to be primarily related to the fact that she was able to judge word length to dictation, and therefore make a decision about which words would be very arduous to attempt orthographically – she refused these items and drew lines to indicate missing words, sometimes having provided the first grapheme. For example, in subtest 40, other than the very first item 'length', the only targets Karen attempted were four letter words ('idea', 'clue', 'pill', 'hand'). As will be discussed later in relation to tests of narrative writing, Karen is, by contrast, very able to spell using a keyboard, touch-typing paragraphs with little difficulty and great speed. It appeared therefore that she had a form of peripheral dysgraphia involving the late stages of the cognitive neuropsychological model of written output: allographic realisation and/or graphic motor planning.

Karen achieved ceiling scores for all reading assessments except synonym judgement, where she had three false negative items (one high

	Assessment	Total score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	5 (12.5%)	HIHF HILF LIHF LILF	1 1 2 1
	41 Grammatical class spelling	9 (45%)	Nouns Adjectives Verbs Functors	3 2 2 2
	42 Grammatical class spelling (controlling for imageability)	7 (35%)	Nouns Functors	4 3
	45 Non-word spelling	5 (20.8%)	3 letter 4 letter 5 letter 6 letter	4 0 1 0
	53 Picture naming: written spelling	14 (35%)	Regular Exception	7 7
Reading	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	60 (100%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	10 10 10 10 10 10
	50 Written synonym judgments	57 (95%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	14 13 15 15
	53 Picture naming: reading aloud picture names	40 (100%)	Regular Exception	20 20
Spoken naming	53 spoken picture naming	40 (100%)		

**Table 6.6:** PALPA scores: Karen

imageability, two low); nevertheless, she scored 95%. Karen exhibited only a very mild reading impairment at the single word level.

### 6.2.3e Participant 5: Albert

	Assessment	Total score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	40 (100%)	HIHF HILF LIHF LILF	10 10 10 10
	41 Grammatical class spelling	18 (90%)	Nouns Adjectives Verbs Functors	5 5 4 4
	42 Grammatical class spelling (controlling for imageability)	20 (100%)	Nouns Functors	10 10
	45 Non-word spelling	18 (75%)	3 letter 4 letter 5 letter 6 letter	5 4 6 3
	53 Picture naming: written spelling	38 (95%)	Regular Exception	19 19
Reading	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	60 (100%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	10 10 10 10 10 10
	50 Written synonym judgments	60 (100%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	15 15 15 15
	53 Picture naming: reading aloud picture names	40 (100%)	Regular Exception	20 20
Spoken naming	53 spoken picture naming	40 (100%)		

**Table 6.7:** PALPA scores: Albert

Albert scored 100% for spoken picture naming, and 95% for the written version of this subtest. His written errors were one letter addition, writing 'star' as 'start' and one exception word, 'shoe' was erroneously written as the semantically related (and slightly misspelled) 'plimsole.' Albert's single



word level writing impairments were generally mild compared to the rest of the group. He scored 100% on subtests 40 and 42, and 90% on subtest 41, with one verb and one functor error perhaps suggestive that items with lower imageability were occasionally more challenging for him. His spelling of non-words to dictation was poorer than his real word performance, with scores of 75% for non-words, compared to 100%, 90% and 100% in subtests 40, 41 and 42; this discrepancy was indicative of a mild degree of phonological dysgraphia.

Albert scored 100% in all four reading subtests and showed no sign of any impairment at the single word reading level.

### *6.2.3f Participant 6: Dean*

Dean's spoken picture naming on subtest 53 was at ceiling, while on the written version he scored 68.9%; there was no significant effect of regularity. His errors were usually letter omissions ('bred' for 'bread', 'ancor' for 'anchor'), with occasional difficulty with word endings ('onine' for onion', 'mounting' for 'mountain', 'sissian' for 'scissors'). Dean found non-word spelling difficult, and could only produce two three-letter and one four-letter target accurately (12.5%), suggesting damage to his phoneme to grapheme conversion mechanism. Dean was more able to spell real words to dictation. His scores on subtest 40 suggested some influence of frequency and imageability, though neither reached significance. Though he had never received a pre-morbid diagnosis, Dean reported that he had always found spelling challenging, and it is possible some of his deficits pre-date his stroke. He appeared to have a degree of difficulty with semantic representations, suggesting his dysgraphia should be placed on the phonological-deep continuum. In the reading subtests, Dean was one of only two participants (with Peter) not to achieve a ceiling score when asked to recognise real or non-words, though he still attained 95%. The false negative items he identified were 'prune', 'sieve' and 'mist.' He made syntactically related errors with one exception word on subtest 53 ('glasses' for 'glass'), and one

	Assessment	Total score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	18 (45%)	HIHF HILF LIHF LILF	8 3 4 3
	41 Grammatical class spelling	10 (50%)	Nouns Adjectives Verbs Functors	2 3 4 1
	42 Grammatical class spelling (controlling for imageability)	7 (35%)	Nouns Functors	1 6
	45 Non-word spelling	3 (12.5%)	3 letter 4 letter 5 letter 6 letter	2 1 0 0
	53 Picture naming: written spelling	29 (68.9%)	Regular Exception	15 14
Reading	24 Visual lexical decision with 'illegal' non-words	57 (95%)	N/A	57 (three false negatives)
	43 Lexical morphology and reading	59 (98.3%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	10 10 9 10 10 10
	50 Written synonym judgments	41 (68.3%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	11 7 14 9
	53 Picture naming: reading aloud picture names	39 (97.5%)	Regular Exception	20 19
Spoken naming	53 spoken picture naming	40 (100%)		

**Table 6.9:** PALPA scores: Dean

(‘sold’ for ‘solid’) on subtest 43. Dean’s synonym judgements were poor (68.3%), with a marked, significant effect for imageability:  $\chi^2 (1) = 6.24$ ,  $p = .013$ . Again, it is possible that Dean had some degree of undiagnosed

dyslexia prior to his stroke, and at T1 appears to be on the phonological-deep dyslexia continuum.

### *6.2.3g Participant 7: William*

Comparisons of William's spoken and written picture naming scores on subtest 53 indicated no marked difference in impairment and that both skills were relatively intact (92.5% and 95% respectively). That his written picture naming was strong, even for irregular items such as 'yacht' or 'anchor', suggested his written lexical (and semantic) representations for these concrete objects are not damaged. His real word spelling to dictation performance was superior to non-word spelling (subtest 40: 65%, subtest 41: 65%, subtest 42: 60%), though less intact than his written object naming. Chi square analysis of subtest 40 indicated no significant effect of frequency ( $\chi^2 (1) = .44, p = .37$ ) but a significant imageability effect ( $\chi^2 (1) = 7.03, p = .009$ ). William's spelling to dictation errors are typically recognisable attempts at the target with minor substitutions or omissions (e.g. 'selbom' for 'seldom', 'medoth' for 'method', 'upwald' for 'upward'). It therefore appears that he is spelling via the lexical route, perhaps with some additional minor orthographic buffer involvement compromising exact retrieval. By contrast, the most striking aspect of William's assessment results was that he finds spelling non words extremely difficult (subtest 45: 12.5%). As noted above, plausible attempts at non-words can only be produced via the phonological route; William's scores, coupled with his superior performance with real word targets, suggest a diagnosis of phonological dysgraphia, with elements of deep dysgraphia.

In the reading assessments, William had no difficulty distinguishing between real and non-words, scoring 100% on subtest 24. Likewise, he achieved the maximum score for reading object names aloud (subtest 53). His synonym judgement was also mostly accurate (95%, with two false negatives – one high, one low imageability – and one low imageability false positive). His performance on subtest 43 was somewhat less confident, with a score of 80%, mechanism is impaired, though he did not perform significantly better

	Assessment	Score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	26 (65%)	HIHF HILF LIHF LILF	9 8 5 4
	41 Grammatical class spelling	13 (65%)	Nouns Adjectives Verbs Functors	3 4 3 3
	42 Grammatical class spelling (controlling for imageability)	12 (60%)	Nouns Functors	4 8
	45 Non-word spelling	3 (12.5%)	3 letter 4 letter 5 letter 6 letter	1 1 0 1
	53 Picture naming: written spelling	37 (92.5%)	Regular Exception	19 18
Reading	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	48 (80%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	7 7 8 9 9 8
	50 Written synonym judgments	57 (95%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	14 14 15 14
	53 Picture naming: reading aloud picture names	40 (100%)	Regular Exception	2020
Spoken naming	53 spoken picture naming	38 (95%)		

**Table 6.9:** PALPA scores: William

on control items than test items. These results suggest William's single word reading is broadly intact.

### 6.2.3h Participant 8: Janet

Janet's spoken object naming was at ceiling, while in the written version of subtest 53 she scored 87.5%; regularity had no significant effect on her

	Assessment	Score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	25 (62.5%)	HIHF HILF LIHF LILF	9 8 2 6
	41 Grammatical class spelling	Declined	Nouns Adjectives Verbs Functors	Declined
	42 Grammatical class spelling (controlling for imageability)	14 (70%)	Nouns Functors	6 8
	45 Non-word spelling	0 (0%)	3 letter 4 letter 5 letter 6 letter	0/4 Then declined
	53 Picture naming: written spelling	35 (87.5%)	Regular Exception	18 17
Reading	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	57 (95%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	8 9 10 10 10 10
	50 Written synonym judgments	56 (93.3%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	14 14 15 14
	53 Picture naming: reading aloud picture names	39 (97.5%)	Regular Exception	20 19
Spoken naming	53 spoken picture naming	40 (100%)		

**Table 6.10:** PALPA scores: Janet

performance. She found non word spelling very difficult and distressing and abandoned the assessment after four incorrect attempts at three-letter items. Like William, this suggested Janet's phoneme to grapheme conversion mechanism is impaired. However, she appeared to attempt to use this route during all of the spelling assessments, predominantly by

producing the first phoneme of a word as a cue - sometimes with her hand to her lips as if to note the shape of the sound – and then retrieving the rest of each item lexically. Janet's real word writing to dictation was relatively sound (scores of 62.5% in subtest 40 and 70% in subtest 42; she declined subtest 41 owing to fatigue), though it was sometimes characterised by several rapid attempts at the target which she immediately recognised to be inaccurate and struck through. On subtest 40, a frequency effect was not significant:  $\chi^2 (1) = 1.76, p = .160$ ), but an imageability effect was:  $\chi^2 (1) = 10.99, p = .001$ . Janet's assessments indicated that her access to the lexical spelling route was fairly intact, but that she was on the phonological-deep dysgraphia continuum.

In the reading assessments, Janet was 100% able to differentiate between words and non-words, and read 97.5% of object names correctly – she made a single semantic error, substituting 'clock' for 'watch.' She made three errors with morphological endings, but scored 95% on subtest 43, and 93.3% on subtest 50, mistakenly identifying two false negative synonyms (one high, one low imageability) and one low imageability false positive. Janet showed only very mildly impaired reading at the single word level.

#### *6.2.3i Participant 9: Doreen*

Doreen performed better with spoken than written targets on the object naming subtest (77.5% versus 47.5%); nevertheless her spoken object naming score was the lowest in the group, reflecting her tendency towards anomia. The remaining spelling assessments indicated Doreen had severe difficulties with writing to dictation, possibly owing to impaired processing of auditory input, as evidenced by her poor performance in the keyboard plus AT version of the GORT-4 reading comprehension task (see Chapter 9). She was unable to produce any plausible attempts at non-words, suggesting major damage to her phoneme to grapheme conversion route. She was able to accurately produce some complete items lexically in other assessments, with no apparent length effect (e.g. 'mother', 'hospital',

	Assessment	Score	Accuracy by variable	
<b>Spelling</b>	40 Imageability and frequency spelling	10 (25%)	HIHF HILF LIHF LILF	5 5 0 0
	41 Grammatical class spelling	7 (35%)	Nouns Adjectives Verbs Functors	1 2 2 2
	42 Grammatical class spelling (controlling for imageability)	0 (0%)	Nouns Functors	0 0
	45 Non-word spelling	0 (0%)	3 letter 4 letter 5 letter 6 letter	0 0 0 0
	53 Picture naming: written spelling	19 (47.5%)	Regular Exception	11 8
<b>Reading</b>	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	17 (28.3%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. cont	2 3 1 3 3 5
	50 Written synonym judgments	41 (68.3%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	12 9 12 8
	53 Picture naming: reading aloud picture names	27 (67.5%)	Regular Exception	15 12
<b>Spoken naming</b>	53 spoken picture naming	31 (77.5%)		

**Table 6.11:** PALPA scores: Doreen

'school', 'elephant') but more often left a blank space or could retrieve only the initial letter of a word. In subtest 40 she scored 25%; half of the ten correct items were high and half low frequency, but all ten targets were highly imageable. This suggests her semantic representations for abstract lexical items were compromised, while she was sometimes able to rely on semantic knowledge to help her retrieve concrete lexical items. However in subtest 42 she scored 0%. On subtest 41 she correctly spelled a single target noun, and two each of the other three word classes (adjectives,

verbs, functors). These two subtests suggested Doreen was unable to systematically rely on semantic representations even for concrete lexical items. This pattern of deficits in both phoneme to grapheme conversion and semantic processing is typical of deep dysgraphia.

Doreen had no difficulty distinguishing between words and non-words, scoring 100% on reading subtest 24. However, further tests revealed she also had marked reading impairments. At 67.5% her subtest 53 score for reading object names aloud was the lowest of the ten participants; there was no significant regularity effect. She scored 68.3% on subtest 50 of synonym judgement, performing significantly better with highly imageable pairs ( $\chi^2 (1) = 3.77, p = .047$ ) as might be expected given the pattern of semantic deficit described above. Doreen had great difficulty with subtest 43, scoring 28.3%, with no significant advantage for control rather than inflected test items, and made a number of semantically related errors on this task such as 'iron' for 'curling', 'silver' for 'sterling', 'shark' for 'jaw', 'purchase' for 'sold.' Doreen had deep dyslexia. This was compounded by her difficulties with retrieving items from the phonological output lexicon both for reading aloud and spoken object naming.

#### *6.2.3j Participant 10: Simon*

Simon was able to produce correct targets reliably in the spoken picture naming test (97.5%). He also performed well in the written version of the subtest, scoring 90%, and three of the four errors he made with exception targets indicated some residual awareness of their irregularity: 'combe' for 'comb', 'sissors' for 'scissors' and 'yoct' for 'yacht.' With 54.2%, Simon achieved the second highest non-word spelling score in the group (only Albert scored more, and the remaining eight participants scored 30% or less). This comparatively high score suggested Simon was able to exploit the phoneme to grapheme conversion route with some success. He also scored well on real word assessments, with no significant imageability or frequency effects on subtest 40 and none for word class on subtests 41 and 42. Simon's patterns of deficit were indicative of a diagnosis of relatively mild and undifferentiated dysgraphia.



	Assessment	Score	Accuracy by variable	
Spelling	40 Imageability and frequency spelling	26 (65%)	HIHF HILF LIHF LILF	9 6 5 6
	41 Grammatical class spelling	17 (85%)	Nouns Adjectives Verbs Functors	4 4 5 4
	42 Grammatical class spelling (controlling for imageability)	14 (70%)	Nouns Functors	8 6
	45 Non-word spelling	13 (54.2%)	3 letter 4 letter 5 letter 6 letter	5 3 2 3
	53 Picture naming: written spelling	36 (90%)	Regular Exception	20 16
Reading	24 Visual lexical decision with 'illegal' non-words	60 (100%)	N/A	60
	43 Lexical morphology and reading	60 (100%)	Reg. inflection Derived Irreg. inf. Reg. control Der. control Irreg. control	10 10 10 10 10 10 10 10
	50 Written synonym judgments	59 (98.3%)	Synonym HI Synonym LI Non-syn HI Non-syn LI	15 14 15 15
	53 Picture naming: reading aloud picture names	39 (97.5%)	Regular Exception	20 19
Spoken naming	53 spoken picture naming	39 (97.5%)		

**Table 6.12:** PALPA scores: Simon

Simon's reading assessment scores were all high: 100% accuracy for real/non-word identification and reading morphological endings, 98.3% for synonym judgement and 97.5% for reading picture names aloud; he did not appear to warrant a dyslexia diagnosis at the single word level.

### ***6.3 Participants' pre-stroke computer use and training plans***

**Peter** reached retirement age and left his post as a higher education lecturer and trainer less than two weeks before his stroke. A mathematician, he taught computer skills, originally to a range of trainee Allied Health Professionals and later specifically to students with dyslexia. He lived with his wife and had three adult children, none of whom lived locally; one was overseas in a different time zone. He reported speaking to them on the telephone occasionally, but said this was not straightforward owing to scheduling and expense. Prior to his stroke Peter used a computer for writing documents at work, but as his stroke pre-dated his interest in email he had little experience of using it. However he was highly motivated to learn to do so independently, as a means of maintaining contact with his family and friends, and this was his primary training goal. Peter was the most severely dysgraphic participant in the study: he found it extremely difficult to spell even short, simple words, and had very little functional writing with either pen and paper or keyboard.

**Rohan** lived alone. Prior to his stroke he had used computers a great deal, but he retired from his job as a lecturer in computer programming due to ill-health at the time of his stroke, subsequent to which he spent 18 months in residential care. He was now living independently with the support of twice daily visits from a care agency. Unlike most of the other participants, Rohan found it challenging to pinpoint specific writing plans he wanted to fulfil and was not able to set training goals. He explained that the main reason for his involvement was his desire to support a PhD project, as he could recall the challenges of collecting data for his own doctorate degree many years before. Rohan wrote with his non-dominant hand, and found it difficult to grip a pen or use a computer mouse owing to generalised motor weakness. His single word spelling was relatively intact but he found narrative writing laborious.

**Sarah** worked as a secondary school teacher of history and English for many years; she resigned to become a full time parent when her son, who was ten years old at the time of her stroke, was born and lived with her

husband and now adult son. She had no previous experience of, or interest in, computer use for either work or leisure prior to stroke, but two years post-stroke she participated in a research project exploring the accessibility of the Internet for PWA, and she had since undertaken a basic computer access course at a local community college. At the beginning of the project she remained a tentative technology user, but had recently acquired a tablet and was particularly keen to use email, and to explore Internet shopping and searching for information.

**Karen** was a secretary and PA in a large secondary school at the time of her stroke. She used a computer a great deal at work and described multitasking as a routine part of her role. Her attempt to return to this post after her stroke was not successful and after a period of dispute with her employers, in which a tribunal found in her favour, she took early retirement. When the study began she lived with her adult daughter, who moved out during the course of the project. Karen's ability to touch-type remained intact, and she could readily produce written text in this way, though she reported this required great concentration and caused fatigue. By contrast she found it very difficult to produce letter shapes orthographically and appeared from observation to have a form of peripheral dysgraphia involving motor production. Karen was retraining as a gym instructor, specialising in working with people with disabilities, and planned to use the AT software packages to support her written coursework.

**Albert** had a PhD in pharmacology, and worked for many years in marketing. He held a number of senior roles and co-authored a book on retail banking; prior to stroke he had used a computer for word processing at work, and for emails at work and at home. At the time of his stroke he had recently retired, though he continued to do some consultancy work and public speaking. He lived with his wife, and his adult daughter and three grandchildren lived nearby. Albert had comparatively mild aphasia but described feeling frustrated by his inability to keep up with complex discussions or to express himself clearly when angry or upset. He also had

arthritis which made writing or typing very laborious. Albert enjoyed telling humorous anecdotes about his work life and began the project with a list of the stories he wished to recount and a very clear plan to commit these to paper.

**Dean** had been a hotel locksmith before his stroke, and was the only participant for whom writing was not a routine aspect of his employment, indeed he described never having wanted an office-based job, and said he had always found spelling a challenge. As the youngest participant he was however a proficient home computer user, mostly for social media and downloading films. Dean was strongly motivated to manage his own administrative affairs rather than request help from his partner or young daughter, and this was his primary training goal. Dean wrote with his non-dominant hand and also practiced using his preferred hand with a splint. He had left his former post owing to ill-health but began voluntary conversation partner work during the course of the project.

**William** had been a journalist for an international news agency prior to his stroke. He used a computer daily, and reported that he used to be an exact and careful writer, comfortable with producing copy to tight deadlines and a fixed word limit. He retired owing to ill health following his stroke, had mild dyspraxia of speech, and towards the end of his involvement in the project he revealed that he had had an operation to remove a benign brain cyst in the year following his stroke. William had a consultative role on a research project at another institution during the project, and was keenly interested in the potential of technology to support PWA, but was less clear about his personal writing plans at the outset. He eventually chose to write narrative accounts of anecdotes from his childhood, and informal journal-style accounts of everyday experiences. He lived with his wife and two teenage children.

**Janet** had been a fashion designer before her stroke. She attempted to return to work afterwards but eventually took early retirement from her high pressure, corporate role, though she continued to design and sell

homeware independently, and had recently taken on an increased freelance workload and created a home studio. Prior to stroke, her work focused mostly on sketching, meetings and travel, though she used email. Post-stroke, she had become a keen user of social media to keep in touch with friends; she accessed this via mobile phone apps. She also already used voice recognition on her mobile phone to successfully dictate text messages and short emails, and avoided conventional writing or typing whenever possible. She was keen to attempt longer emails and to explore other creative writing outlets. Janet lived with her teenaged son and had a long-term partner who lived nearby.

**Doreen** had been a substance misuse worker on a Youth Offending Team, a complex role involving testifying in court, producing written reports using the computer, and facilitating communication with troubled children in whichever way suited their needs (for example some would prefer to write about rather than talk about traumatic experiences). She was unable to resume this work after her stroke, though she still hoped to return, perhaps in a reduced capacity, and also planned to refresh her literacy and numeracy skills at a local college. Doreen had ambitious writing plans including re-engaging with social media, creative writing such as stories for children and therapeutic writing about her experiences of ill-health. She lived with her partner.

**Simon** co-owned a construction company before his stroke; afterwards he and his business partner decided to dissolve the firm and retire. At work he had used a computer to produce letters and compose financial quotes, and now used his iPad for email and Internet searching. He was a volunteer and befriender for a charity supporting people with stroke and aphasia, and had been asked to make a presentation to new members about himself and his life before and after stroke; he planned to use the project sessions to draft out his talk. Simon lived with his wife, three of their four children and one of their three grandchildren.

#### ***6.4 The AT software training intervention program***

The training intervention in the empirical study was designed to be customisable depending on participants' individual goals and diagnostic profiles, in order to be consistent with its theoretical underpinnings in the social model of literacy. Nevertheless, there was a clear and replicable structure which was repeated across participants but still enabled personal tailoring. Key ingredients forming the basis of training for all participants were: topic generation, trial and error dictation, monitoring of participant performance including error management and editing, feedback and prompts for further editing, review of performance and key strategy identification and reinforcement. Each of these is expanded below.

##### ***6.4.1 Topic generation***

For all participants the process of thinking about writing genres and topics began in the T2 interviews, with a discussion of what they had used writing and technology for in the past and what they would like to be able to do now. This tracked through to the first and second training sessions, with the introduction of the goal setting power-point presentation (Appendix 4.3). Each of the genres presented in the slides were discussed, with examples, and a note was made of preferences. At the beginning of each subsequent training session, participants were asked whether they wished to resume the work undertaken in the previous session or begin a new piece of work. For individuals who experienced particular difficulties with topic or genre generation, specific examples were suggested, for example writing about a recent cricket match watched on television (Rohan) or describing photographs of landscapes and buildings (Doreen; see section 6.5.1).

##### ***6.4.2 Trial and error dictation***

Dictation involved a basic introduction to Dragon NaturallySpeaking™ software, including initial voice training, learning how to open the program, wearing and adjusting the microphone headset, and activating the microphone. It also required that participants mastered how to blend verbal narrative with spoken commands for punctuation, navigation and

microphone operation, and formed a substantial part of the training sessions throughout the program. Explicit verbal and written instructions were given on how to perform these tasks, with additional whispered prompts when required, and encouragement to refer back to written sheets. Participants were initially encouraged to pause after a sentence or two, switch off the microphone and listen back to dictated material to assess both its objective accuracy and their subjective satisfaction with their outputs. Over time, participants were given more freedom to elect how frequently to undertake this checking routine during dictation, particularly as their dictation skills improved.

#### *6.4.3 Monitoring of participant performance including error management and editing*

This aspect of training worked closely in tandem with dictation and auditory processing of written work, and again took place throughout the program. Editing was a complex process, involving not only identification of errors, but also locating them amongst the narrative, isolating them, finding an alternative, and correctly producing this alternative in the appropriate place in the text. This was challenging for many, and several alternative strategies were offered (see also sections 8.4.1e and 8.5.2). All participants were shown how to use ClaroRead™ to listen to both their own writing and that of others, including an overview of the different techniques required for different formats e.g. hover and highlight in a PDF, click and highlight in Microsoft Word documents. For the five individuals where single word reading deficits had been identified during diagnostic testing (Doreen, Peter, William, Dean and Rohan, see section 6.2.2c above), particular care was taken to demonstrate ClaroRead™ and encourage its use.

#### *6.4.4 Feedback and prompts for further editing*

Any attempts at editing were met with immediate feedback regarding their accuracy when required; often participants could independently assess this. Judgements were made on an ongoing basis as to whether to point out every error or to leave some unattended. These judgements were

based partly on participants' individual approaches, so that where a strong preference for accuracy had been expressed errors were routinely indicated, whereas with individuals who had explained they were happy to produce broadly comprehensible text this was less stringent. In part judgements were also based on the narrative produced, for example a formal letter which was to be sent to a social care provider would be more rigidly corrected than a casual email to a good friend. Explicit enquiries from participants as to accuracy and error were always responded to honestly by the trainer.

#### *6.4.5 Review of performance*

At the end of each session, participants were asked whether they were satisfied with their progress, and offered general praise and encouragement; wherever possible, specific examples of success were reiterated. A brief verbal summary of the activities undertaken in the session was given, and dictated outputs were saved and printed or emailed to participants according to their preference. Participants were invited to consider what they would like to work on in the next session, and informed that key new learning would be written up in an accessible format in time for their next session. Those who were engaging in independent dictation between training sessions were asked about their writing plans for the week and invited to email new compositions to the student researcher if they were prepared to share them.

#### *6.4.6 Key strategy identification and reinforcement*

Each time any successful strategy was used, this was explicitly identified and positively reinforced, supported by concrete, accessible explanations of why it had worked where appropriate. Examples of effective strategies included use of an assertive, clear tone of voice, flexibly finding alternative phrasing, correctly recalling procedural steps from a previous session, using auditory processing to identify errors, and many more.



#### *6.4.7 Template for Intervention Description and Replication (TIDieR) checklist*

The TIDieR checklist [232] (Table 6.13) has been completed in order that the training intervention is transparently presented and may be replicable in its current form. Tailoring and modifications are briefly described within the table, and in more expanded form in section 6.5.

#### **6.5 Personalisation of the AT software training program**

As described in sections 5.4.2 and 6.4, during the training intervention participants were stepped through the features of the two AT software packages, with the use of support materials, besides suggestions and prompts. One participant, Peter, had been given an earlier version ClaroRead™ software by a former colleague, and had unsuccessfully attempted to train himself independently; another, Janet, was successfully using her mobile phone's dictation app. Other than this, none of the participants had any experience of either software, and because of the linguistic and cognitive demands of AT it is very unlikely any participant could have trained themselves independently; rather, the support of a researcher trained in understanding aphasic strengths and difficulties, and in removing barriers or supporting communication access was a key ingredient in the intervention.

However, there were still many individual differences among the group. These related partly to previous computer and technology experience and confidence, but also to a range of other factors such as their language processing capabilities, as identified during diagnostic testing, their writing goals and the ways in which they wanted to use AT to achieve these specific tasks, and their preferred learning styles. Owing to these differences, the trainer was required to take an active role in individualisation of the intervention. This was an aspect of the training program which was heavily influenced by the gathering and analysis of participant observation (PO) data, as these data permitted detailed tracking and recording of barriers encountered and of strategies attempted, including whether or not these were successful. The video

Item 1: Brief name	Assistive technology software training for people with aphasia - and specifically dysgraphia - after stroke
Item 2: Why	<p>To train 10 PWA to use dictation software to compensate for spelling and writing impairments, and to use reading support software to enable auditory processing of written text when required;</p> <p>To observe and document barriers and facilitators to software use;</p> <p>To examine written outputs for evidence of improved writing skills, whether compensatory (as evidenced by writing via technology) or remedial (as evidenced by pen and paper assessments), and to examine reading comprehension for evidence of improvement when supported by software.</p>
Item 3: What: materials	<p><i>Software resources:</i> Dragon NaturallySpeaking™ Professional Version 12 (equivalent package for Mac users Participants 4 and 8); ClaroRead™ Pro Version 6 (or equivalent for Mac); Microsoft Word (Mac equivalent for participants 4 and 8); Internet and email via browser and provider of participant's choice; Power Point presentation to stimulate goal setting.</p> <p><i>Hardware resources:</i> Seven participants used their own equipment for the intervention; the remaining three were loaned University equipment.</p> <p><i>Paper resources:</i> accessible summaries of software capabilities such as microphone operation; dictation command prompt sheets; tailored written training session summaries; print outs of writing tasks completed in training sessions and independently; blank forms for noting independent use of software, including time spent, activities undertaken and level of satisfaction with progress; additional supporting materials regarding more general technology use e.g. procedure for accessing and sending emails, where required on individual basis.</p> <p><i>Trainer resources:</i> Dragon NaturallySpeaking for Dummies [233]; ClaroRead instruction manual; one meeting with senior executive from Nuance Communications Ltd plus email contact and helpline access; email contact and helpline access from Claro Software Ltd.</p>
Item 4: What: procedures	<p><i>Study:</i> Participants were identified by expressions of interest, either in response to the aphasia team recruitment presentation, or as a result of previous enquiries made by the participant, or - in the case of Participant 6 - referral from another individual already involved in the study. Each person then had the opportunity to discuss the study further with the PhD candidate, and was given a detailed information sheet. If they remained interested they were screened for suitability, and if eligible to participate they were asked to sign a consent form. T1 assessments were undertaken, followed by T2 assessments six weeks later. At the end of the training program, T3 assessments were undertaken. Participants were permitted to keep the two AT software packages for independent use. T4 assessments took place three months after T3.</p> <p><i>Intervention:</i> The two AT software packages were installed on participants' hardware; this procedure and presentation of the goal setting Power Point slides formed the content of the first training session. Some tasks and activities of the remaining</p>

	training sessions were common to all participants: topic generation, trial and error dictation, performance monitoring, feedback and editing prompts, performance review and strategy identification and reinforcement. Others were specific to individual participants (see Item 9).
Item 5: Who provided	PhD candidate with extensive experience of working with people with communication impairments owing to aphasia. Experience of delivering teaching and training programs to range of audiences including BSc and MSc students, health care professionals and people with aphasia, both in groups and one to one, in formats including lectures, seminars, focus groups and individual coaching and support.
Item 6: How	Face to face provision of training sessions (except participant 7, who requested and received two of his training sessions via Skype), mostly one to one (participant 1's partner attended the first three training sessions with him; participants 3, 8, 9 and 10 lived with other family members who occasionally made informal contributions or comments on training).
Item 7: Where	Either in a private room at City, University of London (participants 1, 4, 5, 6, 7) or at participant's home (participants 2, 3, 8, 9, 10), according to their preferences.
Item 8: When and how much	Standard training package: one hour per week for ten weeks. Various adaptations made according to individual requirements and preferences, described in Item 9.
Item 9: Tailoring	Each participant received basic training on accessing and operating both software packages. Participants were encouraged to use both packages in tandem but were permitted to elect not to use ClaroRead if they found it intrusive, distracting or cognitively burdensome, or if they subjectively rated their reading insufficiently impaired to require it. Participants set goals relating to functional writing activities (e.g. composing emails to family members and responding to their replies, writing autobiographical accounts of their career), and sessions were structured around achieving these and enabling participants to continue to fulfil them independently beyond the training period. The trainer gauged individual requirements for supporting materials and provided these in response to need, therefore the volume and content of the materials varied among the group. Participants' approaches to learning and error and their preferred writing techniques were observed informally in training sessions, and on occasion were explicitly referred to by participants themselves. Efforts were made to respect these differences, therefore some participants received step by step procedural instructions throughout the ten sessions, while others were largely observed in later sessions, with comments and instructions provided only when requested.
Item 10: Modifications	<i>Intervention duration:</i> Participant 2 indicated his awareness that the intervention had reached the limits of usefulness for him after 8 sessions and a mutual agreement was made to terminate training. Participant 4 had additional personal and emotional issues which resulted in receiving only 8 sessions. Participants 5, 7 and 8 indicated they were satisfied they could operate the AT packages without further training and support; all received 9

	<p>sessions. Participant 10 ended his involvement after seven sessions owing to an in-patient rehabilitation opportunity; he received two sessions longer than one hour as partial compensation for this.</p> <p><i>Mode of delivery:</i> Participant 7 received two sessions via Skype, owing to his expressed preference for writing without a direct audience.</p> <p><i>Additional individuals present at training:</i> Participant 1 was accompanied by his wife for the first three sessions, owing to her desire to be able to support independent AT use for home practice from the outset. Relatives of participants 3, 8, 9 and 10 were occasionally present but did not actively participate in sessions.</p>
Item 11: How well: planned	Adherence/fidelity was not formally assessed
Item 12: How well: actual	Adherence/fidelity was not formally assessed

**Table 6.13:** TIDieR checklist overview of the AT software training intervention program

recording of training sessions also meant that the challenges of simultaneously training and conducting PO were somewhat alleviated, since the tapes could be reviewed after the sessions had ended. The trainer could then adapt her own behaviour and instructions to suit each participant's preferences. Examples of this are described below.

PO data revealed some participant behaviours which may be prognostic of training success or poorer outcome. These included: excessive self-talk rather than 'on-task talk', as a result of aphasic inability to adequately monitor spoken output; performance anxiety and/or difficulty preparing/producing speech for dictation as opposed to spontaneous speech production; limited flexibility and/or perseveration; and difficulty with editing dictated work. The first three of these factors are described below with examples from PO data; the last, editing, is described in more detail in section 8.4.1e below, as part of the description of the groups' engagement with AT.

#### *6.5.1 Preparing and producing speech for dictation*

Some individuals had a natural ability to formulate and produce connected speech for dictation, with minimal support. For example, Peter was able to dictate a substantial volume of text on his very first attempt in training session 3, and was observed to pay careful attention to pace, pausing and

intonation, all good indicators for accuracy of AT, as this dictated fragment indicated:

“I want to go to Stroke Club on Thursday to meet the woman who is doing things with us to think about meditation. I have been able to meditate or do things like that since about the Seventies” Peter, training session 3.

Successful attempts such as this were met with positive reinforcement by the trainer (‘Fantastic!’), along with explicit identification of useful strategies:

“That was nice and measured. You don’t jump around too much; you could read the news – nice monotone” Trainer, Peter session 3.

Positive feedback on successful strategies, including discussion of why these were useful, was also provided as part of drawing a training session to an end. For example, at the end of Peter’s third training session, the clarity of his dictated speech was again remarked upon, and contrasted positively with his speaking in conversation. This was done in order to offer Peter an opportunity to reflect on his dictation behaviours and cement their benefits.

These promising signs from early training sessions were built upon throughout his training program, and by session 10 Peter was able to produce creative dictation in an ad hoc, relaxed manner, incorporating his own whimsical humour in his narrative:

“A mouse decided to be a technician for a computer full stop So the technicians decided that it would be good to get him hooked up full stop But the technicians wanted a mouse or something that was really small for their purpose full stop” Peter, training session 10.

By contrast, other individuals had substantial difficulty with mastering this type of narrative formulation and production. For example, in her third

training session, Doreen was observed to produce short, simple sentences when describing to the trainer what she would like to dictate, but was unable to replicate these when wearing a microphone and concurrently watching the screen to monitor for the appearance of her dictation. Consequently, very different training strategies were required with Doreen than with Peter. These included prompting Doreen to suggest key phrases to represent the content of each sentence she wished to dictate; these were written down by the trainer and given to her to serve as visual reminders. In session 3 the key words presented were: “31 November 2011. Transferred to [hospital] next day. Intensive care 4 days. Stroke Unit.”

A further training technique was then adopted whereby Doreen rehearsed dictation by telling the trainer the story in a conversational style first, wearing the microphone but with it deactivated, and for her to then attempt to assimilate this more natural delivery into dictation by activating the microphone but turning the computer screen away, to minimise the burden of monitoring and the hesitancy and discomfort this caused.

These techniques resulted in modest improvements, but Doreen’s difficulties persisted, and she continued to require a great deal of support to produce connected, spontaneous speech throughout the program. As a result, an increasingly scaffolded approach was developed, based on Estes and Blooms’ findings [117] (discussed in Chapter 3), which suggested that structured picture description was easier for their participant than free composition. In session 9, Doreen successfully produced connected narrative in response to three photographs of cities and landscapes (Appendix 8.4).

It was striking that Doreen, who struggled with verbal dictation, had both the lowest spoken picture naming score of the ten participants (77.5%) and the lowest score for reading single word picture names aloud (67.5%). In contrast, Peter who fared better with dictation scored 92.5% and 82.5% respectively on these assessments.

### *6.5.2 Limited flexibility and/or perseverance*

Observation data revealed a range of responses to errors or setbacks among the group, somewhat echoing the differences between Ella and Claire which were noted in the pilot study. It appeared that a key factor in successful dictation and editing may be the degree to which a participant is able to rephrase or find a substitute word when faced with AT inaccuracy. For some individuals, this was a skill that came naturally. They appeared to notice an error in the written text, realise that it was a result of their spoken output being rendered inaccurately by the software, find a less ambiguous phrase, and replace the erroneous dictation with a rephrased option with a similar meaning. This was a sophisticated linguistic procedure, and it is not surprising that some participants found it more challenging. There was some evidence that performance in this task may have been related to semantic skills, as signalled by scores on single word synonym judgement. Many of the participants who obtained high scores on this PALPA subtest were also skilled at finding substitute words, including Sarah (93.3%), Karen (85%), Albert (100%), Janet (93.3%) and Simon (98.3%). However, this would appear not to have been the only factor at play, since Peter (81.7%) was also able to fulfil this task, while William (95%) found it more challenging, as described below, in a similar way to Dean (68.3%). It appeared therefore that the compensatory intervention described in this thesis also called upon processing skills that were not readily captured by the largely single word diagnostic assessments administered.

In order to offer further support in developing flexibility in dictation when required, the trainer first explicitly identified the problem, explaining that AT cannot always differentiate between two words which sound very similar, and that when this occurs it can be useful to think of a substitute. This was supplemented by offering an alternative word if appropriate. For example, in his fourth training session, William attempted to describe a minor car accident which had occurred on his way to the University, and Dragon NaturallySpeaking™ was repeatedly unable to produce the phrase

‘wing mirror’ accurately. With prompting, William was able to substitute this with ‘side mirror’, which appeared correctly after a couple of attempts. In later sessions, he was able to recall this technique and use it independently (as shown in his writing sample in section 8.5.2).

In training session 4, William also attempted the phrase ‘faster than after the smash’ and this was reproduced as ‘foster son after the smash.’ Despite its accuracy, he perseverated the phrase ‘after the smash’ several times. He was given explicit information on the software’s capacity to contextualise words based on others in proximity to them, and this resulted in greater awareness of repetition, and an immediate reduction in the frequency of this behaviour.

Dean also sometimes perseverated over certain phrases, particularly when engaging in a complex narrative such as persuasive text. For example, as shown in his writing sample in section 8.5.2, in his third training session he found it difficult to articulate his personal and financial circumstances in a letter. This required a different type of training support, designed to unpick the exact nature of his complaint and jointly construct a narrative, by reflecting Dean’s concerns back to him coupled with making suggestions for finessing the text, as shown here:

Trainer: “So it sounds like you’re concerned about their decision – you probably need to tell them why you don’t think it’s the right decision so that’s the bit to say next”

Dean: [dictates] “I think that you need to reassess me and look at my situation before you make this decision, I am finding it very hard go to sleep” [to trainer] “I was on a flow there and she [Claro ‘voice’] said something and it’s gone out of my head now”

Trainer: “When you turn it on, explain the things that are difficult”

Dean: [dictates] “to cope with my situation and I need help to live my life as normal as possible” Dean, training session 3.



Later sessions with Dean appeared to indicate this technique had been absorbed and was used with minimal prompting. In session 7, he decided to make a list of notes to himself so that he would not forget the issues he wanted to raise at a Citizens Advice Bureau appointment. He dictated the following:

“Note 1 ask about them getting letter from my GP new line  
note two need to find out who’s telling the truth about the GP  
letter new line they said they sent a letter to my physio which  
isn’t my physio so she’s only going by the notes from my  
previous physio new line from my previous application form  
nothing has changed which has been two years from this date  
two years ago so my circumstances hasn’t changed which I find  
a bit baffling” Dean, training session 7.

### *6.5.3 Self talk versus ‘on-task’ talk*

Video data revealed that some individuals were able to suppress self-talk much more readily than others. For many, some simple procedural instructions from the trainer were sufficient to enable participants to reduce additional verbal output to a minimum. The procedure followed included: trainer offering a concrete and humorous example that the microphone will pick up all speech, by recounting an occasion when dictating and breaking off to answer the telephone without deactivating the microphone. Then, if necessary, an explicit gesture was given when required, to encourage the participant either to fall silent or to switch off the microphone, in order to minimise extraneous speech appearing on the screen, and offer a space for planning and discussion without the microphone recording.

One participant who struggled to suppress verbal reactions and unconscious utterances was Rohan. He habitually punctuated dictation with the word ‘Okay’ and this was compounded by his uneven and disconnected dictation style. With Rohan, an additional training technique was incorporated, whereby he was encouraged to think of a simple,

procedural set of instructions, and to deliver them one by one, pausing between each. This exercise was accompanied by verbal scaffolds designed to help him structure a narrative sequence, with the use of prompts such as 'first', 'next' and 'finally'. In session 5 there was evidence that this strategy produced positive results; he dictated:

“To go to the shop first go down the stairs then open the door and walk out then on the pavement walk hundred yards then you come to the main road durin wicross the road and then walked neither 10 yards lead into the shop” Rohan, training session 5.

While this was not entirely accurate, it represented a marked improvement. This was reinforced with encouragement, and an explanation that the procedural narrative had helped him focus on smooth, calm delivery. Despite the introduction of this technique, Rohan continued to find it very difficult to limit self-talk throughout the program, particularly when attempting novel compositions such as emails, rather than structured tasks.

## ***6.6 Summary***

Chapter 6 gave detailed profiles of the participants in this study. It began with a description of their characteristics, including age range, mean time since onset, education level and employment status, besides an overview of how they were recruited. Then a brief picture of the group diagnostic profile as measured by PALPA assessments was given, indicating that scores for spoken naming were highest, that there was a very wide range of performance on spelling tasks and that as a group the participants' single word reading was comparatively less impaired than their writing. A portion of the chapter was devoted to in depth, case by case diagnostic information, including full details of each person's test scores, supported by examples of errors made, followed by conclusions drawn regarding each individual's dysgraphia and dyslexia. The chapter then gave a narrative account of each person's prior employment and training plans, drawn from qualitative data from the in-depth, semi structured interview conducted at

T2. It moved on to describe the AT software training program, with reference to the TIDieR checklist. The chapter closed with an account of how the AT software training program was customised for individual participants in order to meet the requirements of their diagnostic profiles and learning styles.



## **Chapter 7: Results of group outcome measures**

This chapter begins by giving descriptive statistics for the cognitive screening/monitoring assessment (CLQT) and the language screening assessment (CAT language battery). The results of the two assessments of single word writing (PALPA 40: imageability spelling) and single word reading (PALPA 50: written synonym judgements) used to monitor for a remediatory effect are then presented. These are followed by the outcome measures used to address RQ1 and RQ2:

RQ1: Does AT software training compensate for writing and reading impairments and lead to improved performance in narrative writing and reading comprehension?, using the CAT written picture description and constrained writing task (narrative writing), and the GORT-4 (reading comprehension);

RQ2: Does training have an impact on social participation, mood and quality of life?, using SNA (social participation), the GHQ-12 (mood) and the SAQOL-39g (quality of life).

Group descriptive statistics and line graphs of mean scores for each assessment are given; individual descriptive statistics can be found in Appendices 7.1 to 7.10. Graphs showing the individual performance patterns which made up the group performance are also given for the outcomes where the training package resulted in positive change for the group. The results of RQ3 and RQ4 are addressed in Chapter 8 using qualitative data; those data are also used to expand and illuminate the quantitative data presented in the current chapter.

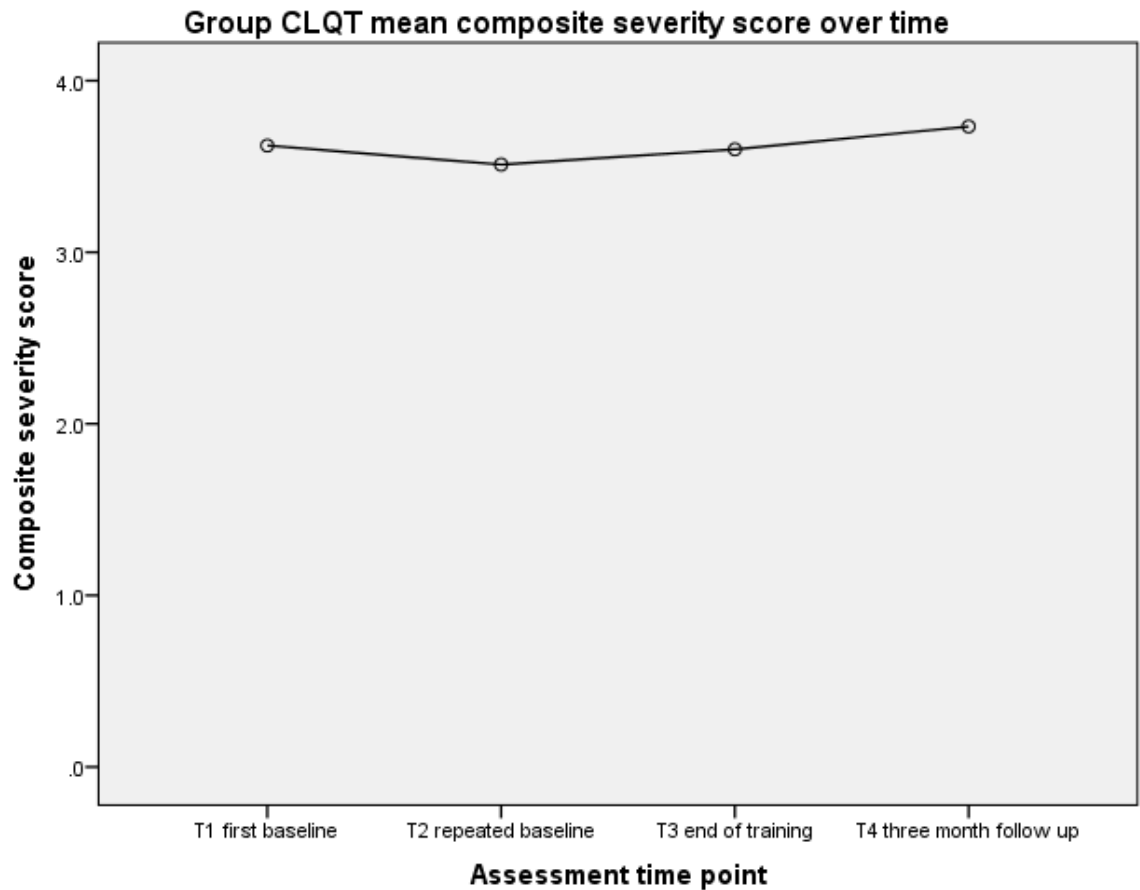
### ***7.1 Screening/monitoring assessments of cognition, screening assessment of language and monitoring assessments of single word spelling and reading***

#### ***7.1.1 Cognition: the CLQT***

The CLQT was used to screen participants for suitability for the study at T1, and to monitor whether any participant experienced a decline in cognitive performance over the course of the study at T2, T3 and T4. Across time

	Scale score range		Group score range	Mean (SD)	Median (IQR)
Cognition: CLQT composite severity rating	0 – 4.0	T1	2.8 – 4.0	3.64 (.44)	3.80 (3.45 – 4.00)
		T2	2.6 – 4.0	3.52 (.58)	3.70 (3.05 – 4.00)
		T3	2.6 – 4.0	3.62 (.51)	3.80 (3.30 – 4.00)
		T4	3.0 - 4.0	3.73 (.39)	4.0 (3.40 – 4.00)
Language: CAT domain T-scores (conducted at T1 only)	25 - 75	Spoken comprehension	52 - 67	62.60 (5.40)	64.00 (60.00 – 65.00)
		Written comprehension	51 – 68	63.90 (5.78)	66.50 (59.00 – 68.00)
		Repetition	48 – 64	57.30 (4.95)	57 (54.25 – 62.00)
		Spoken picture description	57 - 75	65.70 (6.93)	64.50 (59.00 - 73.50)
		Reading	46 – 71	58.70 (7.95)	58.00 (54.00 – 66.00)
		Writing	50 – 65	58.60 (5.06)	59.50 (55.50 - 62.50)
		Written picture description	42- 72	56.90 (9.05)	59.00 (51.75 – 61.25)
Single word spelling: PALPA 40 scores	0 - 40	T1	0 – 40	18.90 (15.01)	25.50 (.00 - 30.00)
		T2	0 – 38	23.50 (13.34)	30.50 (11.75 – 33.50)
		T3	1 – 38	22.50 (13.52)	28.00 (7.25 – 33.00)
		T4	0 - 39	22.89 (13.15)	30.00 (12.50 - 33.00)
Single word reading: PALPA 50 scores	0 - 60	T1	41 – 60	52.80 (6.99)	56.00 (47.00 – 57.50)
		T2	41 – 60	54.10 (6.29)	57.00 (48.50 – 58.25)
		T3	45 – 60	53.80 (4.71)	54.00 (50.00 – 58.25)
		T4	46 - 60	54.00 (4.82)	57.00 (49.00 – 57.00)

**Table 7.1:** Group screening and monitoring assessment scores (CAT n = 10, other assessments n = 9)

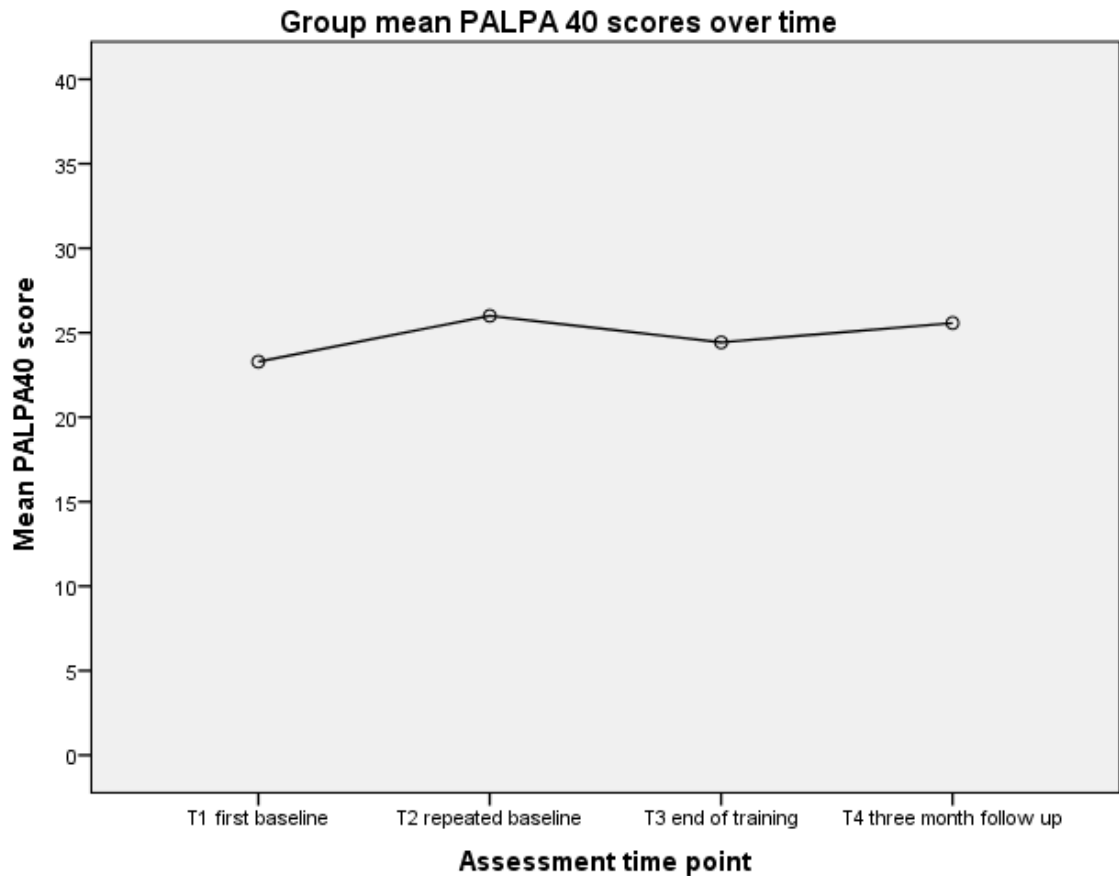


**Figure 7.1:** Group CLQT mean composite severity score over time

points, scores on the CLQT were high with means ranging 3.52 – 3.73 and medians 3.70 – 4.00 (Table 7.1). There was no significant change in the group’s cognitive performance over time: Friedman’s  $\chi^2 (3) = 6.45, p = .092$  (Figure 7.1).

#### *7.1.2 Language: the CAT language battery*

T-scores on the CAT ranged 42-72, with higher scores indicating superior language function. Examination of the mean group T-scores for comprehension of spoken language (62.60), comprehension of written language (63.90), repetition (57.30), spoken picture description (65.70), reading (58.70), writing (58.60) and written picture description (56.90) revealed generally better group performance on comprehension tasks and slightly poorer performance on language production tasks, with the exception of spoken narrative (picture description). Predictably, owing to



**Figure 7.2:** Group mean PALPA 40 scores over time

the study inclusion criteria, there was evidence of superior spoken picture description and poorer writing performance in this task.

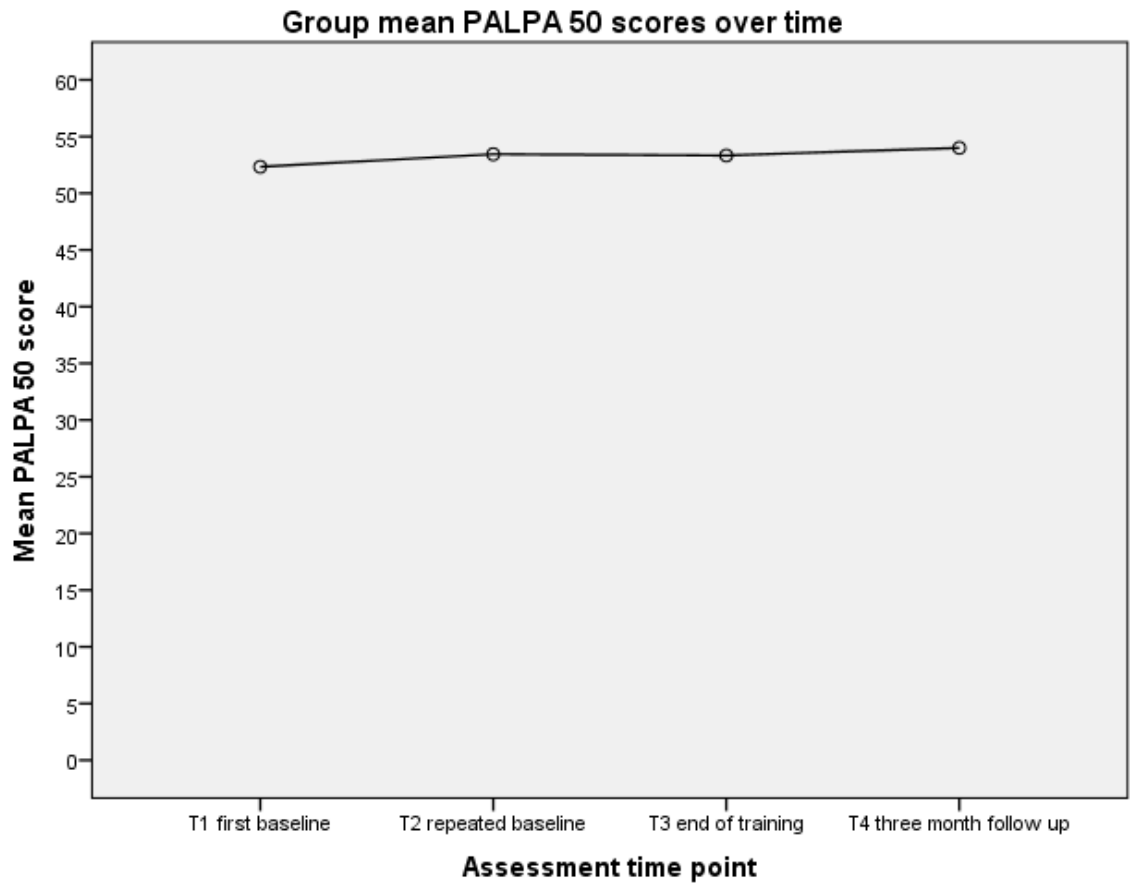
#### *7.1.3 Single word spelling: PALPA 40: imageability spelling*

Scores on PALPA 40 covered the whole scale score range from 0 to 40, with a mean (SD) of 18.90 (15.01) at T1, 23.50 (13.34) at T2, 22.50 (13.52) at T3 and 22.89 (13.15) at T4. There was no significant change in the group's single word spelling scores over time: Friedman's  $\chi^2$  (3) = .51,  $p$  = .163 (Figure 7.2), therefore the AT training appeared to have no remediatary effect on this skill.

#### *7.1.4 Single word reading: PALPA 50: written synonym judgements*

Scores on PALPA 50 ranged from 41 to 60, with a mean (SD) of 52.80 (6.99) at T1, 54.10 (6.29) at T2, 53.80 (4.71) at T3 and 54.00 (4.82) at T4. There was no significant change in the group's single word reading scores over





**Figure 7.3:** Group mean PALPA 50 scores over time

time: Friedman's  $\chi^2 (3) = .95, p = .814$  (Figure 7.3), therefore the AT training also appeared to have no remediatory effect on this skill.

## ***7.2 Outcome measures for research question 1, of narrative writing and reading comprehension***

Table 7.2 details participant scores on the outcome measures used across time, including scale score range, group score range, means (SDs) and medians (IQRs). Means (SDs) are used in the text and the graph to describe the data; given the small sample size and the use of non-parametric statistics, the medians (IQRs) are additionally given in the table.

		Scale score range		Group score range	Mean (SD)	Median (IQR)
Narrative Writing	CAT written picture description pen & paper T-score	25 - 75	T1	42 – 72	56.90 (9.05)	59.00 (51.75 - 61.25)
			T2	42 – 75	58.80 (12.26)	62.00 (42.00 - 67.25)
			T3	42 – 75	59.10 (12.71)	64.50 (42.00 – 67.50)
			T4	42 – 75	60.22 (12.32)	62.00 (47.00 – 70.00)
	CAT written picture description keyboard T-score	25 - 75	T1	42 – 75	60.22 (9.54)	61.00 (55.00 – 67.50)
			T2	25 - 75	58.22 (16.92)	60.0 (49.00 – 71.00)
			T3	42 – 75	68.44 (10.77)	75.00 (66.0 – 75.00)
			T4	42 - 75	68.00 (11.24)	75.00 (62.00 – 75.00)
	Constrained writing pen and paper total tokens	N/A	T1	0 – 75	27.33 (23.85)	26.00 (7.50 – 42.50)
			T2	0 – 82	27.00 (27.10)	26.00 (.00 – 43.0)
			T3	0 – 94	27.78 (30.87)	26.00 (1.50 – 45.50)
			T4	0 – 93	30.22 (30.84)	26.00 (0 – 49.50)
	Constrained writing pen and paper % lexical variety	0 - 100	T1	0 – 100	68.64 (39.64)	83.70 (38.65 – 94.45)
			T2	0 – 100	60.30 (46.0)	82.00 (.00 – 100.00)
			T3	0 - 100	64.47 (38.02)	75.00 (35.7 – 90.4)
			T4	0 – 96.2	53.40 (40.64)	76.20 (.00 – 80.00)
	Constrained writing keyboard total tokens	N/A	T1	0 – 139	35.78 (41.68)	16.00 (14.00 – 44.00)
			T2	0 – 174	39.56 (53.20)	19.00 (12.50 – 48.00)
			T3	4 – 248	113.44 (85.54)	95.00 (39.00 – 196.50)
			T4	1 - 428	152.11 (144.14)	85.00 (49.50 – 273.00)
	Constrained writing keyboard % lexical variety	0 - 100	T1	0 – 93.8	70.97 (28.58)	81.30 (64.90 – 88.35)
			T2	0 – 100	74.14 (30.08)	84.20 (67.85 – 91.65)

			T3	51.2 – 100	68.70 (16.85)	66.20 (51.25 – 80.20)
			T4	51.1 – 100	67.16 (15.15)	66.70 (54.40 – 73.00)
			T1	0 – 33.8	18.58 (13.38)	20.30 (3.70 – 31.50)
			T2	0 – 31.4	18.22 (13.83)	24.60 (.00 – 28.90)
	Constrained writing pen & paper SVJ total score	0 – 40	T3	0 – 37.4	17.31 (14.76)	25.20 (2.00 – 29.40)
			T4	0 – 33.2	18.26 (14.53)	27.40 (.00 – 30.25)
			T1	0 – 36.0	21.11 (12.89)	29.60 (9.10 – 30.30)
			T2	0 – 37.4	22.89 (12.88)	25.20 (12.10 – 32.90)
	Constrained writing keyboard SVJ total score	0 - 40	T3	8.0 – 33.0	23.24 (8.61)	25.60 (15.20 – 30.00)
			T4	3.0 – 33.4	21.87 (10.14)	24.40 (13.40 – 29.23)
Reading comprehension	GORT-4 pen & paper standard comprehension score	1 – 20	T1	1 – 9	4.30 (2.45)	3.50 (2.75 – 6.25)
			T2	1 – 9	4.10 (2.56)	3.00 (2.75 – 5.75)
			T3	1 – 8	4.50 (2.22)	4.50 (3.00 – 5.75)
			T4	1 - 9	4.67 (2.83)	3.00 (3.00 – 7.50)
	GORT-4 keyboard standard comprehension score	1 - 20	T1	1 – 5	2.90 (1.29)	3.00 (2.00 – 3.50)
			T2	1 – 8	4.70 (2.31)	4.00 (3.00 – 7.25)
			T3	2 – 9	5.60 (2.17)	5.50 (4.00 – 7.25)
			T4	2 - 10	6.67 (2.65)	7.00 (4.50- 9.00)

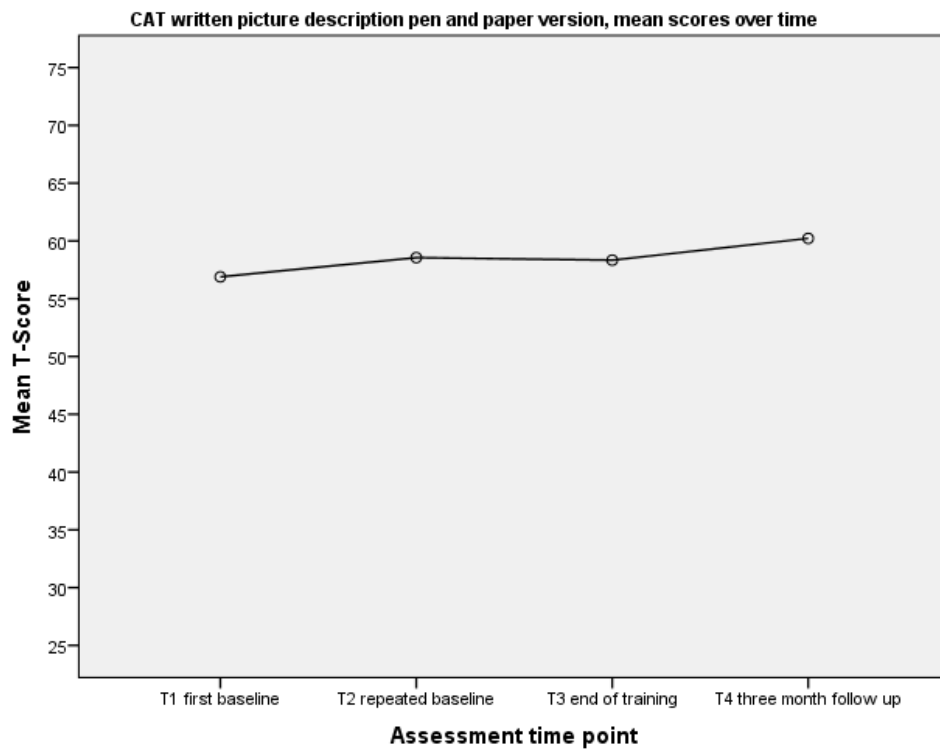
**Table 7.2:** Group descriptive statistics for assessments of narrative writing and reading comprehension (n = 9)

There was no significant change in the pen and paper condition for any of the three assessments of narrative writing and reading comprehension:

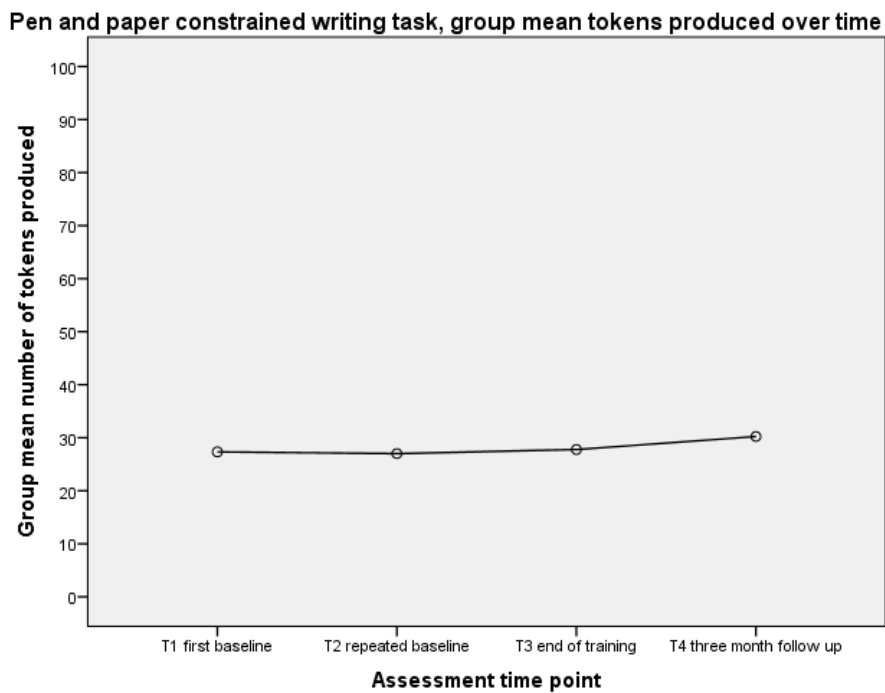
- CAT written picture description: Friedman's  $\chi^2 (3) = 6.92, p = .075$  (Figure 7.4);
- Constrained writing task:
  - total tokens produced ranged 0 – 93, with a mean range of 27.00 – 30.22: Friedman's  $\chi^2 (3) = 2.17, p = .538$  (Figure 7.5);
  - Constrained writing task lexical variety ranged from 0 – 100%, with a mean range of 53.40 – 68.64.: Friedman's  $\chi^2 (3) = 5.23, p = .156$  (Figure 7.6);
  - Constrained writing task social validity judgement rating sub-measures (effectiveness: Friedman's  $\chi^2 (3) = .23, p = .974$ ; informativeness: Friedman's  $\chi^2 (3) = .44, p = .932$ ; grammaticality: Friedman's  $\chi^2 (3) = .31, p = .957$ ; or comfort: Friedman's  $\chi^2 (3) = 1.06, p = .798$ ) and mean total score: Friedman's  $\chi^2 (3) = .82, p = .843$  (Figure 7.7);
- GORT-4 reading comprehension: Friedman's  $\chi^2 (3), = 3.81, p = .663$  (Figure 7.8).

By contrast, there was a significant improvement in group performance over time when keyboard use was permitted:

- CAT written picture description: inspection of the mean values showed T scores were stable at repeated baseline (T1 = 60.22, T2 = 58.22), had significantly increased after training (T3 = 68.44) and that this increase was maintained at three month follow up (T4 = 68.00): Friedman's  $\chi^2 (3) = 8.27, p = .041$  (Figure 7.9);
- Constrained writing task: total tokens produced by the group in the keyboard condition ranged 0 – 428, with means of 35.78 at T1, 39.56 at T2, 113.44 at T3 and 152.11 at T4; Friedman's  $\chi^2 (3) = 13.65, p = .003$  (Figure 7.10);
- GORT-4 reading comprehension: Friedman's  $\chi^2 (3) = 21.07, p < .001$  (Figure 7.11).

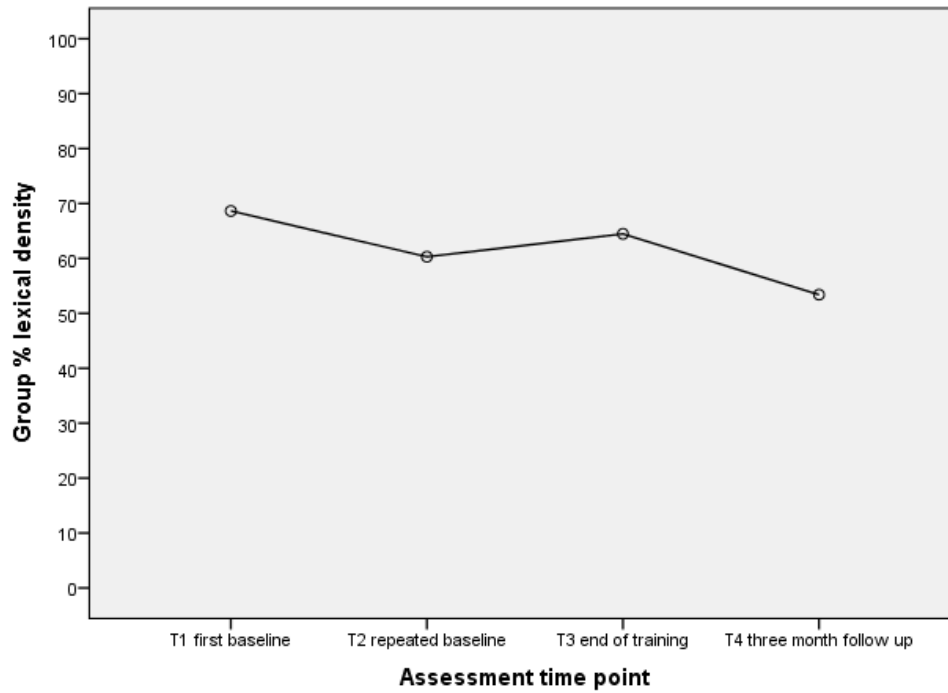


**Figure 7.4:** CAT written picture description pen and paper version, mean scores over time



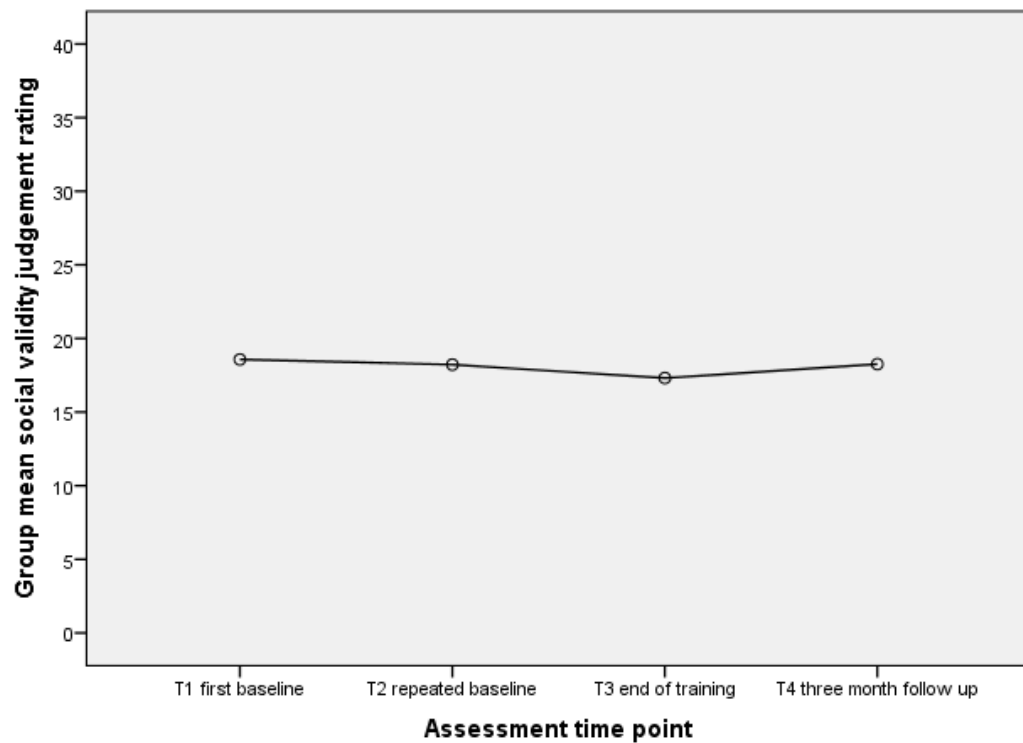
**Figure 7.5:** Pen and paper constrained writing task, group mean tokens produced over time

**Pen and paper constrained writing task, group mean % lexical density over time**

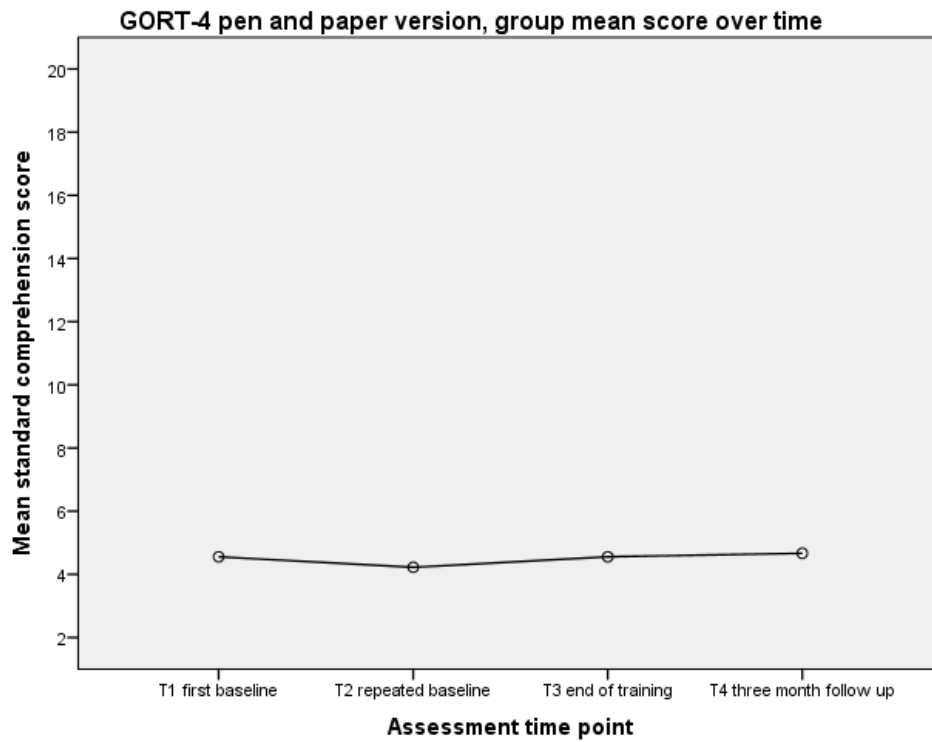


**Figure 7.6:** Pen and paper constrained writing task, group mean % lexical density over time

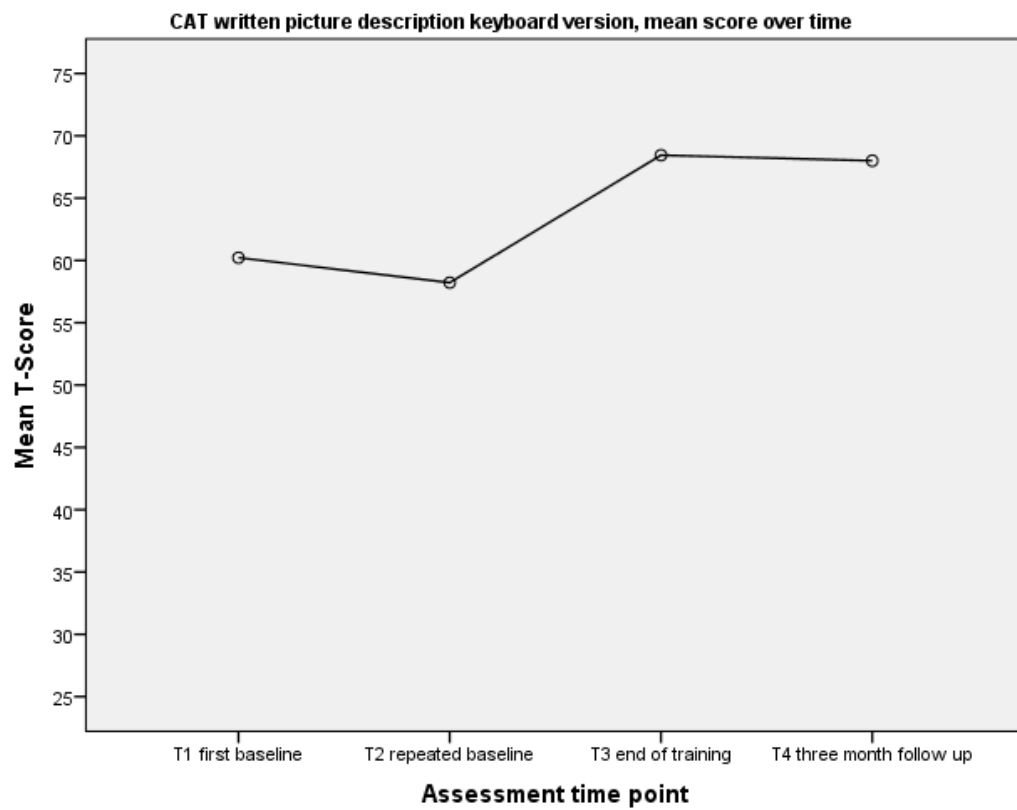
**Pen and paper constrained writing, group mean social validity judgement rating over time**



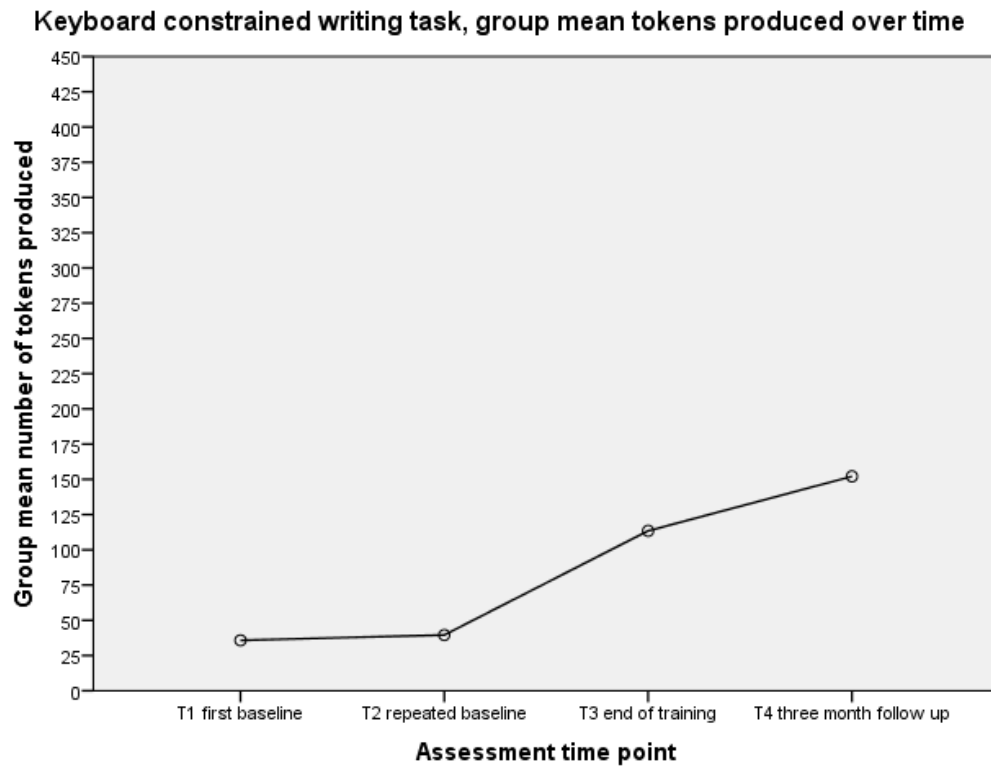
**Figure 7.7:** Pen and paper constrained writing, group mean social validity judgement rating over time



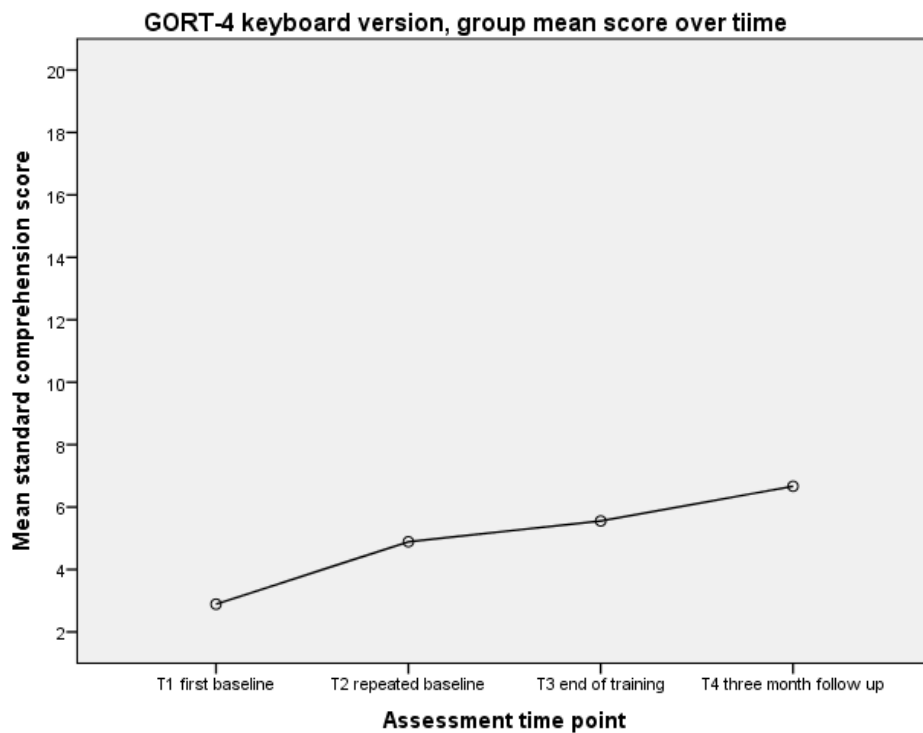
**Figure 7.8:** GORT-4 pen and paper version, group mean score over time



**Figure 7.9:** CAT written picture description keyboard version, mean score over time



**Figure 7.10:** Keyboard constrained writing task, group mean tokens produced over time



**Figure 7.11:** GORT-4 keyboard version, group mean score over time



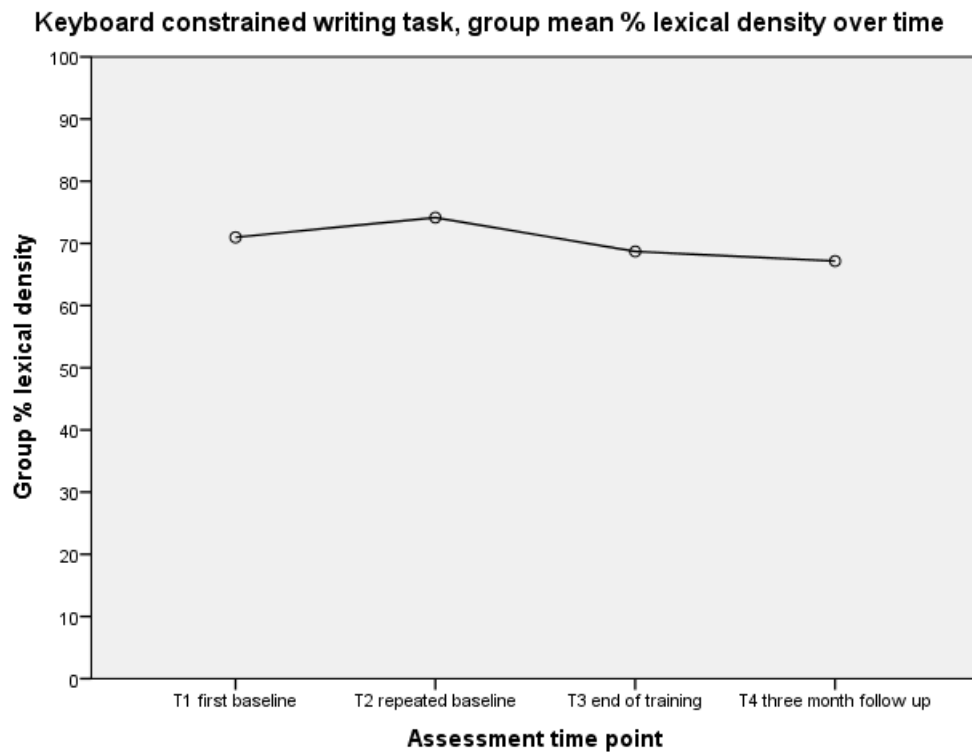
However, using AT did not cause a significant change in lexical variety in the constrained writing task across the group: Friedman's  $\chi^2 (3) = 2.59$ ,  $p = .459$  (Figure 7.12). The group range was 0 – 100% at T1 and T2, and 51.1 – 100% at T3 and T4, with mean scores of 70.97 at T1, 74.14 at T2, 68.70 at T3 and 67.16 at T4.

Nor was there any change in the social validity judgment ratings of group performance over time in the keyboard condition, in any sub-measure (effectiveness: Friedman's  $\chi^2 (3) = .87$ ,  $p = .832$ , informativeness: Friedman's  $\chi^2 (3) = 1.92$ ,  $p = .589$ , grammaticality: Friedman's  $\chi^2 (3) = 2.62$ ,  $p = .455$  or comfort: Friedman's  $\chi^2 (3) = 2.66$ ,  $p = .448$ ) or the overall mean group score: Friedman's  $\chi^2 (3) = 3.0$ ,  $p = .392$  (Figure 7.13). Therefore in this assessment, AT software had no impact on how the group of participants' narrative compositions were judged by independent raters.

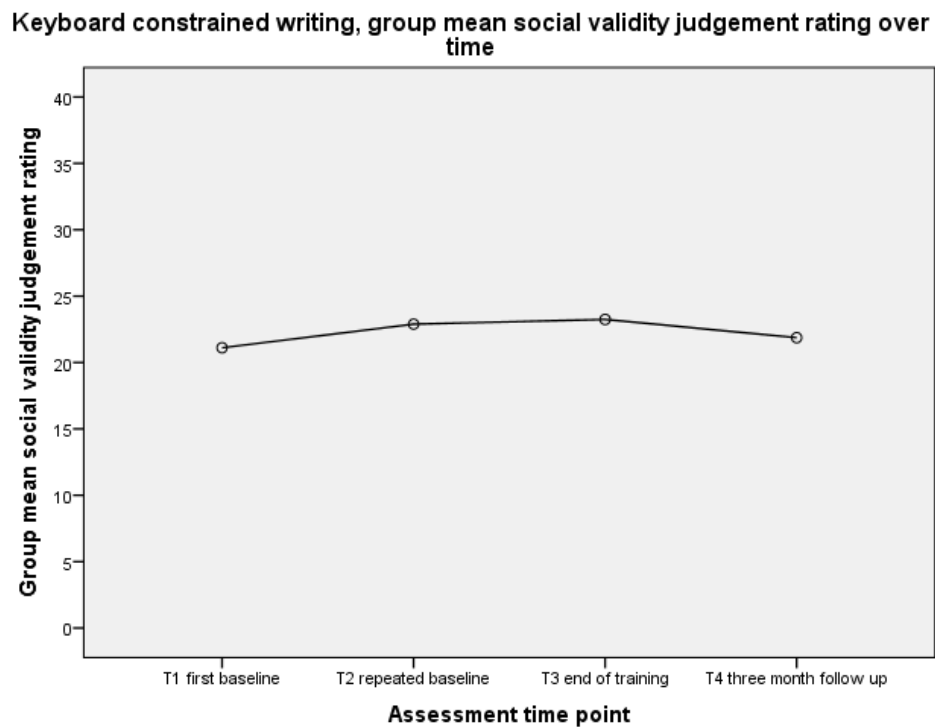
#### *7.2.1 Individual differences in performance on narrative writing and reading comprehension*

The group results in the writing and reading outcome measures concealed individual variation. Therefore, Figures 7.14 – 7.16 show individual scores in relation to the mean for the outcomes where significant improvement was seen in the keyboard condition: the CAT written picture description, the total token count for the constrained writing task and the GORT-4 reading comprehension.

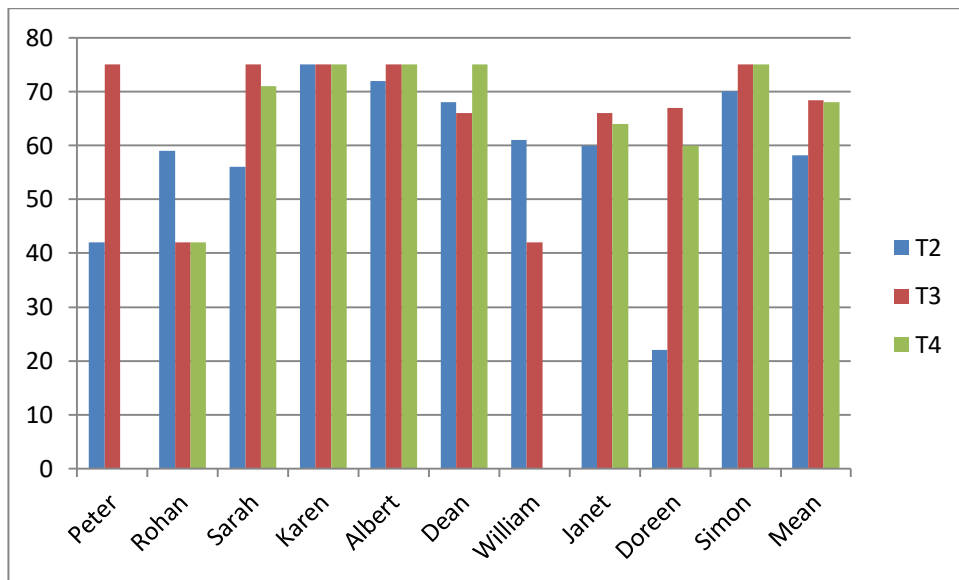
In the post-intervention keyboard versions of the writing tasks, variability among the group was more marked in the CAT written picture description than in the constrained writing task. Notably, Rohan and William's keyboard performance declined in the CAT, despite improvements in keyboard constrained writing. A majority of participants produced substantially more written text in the keyboard condition for constrained writing, a similar finding to those of Caute and Woolf [115] and Bruce et al [118]. The starkest differences between the pen and paper and keyboard conditions were evident in Karen and Peter's performances, as they were unable to produce any narrative pen and paper output at any time point.



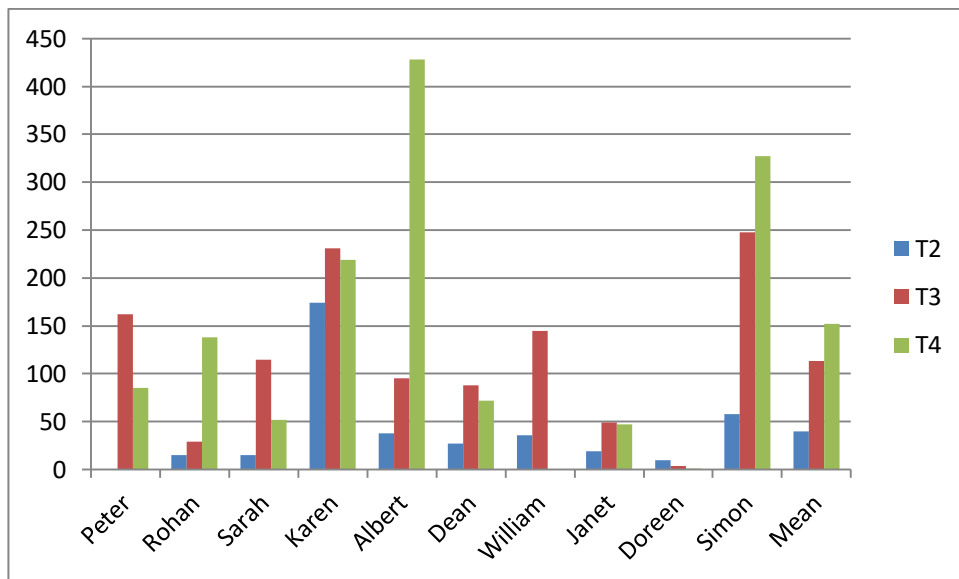
**Figure 7.12:** Keyboard constrained writing task, mean % lexical density over time



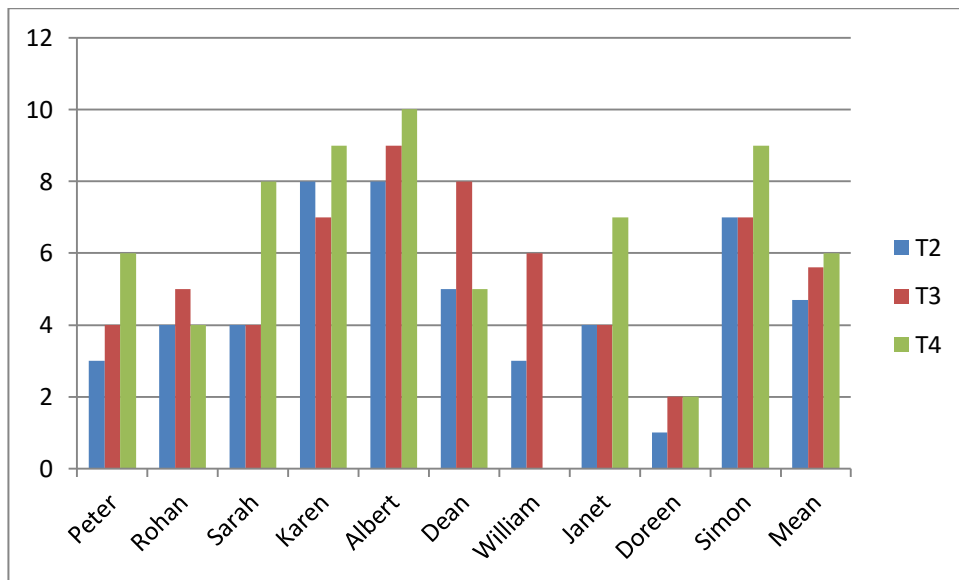
**Figure 7.13:** Keyboard constrained writing, group mean social validity judgement rating over time



**Figure 7.14:** Keyboard CAT written picture description individual scores



**Figure 7.15:** Keyboard constrained writing total token individual scores



**Figure 7.16:** GORT-4 comprehension individual scores

Peter could only produce keyboard output when using AT for dictation at T3 and T4; Karen produced lengthy texts with the keyboard throughout, a pattern which would be predicted by her intact touch typing abilities compared to her severely impaired allographic realisation skills.

There were two non-responders in the AT narrative writing tasks (CAT written picture description and constrained writing): Doreen and Rohan, the two candidates who experienced most difficulty with the AT training. Doreen's output was very limited in both conditions, with a pen and paper range of 0 – 15 and a keyboard range of 1 - 14; she found this task highly challenging and tended to discontinue it once minimal output had been produced, regardless of whether she had reached the time limit given. Rohan's performance was also limited and broadly similar in both conditions, with a pen and paper range across the four time points of 18 – 28, and a keyboard range across T1 to T3 of 14 – 29. At T4, Rohan produced substantially more output using keyboard plus AT, with 138 tokens, but unfortunately his output made scant sense when read. This may have been a result of his poor memory skills, which meant that after three months without training sessions his ability to monitor the screen had declined, and he spoke fluently but without checking what was produced.

In the narrative reading comprehension task Karen appeared to experience an initial reduction in comprehension when using ClaroRead™, followed by overall gain. Five other participants (Peter, Sarah, Albert, Janet and Simon) showed further gains at T4. These findings suggest a period of adjustment to processing synthesised speech may be required for some AT users with aphasia in order to gain maximum benefits. Conversely, Rohan and Dean showed improvement at T3 but this was not maintained at follow up. Doreen's modest gains were maintained at follow up; William also made gains at T3 but did not wish to complete T4 assessments.

There were no ceiling effects in the constrained writing keyboard task (where an unlimited amount of text may be produced), nor in the reading comprehension with AT task. Figure 7.14 appears to show ceiling effects for Karen at T2, owing to her intact touch typing skills, which were in stark contrast to her severely impaired handwriting.

### ***7.3 Outcome measures for research question 2, of social participation, mood and quality of life***

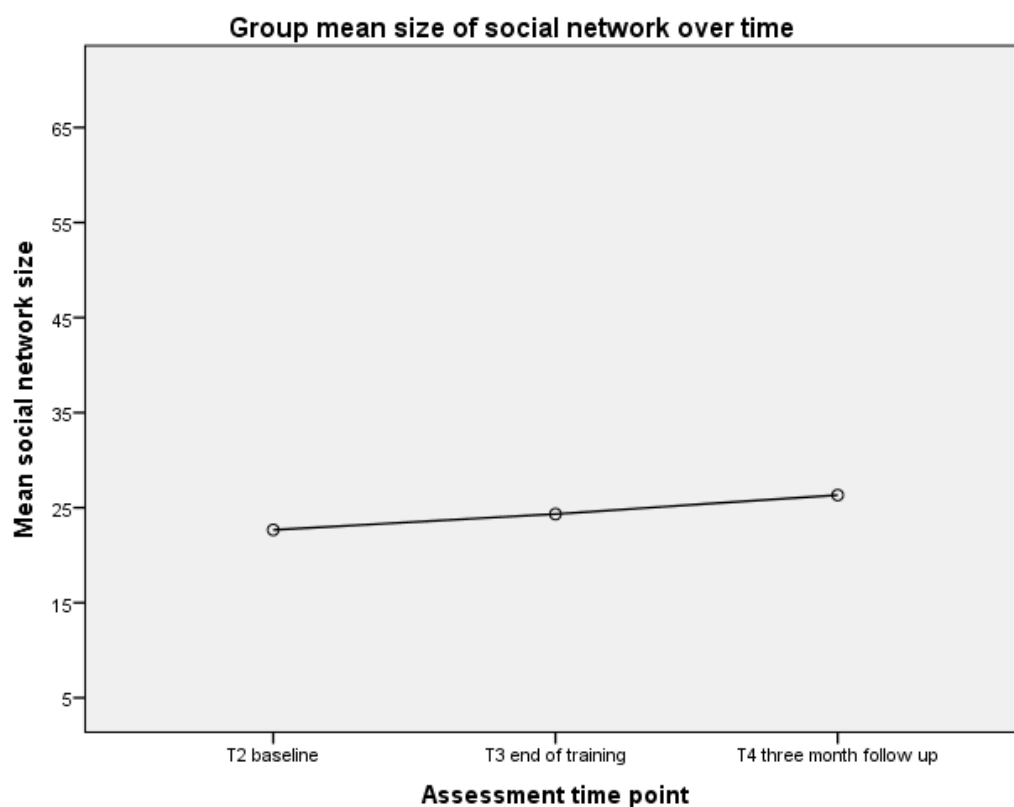
Table 7.3 details participant scores on the outcome measures used across time, including scale score range, group score range, means (SDs) and medians (IQRs). Means (SDs) are used in the text and the graph to describe the data; given the small sample size and the use of non-parametric statistics, the medians (IQRs) are additionally given in the table. There was no measure of social network size at T1, since this is a time-consuming assessment and it was considered unlikely there would be a change in network size in the six week period between the two baseline assessment periods.

#### ***7.3.1 Assessment of social participation: SNA***

The size of participants' social networks varied widely. The smallest had six individuals (Rohan, T3) while the largest had 65 (Edward, T2 and T3). There was a significant increase in the overall size of participants' social networks post-training: Friedman's  $\chi^2 (3) = 10.64, p = .005$  (Figure 7.17).

	Scale score range		Group score range	Mean (SD)	Median (IQR)
Social participation (SNA)	N/A	T2	7 – 65	22.67 (13.78)	23.00 (10.50 – 32.00)
		T3	6 – 65	24.33 (14.08)	23.00 (13.00 – 32.50)
		T4	9 - 54	26.33 (13.65)	23.00 (16.00 – 34.50)
Mood (GHQ-12)	0 - 12	T1	0 – 11	3.67 (4.12)	2.00 (.00 – 7.00)
		T2	0 – 12	3.00 (5.12)	1.00 (.00 – 6.50)
		T3	0 – 12	2.56 (3.81)	1.5 (.00 – 3.50)
		T4	0 - 12	1.78 (3.87)	1.00 (.00 - 1.00)
Quality of Life (SAQOL-39g) physical subdomain	1 - 5	T1	2.4 – 4.8	3.93 (.74)	4.10 (3.55 – 4.55)
		T2	2.9 – 4.9	4.01(.75)	4.00 (3.40 – 4.80)
		T3	2.6 – 4.9	3.93 (.87)	4.20 (3.00 – 4.70)
		T4	2.4 – 4.9	4.01 (.81)	4.10 (3.50 – 4.80)
Quality of Life (SAQOL-39g) communication subdomain	1 – 5	T1	2.1 - 4.4	3.56 (.78)	3.70 (3.00 – 4.25)
		T2	2.9 – 4.7	3.77 (.65)	3.70 (3.20 – 4.45)
		T3	2.0 – 4.7	3.80 (1.01)	4.00 (2.95 – 4.65)
		T4	2.7 – 5.0	3.93 (.76)	4.00 (3.35 – 4.65)
Quality of Life (SAQOL-39g) psychosocial subdomain	1 - 5	T1	1.8 – 4.5	3.26 (.90)	3.30 (2.45 – 3.90)
		T2	1.1 – 4.2	3.31 (1.06)	3.60 (2.70 – 4.10)
		T3	1.3 – 4.4	3.33 (1.02)	3.80 (2.60 – 4.00)
		T4	2.1 – 4.4	3.53 (.79)	3.70 (2.95 – 4.25)
Quality of Life (SAQOL-39g) overall score	1 - 5	T1	2.2 – 4.4	3.58 (0.71)	3.80 (3.05 – 4.05)
		T2	2.4 – 4.4	3.68 (0.72)	3.90 (3.00 – 4.25)
		T3	2.0 – 4.4	3.64 (0.91)	4.20 (2.85 – 4.30)
		T4	2.5 – 4.7	3.78 (0.71)	3.90 (3.20 – 4.35)

**Table 7.3:** Group descriptive statistics for assessments of social participation, mood and quality of life (n = 9)



**Figure 7.17:** Group mean size of social network over time

### 7.3.2 Assessment of mood: GHQ-12

There was a trend towards lower distress across the four time points, from a mean score (SD) of 3.67 (4.12) at T1 to 1.78 (3.87) at T4. There was wide variability within the group, with a score range of 0 -11 at T1 and 0 -12 at all other time points, and there was no significant change over time: Friedman's  $\chi^2$  (3) = 2.10,  $p$  = .552 (Figure 7.18).

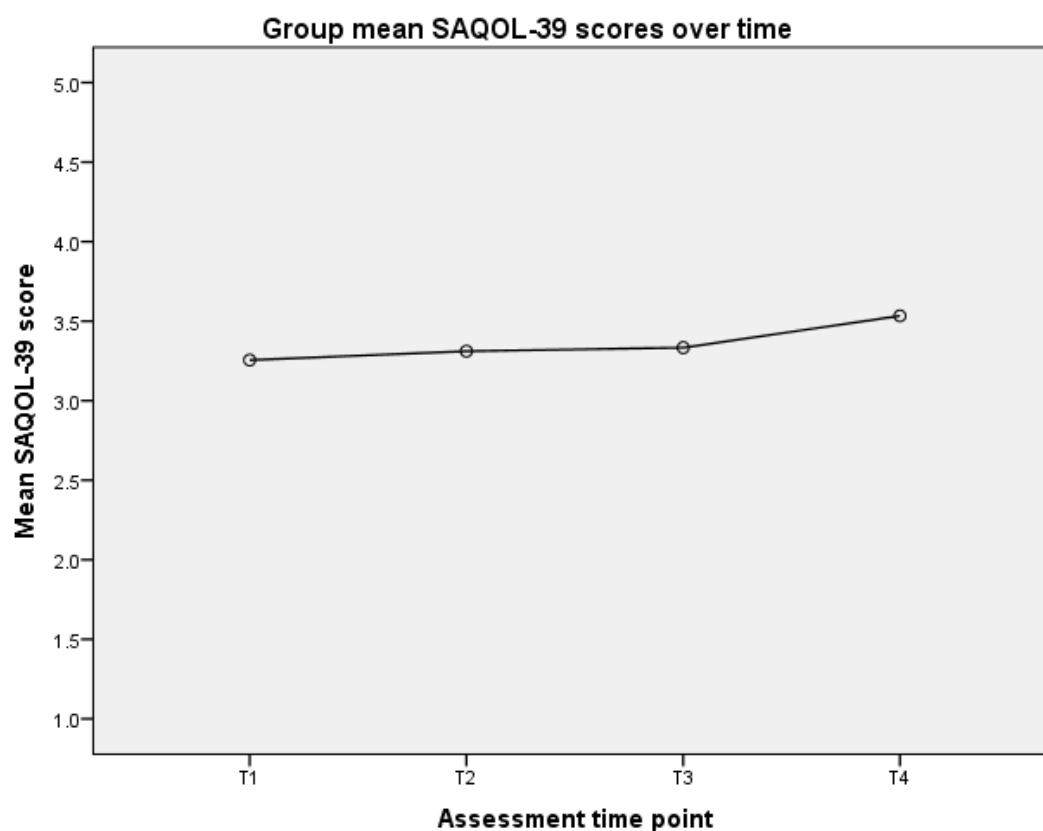


**Figure 7.18:** Group mean GHQ-12 score over time

### 7.3.3 Assessment of Quality of Life: SAQOL-39g

Group scores on the SAQOL-39g showed a trend towards higher scores, where higher scores indicate improvement in quality of life, across the four time points for two of the three domains (communication and psychosocial), and for overall score. To minimise multiple comparisons, only the overall score was compared statistically. The score range was 2.2 – 4.7, with the lowest mean (SD) of 3.58 (0.71) at T1, and the highest at T4: 3.78 (0.71). Again, perhaps owing to the wide variability within the group, there was no significant change: Friedman's  $\chi^2$  (3) = 4.66,  $p$  = .199 (Figure 7.19).





**Figure 7.19:** Group mean SAQOL-39g scores over time

#### **7.4 Summary**

Chapter 7 began by presenting descriptive statistics for the screening and monitoring assessments used in the study, which tested cognition, language, single word writing and single word reading. The remaining part of the chapter then focused on the results of all the quantitative outcome measures, used in this study to address RQ1 and RQ2. It described how both group narrative writing and group reading comprehension were significantly improved by the use of AT, and that no such improvement was seen in the pen and paper condition over time. Finally, it revealed an increase in the mean size of the group's social networks over time, but no significant improvements in mood or quality of life for the group as a whole.



## **Chapter 8: Findings from qualitative observation and interviews**

This chapter begins with a description of how qualitative data for the study were gathered and analysed. Participants' reflections on life before and after stroke, with regard to their writing, reading, computer use and social participation are given, followed by their evaluations of the two software packages. Samples of participants' writing including procedural editing notes are given, then a selection of completed written texts. These are followed by observation data regarding mood and quality of life, and participants' comments on the wider implications of AT training for them. Finally, additional research observations from the training sessions are given regarding hardware, software and technical support, participants' further writing and computing support requirements and the nature of writing itself. Throughout the chapter, the data described are used to answer RQ3 and RQ4:

RQ3: What are the barriers to AT use by PWA?

RQ4: What strategies or supporting materials for using AT help overcome these barriers?

A summary of the barriers and facilitators to using each AT package is given, along with those relating to wider technology use and personal factors. The data are further used to augment and illustrate the quantitative assessments described above, relating to RQ1 and RQ2: whether AT can compensate for writing and reading impairments, and whether it can promote social participation and improve mood and quality of life. All the data presented in this chapter are illustrated with verbatim quotes from participants when appropriate.

### ***8.1 Qualitative data collection and analysis***

As indicated in Figure 1.1 (page 95), participant interviews were scheduled to occur at T2, T3 and T4, which would have resulted in a total of 30. In all, 27 interviews took place (see Appendices 4.1 and 4.2 for topic guides). Of the three missing interviews: William declined to be interviewed at T2 owing to constraints on his time and availability; he also declined to

participate in follow up assessments therefore was not interviewed at T4. Janet also declined a T4 interview as she felt she had nothing she wished to add to her previous comments.

Observational data were collected throughout the training period. In all, 90 one-to-one training sessions were delivered during the study. Four people received ten (see Table 6.1), while the other six either felt they had mastered the skills they needed to use the software independently, or we had concluded together that they had gained as much benefit as they could from the training, in a slightly shorter timeframe. The fewest sessions any individual received was seven: Simon reached the top of a waiting list for an intensive in-patient physiotherapy course during his involvement and elected to attend this; some of his training sessions were longer than one hour to compensate. Detailed observation notes were made immediately after 80 sessions, and 59 were also video recorded, in order to capture instances of software use in real time, and interrogate them for barriers to success, and strategies developed to overcome them.

Because the observation notes and interview transcripts related to one another so directly, as described in Chapter 4, it became clear that they were best suited to a single overarching thematic index (Appendix 8.1) which would allow them to be analysed as one body of data. The sections that follow detail the main themes and subthemes which emerged from Framework analysis, the procedure for which is described on page 105. There were seven main emergent themes: 1. Pre-stroke life and literacy, 2. Post-stroke life and literacy, 3. Training, 4. Social participation, mood and quality of life, 5. Dragon NaturallySpeaking™, 6. ClaroRead™, 7. Other software issues. There were a total of 45 sub-themes, including a category for 'Other' in every chart, to ensure all data were included. Appendix 8.2 shows a section of a sample chart, containing the references to stroke and life post-stroke made by Peter and Doreen, in order to illustrate the Framework process. In the data analysis below, these are presented in a different order to enable issues relating to quantitative outcome measures to be described first, followed by those relating to the AT training. This

structure also permits subthemes spanning several themes to be linked in a coherent narrative structure; for example, where participants talked about the relationship between their prior computing experience (subtheme 1.3), adaptations and strategies they had already attempted (subtheme 2.3) and their AT training aims (subtheme 3.1). A final point to note regarding the Framework analysis is that, unlike the quantitative outcome measures, the qualitative data collected were not analysed in a pre- and post-intervention format. When the qualitative data was inspected, it became clear that for the participants themselves the salient points in time, in terms of their lived experience of writing loss and the other emergent themes, were pre- and post-stroke rather than pre- and post-intervention. This is perhaps unsurprising since the intervention had compensatory goals and therefore did not directly ameliorate their writing, though it did have a positive impact on their lives, as described in section 8.3.5 below and in Appendix 8.3.

### ***8.2 Participants' former employment and training program plans***

At T2 interview, participants were asked about their former employment and the tasks they would like to pursue in the training sessions; this information is summarised in section 6.3 above (page 126). As indicated in Table 6.1 (page 109), seven of the ten participants were working at the time of their stroke, and the same number were still below the current UK retirement ages (65 years for men, 60 years for women) at T1; four of them were engaged in some form of work/volunteering/training when they joined the study.

### ***8.3 Reflecting on life before and after stroke***

The findings in this section speak mostly to research questions 1 and 2; however, discussion of these issues led naturally to conversations about factors which hinder or facilitate the various activities discussed, thereby also addressing research questions 3 and 4. The data are presented together for clarity.

### *8.3.1 Writing*

The group was highly educated and literate, and writing was regarded as an important activity by almost all of them in their pre-stroke lives. In the workplace, a wide range of writing activities had been undertaken, including: marking students' work, lesson preparation, administrative tasks, taking notes and producing meeting minutes, writing up interviews, composing reports, book chapters or journal papers and producing news headlines and stories. Several people had also habitually written at home, predominantly as a means of maintaining contact with family and friends: Rohan described himself as a formerly 'prolific' emailer (Rohan, T2 interview), writing daily to his siblings and cousins overseas, and Sarah used to send handwritten letters, following up visits and gifts with a note of gratitude.

More striking than the range of writing tasks undertaken, however, was the high value participants had clearly placed on them: for some at least, their writing skills and outputs formed an important part of their self-worth. For example, despite having retired several years ago, Albert continued to carry a copy of his CV with him, taking it out during his pre-training interview. He explained he had always felt it was crucial to condense one's achievements such that they can fit on a single page, and had neatly colour coded the text to indicate different skill sets and professional interests. He also gave me a copy of his published book, signed with an encouraging handwritten message regarding thesis completion, and telling me this would have cost me £60 to purchase. During training, William spoke eloquently about his identity as a sub-editor, and how his view of his skills had changed with the onset of aphasia:

'I was so, I was always – will spot the grammar and spelling words, I mean all the time. But now it's easier to use the machine, which is a shame – but also my explanation, my expression, is pretty bad, and a bit dull, the words. [Before my stroke, I] was writing facts and figures' (William, training session 8).

The value and role of literacy in participants' lives, and the impact of its loss on their identity and self-image, was not directly addressed with a research question in the empirical study, nor specifically probed for in interview. Nevertheless, it was striking that so many references to this were found in the observation notes during the course of training, some of which are therefore presented here to give context to individuals' motivation for taking part.

Some participants had been resourceful in developing strategies to maximise their preserved writing abilities. In the years following her stroke, Sarah still took pride in sending handwritten notes, now drafting them in full before painstakingly copying them out. Karen had created templates to organise her lecture notes; she had shared this template with a peer who in return shared her notes. Janet had hoped to refresh her skills by attending a literacy and numeracy course at her local community college, but found it too basic to be of benefit.

Though eight of the ten participants reported receiving at least some SLT post-stroke, the lack of formal therapeutic focus on functional writing was a theme common to all of the participants. Peter, the most severely dysgraphic individual, had undertaken some independent handwriting and letter formation practice, as he was anxious not to neglect traditional writing in favour of a keyboard:

'Not from them [speech and language therapists] but I'd do that myself. I was thinking that I should do something about the letters, and so I've got two books on writing, doing things like 'A's and 'B's and 'X's and 'Y's. Because I want to get that done as well as going to the computer' (Peter, T2 interview).

Albert had been given handwriting exercises by his therapist but felt they had been of limited usefulness:

‘In terms of writing, a sheet of paper was given to me and it had the alphabet written on it in copperplate and I had to do copperplate writing. I finished that and then they brought me something else and said “Well you’ve finished the course now”’ (Albert, T2 interview).

Both Simon and Dean spoke of the added difficulty of learning to write with their non-dominant hand owing to hemiplegia, and Simon also reported that in therapy the emphasis for him had been verbal communication:

‘They were really encouraging to get me to speak again but I haven’t done anything on writing, because I’m right-handed so I’ve actually had to learn to do left-handed but that’s the only thing they did, and then once you come out of hospital, which was four months [after the stroke], then I didn’t get any help at all’ (Simon, T2 interview).

Sarah touched on the fact that, in therapy, writing can sometimes primarily be seen as a means of cueing spoken communication rather than as a communicative activity in its own right; when asked whether she had received writing therapy she responded: ‘Not a lot. Only because I’m not good at writing down’ (Sarah, T2 interview). A couple of participants mentioned that they did now use writing to support other communicative and memory deficits. Doreen acknowledged that sometimes writing the first letter of a word she was grasping for could help her resolve word-finding difficulties, but wept as she said: ‘It’s annoying.’ She explained that she continued to practice spelling and writing at home, but found this very challenging: ‘I do some writing, but that’s with myself – sentences? But not successfully’ (Doreen, T2 interview). Albert said:

‘My diary is my bible. Before I could always remember what my appointments were in business and who they were with, in fact I had a phenomenal brain in that respect. I have learnt to adjust but it’s been big hurdle for me’ (Albert, T2 interview).



### 8.3.2 Reading

Reading for pleasure also featured strongly as a leisure activity for a majority of participants prior to stroke. Peter enjoyed detective stories, science fiction and fantasy novels. He also collected dictionaries, and still had one given to him by his older sister when he began attending Grammar school aged 11, more than 60 years before. Sarah said: 'I used to read a lot . . . biographies, novels, autobiographies, just anything' (Sarah, T2 interview); Doreen read approximately one non-fiction library book per week, besides lots of background reading for her work. Janet enjoyed 'trashy, fun' books, and joked wryly about the frustration of having read three of a ten book series at the time of her stroke, and needing to know how the story ended (Janet, T2 interview). Rohan read a daily broadsheet newspaper and two academic journals related to his field, and Albert read two or three novels a week. A minority of participants were not such keen readers prior to stroke: Karen said that her life was so busy that whenever she settled down to read she would invariably fall asleep, Simon explained: 'I was a slow reader and I used to read every word . . . nothing serious but I read a couple of biographies or whatever' (Simon, T2 interview) and Dean said he read: 'Newspapers mainly, and magazines'; he had also enjoyed the autobiography of his favourite footballer (Dean, T2 interview).

Stroke and aphasia necessitated participants adjusting both their approach to reading and their choices of material. Doreen could no longer access novels but enjoyed dipping into a pocket-sized book of proverbs and sayings entitled 'Live, Laugh, Love' [234], explaining: 'I can't read it aloud, but I can in my mind!' (Doreen, T2 interview). Dean referred to the challenge of retaining information and concentration, saying: 'I do find when I'm reading anything I kind of go off trail or maybe something else will just come into my mind, [I] kind of lose what I'm reading' (Dean, T2 interview). Peter echoed this, citing a fondness for limericks as they suited his attention span, and reporting that he still enjoyed re-reading familiar books such as *Alice in Wonderland* [235]. He could manage short stories 'as long as they are not intellectual' but had donated many of his longer books

to charity shops (Peter, T2 interview). Likewise, Sarah said she continued to read short stories and to look at the newspaper, but no longer attempted novels, adding: 'I'm not good at reading, it's very, very hard indeed' (Sarah, T2 interview). Simon had read just one book, the autobiography of a Paralympian athlete, since his stroke more than three years before. Albert's reading rate had also reduced substantially – since his stroke a novel took him two to three weeks to finish and he had begun needing to renew items at the library – nevertheless, he had adopted strategies to support his reading, such as recapping the plot after a break and creating short versions of characters' names to aid his recall, and said: 'Reading is about the only thing out of which I can get satisfaction, it is a major part of my life' (Albert, T2 interview).

### *8.3.3 Computer use*

Computer experience prior to stroke ranged from minimal – Sarah's husband had a home PC but she had felt no inclination to engage with it herself and her teaching preparation was purely paper-based – to those for whom software use had been an enduring and central part in their professional lives: for example, Rohan's main role had been teaching under-graduates how to program and to set up computer networks. Between these extremes, most participants used computers very regularly. Some participants said workplace computer use had become widespread during the course of their careers, and they had had to adapt their practices accordingly, for example Albert explained:

'In the beginning when there were no computers, you had an IBM electric ball typewriter, word processing. I came into computing as it came into banks and it was "a thing", computer departments were always the be all and end all' (Albert, T2 interview).

Janet described herself as a former 'technophobe' who was forced to learn email and expressed surprise at how 'seduced' she felt by 'my beautiful computer, that they just plopped there [on my desk]' (Janet, T2 interview).

Others said that using computers had always been an integral aspect of their work, but its function had evolved over time: for example, Doreen recalled how joint report writing became more streamlined once she and her colleagues could share a document and add comments by tracking changes rather than printing them and making annotations with pen in the margin. While most had used basic Microsoft Office packages or their equivalent for tasks such as letter writing from templates, some had also developed more specialist software skills: Karen had used Dreamweaver software to build webpages, and Peter described his historical use of Fortran, a programming language, and of BBC computer hardware, now long outmoded but regarded by him as superior to more recent developments. Dean had not had a computer at work but in his leisure time had used his laptop frequently, 'to go on Facebook or maybe look something up [on the Internet]' (Dean, T2 interview). Doreen had also used social media including Facebook prior to her stroke and had regarded this as a useful means of keeping a benevolent eye on the young people she had worked with, and Janet continued to use both Facebook and Instagram enthusiastically. The remaining seven participants were not social media users, and Simon was vehemently opposed to its increasing popularity, saying:

'I absolutely detest the fact that kids put onto Facebook "Oh I'm going on holiday to Barbados," well: I don't give a flying! I don't agree with that, I need to speak to people face to face rather than on the Internet, and I think the information that they give – I say to the kids now, that people when they employ you, [they] look at those sort of things and [social media users] say "Oh I got hammered last night" and put it on there, it's bloody stupid' (Simon, T2 interview).

Since stroke, there was a prevailing sense of feeling deskilled, and sometimes demotivated, with regard to computer use. Simon said he had had to relearn basic computer skills after his stroke, but had recovered his

former skills sufficiently to construct a PowerPoint presentation with his daughter's support. He also used the Wikipedia directory on his iPad, though he sometimes found this produced more information than he could absorb. Peter already had a version of ClaroRead™ installed on his laptop, given to him by a former colleague, but was uncertain how to operate it and used his computer purely to access news online. Rohan had many items of computer hardware in his living room, however he appeared to have limited recall of which software packages were installed on either of his two laptops, and now used them mainly to Skype his relatives overseas. Despite the basic skills workshop she had attended, Sarah said that she lacked confidence. When asked to demonstrate what she could already do, she lifted the mouse off the desk, pointing at the screen and clicking as though it were a television remote control, suggesting her memory of previously learned skills may also have deteriorated. Albert said:

‘I was learning, I mean I was doing quite well in basic computing, but after the stroke I lost the ability and I suppose the urge to some extent. Now my 15 year old grandson comes up to me and says “What on earth are you doing?!”’ (Albert, T2 interview).

There was a divide amongst the group regarding attitudes to requesting help. Simon, Albert, Karen and Sarah all spoke positively about receiving help from children or grandchildren, and Dean and Rohan both frequently invited and welcomed advice from peers who worked in IT or computing – a cousin and an ex-colleague respectively. Doreen was disappointed that her partner and siblings were not more able or inclined to offer encouragement. However, the rest of the group preferred not to ask their spouse or partner for advice: Peter explained this would often result in disagreements owing to differing problem-solving approaches, while Dean said he felt this would represent an additional burden on his busy partner, adding that his ideal scenario would be to do some of her administrative computing tasks rather than vice versa.

In contrast with the rest of the group, Janet reported using software more since stroke, having become very keen on social media platforms such as Instagram and Facebook - mostly accessed via mobile phone apps - as a means of maintaining contact with friends. Dean also continued to use Facebook without difficulty, and frequently watched films online. Doreen expressed sadness that she had lost touch with many of the young people she had worked with since she ceased accessing Facebook after her stroke.

#### *8.3.4 Social participation*

Many of the group described full and active social lives pre-stroke, and a marked reduction in participation in the aftermath of illness. Sarah said that before stroke her social life was 'very good.' She took Italian lessons, played squash and hockey and went to the gym twice a week, saying she had always been very sporty 'even as a child' (Sarah, T2 interview). Many of these outlets were lost to her owing to physical impairments and though Sarah went on outings with her husband and son and was still able to drive, she felt less independent. This was a theme echoed by Doreen, who felt isolated and neglected because her friends always appeared busy with work. She reminisced about her fondness for high heels and smart workwear; by contrast for training sessions in her home she often wore nightwear and a leg splint. During one visit she became very distressed because she felt compelled to cancel a hairdresser's appointment since her partner could not escort her there.

For some participants, work and social lives had been linked, and changes in the former had also resulted in shifts in the latter: Rohan explained that his entire friendship circle had been composed of work colleagues, and that besides office contact they would meet once a week for a drink in a pub, and also kept in touch by telephone. When his work life ended, a significant portion of his friendships also dwindled, and though a couple of his closest friends and colleagues visited him at home when they could find time, the dynamic of their friendship had changed now that Rohan no longer worked in their mutual field of expertise. Karen's social life had also been bound up with work, as she had worked within her local community

and often saw colleagues socially. She used to be so busy that she felt she had no time for outside interests, but appeared to regard this as a desirable state, saying:

‘For me that was relaxing, because it was an area [of London] I had grown up in. People always say “Have you got a hobby?” I’ve never ever had a hobby honestly!’  
(Karen, T2 interview).

Not surprisingly, when Karen’s workplace dispute began post-stroke it was challenging to keep this from impacting on her wider community life.

Men with wives and children/grandchildren appeared to have fared comparatively well among the group at maintaining outside interests and links, despite sometimes feeling their competence had diminished. For example, Simon now found playing golf more difficult, but still enjoyed visiting his club for a drink and conversation. Albert continued to play bridge regularly, though he struggled somewhat more with his perceived change in ability:

‘I was a very determined man and that sort of causes the frustration, I told you that the word that described my stroke best: Sheer. Bloody. Frustration. I’ve always challenged the status quo, I’ve transferred my ability from one business to another, but they’ve always been- I’ve been with big companies at a director level, so you can imagine how having a stroke brought me down to earth’  
(Albert, T2 interview).

In the past, Dean had been frenetically busy:

‘I was literally in the fast lane then. Working full time, I’d go home and sometimes I don’t even have nothing to eat and I’d say: “Oh, I’ve just got to go up the road to get a paper,” and then I’d go out and then I’d find myself somewhere else. Even though I had work the next day,

going to bed around two or three, getting up at seven to go to work. I was getting bored too easy, everything was fast which obviously wasn't good because I had high blood pressure, [doctors] were saying to me "You need to slow down"' (Dean, T2 interview).

Yet although a majority felt their social participation had declined since stroke, some commented on positive changes. Janet was able to spend more time with her friends and her son now that she had left the pressure and long hours of her corporate role behind. She said:

'It's interesting, if I wasn't a stroke, actually I would like my life now. Which is quite amazing. I mean sometimes I can't speak properly which is awful, sometimes I'm really "Oh, oh" [indicating feeling downhearted] but I've just got to think "I'm great" sort of thing' (Janet, T2 interview).

Similarly, Dean described the benefits of reappraising his lifestyle as a result of illness:

'It's bad that I've had a stroke but in a way it's kind of slowed me down, made me look at the way my life's going, so now I'm going to the gym and I'm being a bit more healthier, being a bit more careful in the things I'm eating, eating a bit more salmon; I suppose it's good in that way that I've had a stroke, if you can say that' (Dean, T2 interview).

Several participants attended support and communication groups for people with stroke and aphasia, and some had taken on formal or informal roles running these groups or providing conversation and friendship for others who had had a stroke.

### *8.3.5 Mood and quality of life*

As a group, perhaps owing to the length of time since onset of stroke and aphasia, there was an overall picture of having already adjusted to living with a chronic condition. Nevertheless, there was some variation, which was illuminated to a degree by observation data. Peter, Rohan, Sarah and Simon presented as cheerful and relaxed throughout training. William's mood was somewhat changeable, as were his levels of engagement with and enjoyment of the training; his time keeping and attendance were also erratic. Albert experienced a period of uncertainty and discomfort owing to a health complaint (unrelated to stroke) which resolved over the course of the project, affecting his sense of well-being; several training sessions also had to be rescheduled to accommodate his poor health, but he remained committed and enthusiastic throughout. Dean and Janet both appeared to experience improvement in mood during the project; several times during her training Janet expressed pleasure that her career was progressing well after a slack period, which may have accounted for this shift. Karen was diagnosed with depression during the course of the project, and began receiving counselling; she also had many ongoing family concerns which persisted throughout, and her mood was consistently low. She described sleep disturbance and fatigue, and was prone to cancelling training sessions at short notice. Doreen frequently became markedly distressed during training, and with her permission she was referred for counselling. Doreen was emotionally labile as a result of stroke, and AT training appeared to emphasise her deficits and lower her mood.

Objectively, Karen and Albert were the least impaired participants communicatively, physically and in terms of writing function, yet they described their quality of life as poor: as described above, both were experiencing other health or psychological issues. During the course of his training, William made many remarks indicating he continued to feel the loss of his former profession, and that this had a negative impact on his life; Doreen experienced similar emotions, to a far greater degree. Conversely, Rohan was cheered by the fact that his physical condition was



improving steadily, and was beginning to take short walks around his neighbourhood and to his local shops, and to make plans to visit family overseas. Simon described feeling fortunate that he had a spouse and children, as he knew of other individuals who had had strokes who did not have families and whose quality of life he regarded as far poorer than his own. Sarah continued to regret that her physical impairments impeded her independence, but had a broadly upbeat outlook on her quality of life, as did Janet and Dean, both of whom could see positive outcomes of their strokes besides disadvantages, as described above.

Several participants explicitly referred to the positive social and psychological impacts of AT training on their quality of life, comparing being able to re-access writing to releasing a blockage or filling a gap. Albert said: 'I had a hole in my life in terms of communicating and you've filled that void, and that's why I've enjoyed it so much' (Albert, T3 interview). Doreen described her sense of being full of things she wished to communicate that she had been unable to share: 'So many words up here, I'm getting [crying]. It's a new beginning for me, this is' (Doreen, training session 4). Peter became quite emotional on several occasions during training sessions, and his wife reported this also happened at home when he received replies to his written correspondence. He explained:

'It's because I haven't had any way of talking to them [his children] in emails. This is something I have not been able to do for ten years. Ten years! You have got [rid of] a blockage in my thoughts, it's fantastic, just marvellous, beautiful.... Do you understand, it was like a river – not a river but a big lake and there was a dam there, and what you really wanted to do was get the dam away. As a result of my stroke, my dam was there and my lake was bigger and bigger' (Peter, training session 9).

This positive response was reiterated by both his son and a close friend in their replies to Peter, as shown in Appendix 8.3.

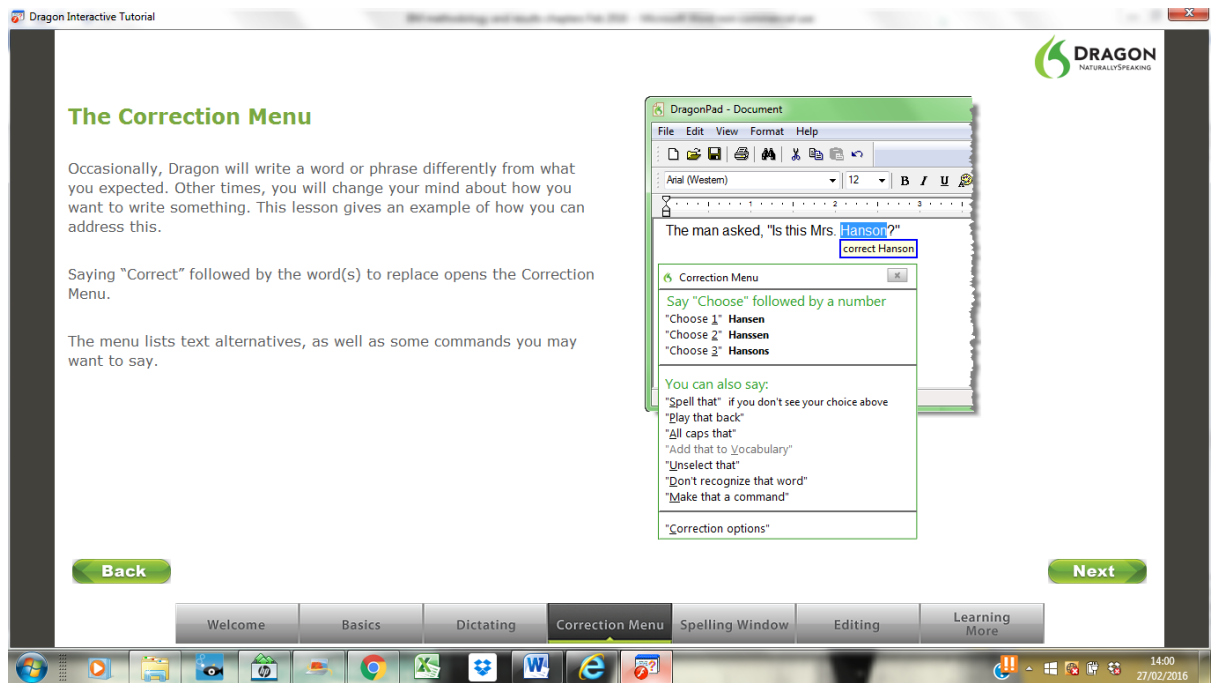
## **8.4 The software packages: participants' evaluations**

### **8.4.1 Dragon NaturallySpeaking™**

#### **8.4.1a Interactive tutorial**

One of the built-in features of Dragon NaturallySpeaking™ is a tutorial designed to familiarise new users with a range of software functions, including activating, ending and pausing microphone use, dictation, and commands for inserting punctuation and for navigation. In the tutorial, written instructions appear on the screen which the user is required to follow in order to undertake verbal tasks which illustrate these functions. This was used with the pilot study participants and attempted with most of the members of the training group. However, the feature was almost universally disliked: participants found it difficult to manage owing to the speed required to gain accurate results, and the cognitive burden of simultaneously reading instructions, producing speech and checking it for accuracy. As shown in Figure 8.1, the screen appears busy and complex, and the language is not accessible for PWA. The tasks also appeared rather abstract and meaningless to some; for example in the exercise in the figure, users are required to repeat the following sentence: 'The man asked, "Is this Mrs Hanson?"' which created confusion as to who these characters were and why they would wish to write about them. It was anticipated that for Doreen this would be highly off-putting, therefore it was omitted from her introductory training and replaced with a more straightforward overview of each task in isolation, each with a demonstration then an opportunity to practise each skill.

In contrast with the rest of the group, Simon responded very positively to the tutorial, and reported that he had also repeated it independently several times, saying 'You know men and their new toys' (Simon, training session 2). This was perhaps indicative of his confidence and willingness to experiment, but may equally have been because he was one of the most fluent speakers in the group and so saw better results from the tutorial.



**Figure 8.1:** Dragon NaturallySpeaking™ Interactive Tutorial screenshot

#### *8.4.1b Initial voice training*

The conventional way in which to train Dragon NaturallySpeaking™ to recognise a new user's voice, vocabulary and writing style is to read aloud from a selection of texts provided as part of the software. These are listed in Table 8.1, along with the indication of complexity and genre provided by the software. Most of the group coped well with this task, particularly when assured that the main focus was to produce four minutes of connected speech, and therefore that specific reading errors would not affect overall outcome. Almost all of them opted to read the instructional text on speech recognition, which also provided a useful first overview of the software's main functions; Albert selected President Kennedy's inaugural address, but also went through the instructional text when offered the opportunity to do so in a subsequent training session. However, for Peter and Doreen, it was clear that even the least complex passages would be too challenging for them to read. In previous iterations of Dragon NaturallySpeaking™ this would have represented a major barrier to their participation in the training program. Fortunately, the most recent versions will accommodate any form of speech for voice training, so they

<b>Title</b>	<b>Complexity and genre</b>
What to expect from speech recognition	Easier reading: instructional
President Kennedy's inaugural address	Medium reading: historical speech
Dave Barry in Cyberspace	Medium reading: humour
Dogbert's top secret management handbook	Harder reading: humour
Pigs, wolves, owls and more: stories by children	Reading for children
Alice's adventures in Wonderland	Reading for teens: fantasy

**Table 8.1:** Choice of passages to be read aloud for voice training

both simply wore their microphone headset and activated it, then either engaged in informal conversation about the previous weekend (Doreen), or retold a story from memory (Peter), until a four-minute sample of their speech had been collected.

#### *8.4.1c Dictation*

The majority of participants found the core activity of dictation to be the software function they could exploit most fully. Peter, Sarah, Dean, Janet and Simon were almost immediately able to produce accurate sentences and narrative paragraphs without difficulty; indeed, Peter's speech for writing revealed noticeably less circumlocution than his spoken conversation. Sarah noted with pride that her 'BBC English' helped her ensure accurate dictation (Sarah, training session 4). By contrast, she initially felt some discomfort with microphone use, attempting to switch it off every time she wished to pause. Once reassured that she could simply fall silent, leaving the microphone active but resting while she composed her thoughts, her delivery became much smoother. Albert was initially a tentative and somewhat anxious user. He commented insightfully on this, noting he felt 'conscious' of the 'synthetic' set up and the demands of monitoring both the screen and the microphone, planning his speech and the presence of an audience (Albert, training session 2). Nevertheless, Albert soon became one of the most prolific and confident writers in the group. Though Karen chose not to write new material during training, she

was instantly able to achieve perfect accuracy when reading aloud to test the software.

Peter and Albert were both keen to understand more about the underlying mechanisms of Dragon NaturallySpeaking™, asking how it is able to discern between homophones. Like Albert, Simon remarked on the additional skills required for dictation rather than conventional writing, saying:

‘You have to have the brain power: [it] is more than just writing it, because you write it without having to think about your hand movements; now you’ve got to see it and hear it and so it adds more complex things to your brain’ (Simon, training session 6).

Rohan, William and Doreen had markedly more difficulty with producing dictation than the rest of the group. To briefly illustrate: Rohan found it challenging to speak naturally and calmly for dictation, and often used a loud and staccato style. On one occasion, he rehearsed something in a normal voice, not realising the microphone was on, and his dictation was produced perfectly on the screen; when he tried again using his favoured dictation style there were numerous errors in the text. William was deeply frustrated by the inaccuracies which occurred when he attempted polysyllabic words and complex sentences, and would often repeat these words several times with mounting irritation. Unfortunately, this strategy was highly unlikely to result in success since one of the features of Dragon NaturallySpeaking™ is its capacity to make sense of surrounding items to contextualise a target, which becomes increasingly difficult when there is repetition. With encouragement William would sometimes delete errors before repeating words or attempting to rephrase, but this made for onerous work. Doreen experienced high levels of distress owing to her word finding difficulties, which appeared to be compounded by contemplating a blank computer screen. She also found it difficult not to vocalise her frustration when a word eluded her, and would often exclaim ‘Oh God!’, which would then appear in her text. Her emotional state

affected her voice, in turn making her speech more difficult for the software to recognise.

#### *8.4.1d Commands*

Participants were given prompt sheets with frequently used commands for punctuation and navigation, and these were modified to suit each individual's needs as training progressed; Janet's is shown in Appendix 8.2. Some participants were very proactive about learning as many commands as possible, for example Albert asked how to create a new paragraph at the outset of his training, and later enquired how to underline text. As with dictation, Peter was keen to understand how the software processed whether spoken punctuation should appear as a symbol or a written word, which led to an interesting discussion of the Dragon NaturallySpeaking™ 'mode' system. Karen, who was previously a school secretary and very familiar with dictating text, instantly grasped the procedure for using commands, and adopted it intuitively with little training.

However, some participants found certain commands difficult to use consistently. For example, Albert often said 'stop' instead of 'full stop', resulting in 'stop' appearing as dictated text rather than the symbol he sought, and once politely said 'please scratch that' rather than the more imperative 'scratch that.' Albert's issues appeared to relate to memory, while for others the problem was one of production: for example, Janet and William both struggled with saying longer punctuation commands such as 'exclamation mark,' 'new paragraph' or 'open quote' sufficiently quickly for them not to be misinterpreted as dictation. There were numerous instances of failure to turn the microphone on/off with a voice command at the beginning and end of dictation, which resulted either in dictated sentences failing to appear, or in conversation between participant and researcher mistakenly appearing on the screen. Some participants chose to operate the microphone manually instead, though they commented that this would be easier if the on/off button on the screen was larger. More broadly, over half of the group actively preferred to use the keyboard in

order to insert any punctuation marks, particularly those who were able to use both hands and could therefore operate the Shift key.

One particular command which was routinely and effectively used by all was 'delete that'. This command deletes the latest piece of dictation produced, in 'chunks' according to bursts of spoken output. This usually worked well, though occasionally too much text disappeared and its dictation would have to be repeated, or chunks were too short and multiple commands were required in order to remove longer sentences. Deleting unwanted text was far more challenging if it was not that which had been most recently dictated, for example if an error was noticed during proofreading. To complete this process with a voice command involved first selecting the text required to be deleted by saying 'select' followed by the word/s for deletion, and then either choosing a suggested replacement if a suitable one was offered in the activated drop box, or using the 'delete that' command then dictating an alternative. An additional complication was that the 'select' command highlighted every instance of a particular word, even if only one of these was intended for deletion. The pragmatic alternative used by participants was to manually select a word with the mouse and cursor, then to dictate a different word in its place, before finally moving the cursor back to the end of the document. For Rohan, who had the most marked motor impairments of the group, this was not a workable solution, and added a further layer of difficulty for him.

#### *8.4.1e Editing*

Simon, who produced one long narrative text of approximately 2,000 words, gave many interesting insights into the editing process over the course of his training. He had begun by dictating large volumes of text without paying much attention to the screen, keen to get a draft on paper and stretched by the demands of monitoring his written output as well as thinking about what he wished to say. However, he reported that this strategy turned out to be unsatisfactory, since when he returned to his document in order to edit it, he noticed errors but by then could not

always recall what he had been intending to write. He concluded that it would ultimately be less burdensome to correct his work as he wrote, paragraph by paragraph:

‘It took me two hours just to do [edit] the first two or three paragraphs, I thought: “Sod this, pain in the arse!” And when I read over it I thought: “What a load of garbage!” So it’s good in that respect because if you do paragraph by paragraph then you think: “Hang on, now I’m more – not confident, but that sounds right, then we’ll move on”, rather than spewing out a whole load of garbage that was not relevant or whatever’ (Simon, training session 4).

As with dictation, Simon also described the cognitive challenge of editing by voice, explaining:

‘It is difficult correcting because your brain is thinking twice, you’re thinking about what they’re saying and – well three times: what you’ve said, what you’re trying to say, and what you need to change’ (Simon, training session 7).

By the end of his training, Simon was sufficiently confident using both software packages in tandem that he could listen back to a paragraph using ClaroRead™, decide how he would like to change it, then delete it and re-dictate a new version using Dragon NaturallySpeaking™. He said this was easier for him than selecting single words and changing them one by one; clearly though this required strong memory and processing skills and was not an option available to everyone. The rest of the group tended to select single words or much shorter sections of text with the mouse, delete it and then re-dictate it. Some individuals with milder spelling impairments also actively enjoyed the opportunity to insert the occasional single word with the keyboard.



#### 8.4.2 ClaroRead™

##### 8.4.2a Prosody

Doreen described the spoken output of ClaroRead™ as ‘clear’ but most other participants evaluated it less positively (Doreen, T3 interview). The group were particularly united by their antipathy towards the unnatural prosodic pattern of the software’s ‘voices’ and the way this made their compositions sound flat. Sarah said:

‘The person that speaks, speaks [laughs] terribly! I don’t like that at all. They are American anyway, and also they are just dull. But also they are reading back words but without meaning, for example I say [conversationally] ‘What are you going to do today?’; [staccato] “What ... are ... you going...to ....do today”’ (Sarah, T3 interview).

Simon agreed, pointing out that ClaroRead™ sounded as though it lacked punctuation:

‘I found that immensely irritating: when they spoke they probably wanted to put a comma in and didn’t, and they said something like [adopts robotic monotone] ‘we are going to .... the zoo’ and it was so annoying. If they could change the voice so it was more, it had more up and down what do they call – [referring to varied intonation]’ (Simon, T3 interview).

Dean joked that he would like the software to be more personalised: ‘It could’ve had like a more sexier voice. Like “Welcome Dean, how are you?! How’s your day been?” [laughs]’ (Dean, T3 interview).

However, though he found it distracting, Simon noted that ClaroRead™ bland prosody could also potentially be helpful:

‘Especially when I was editing. When it’s finished it’s nice because then it reads properly; when it’s not reading

properly it sounds so desperate you think “Oh my God!””  
(Simon, training session 4).

To clarify what Simon meant here: he was initially correcting his work by sight, then listening back to it once he felt it was almost correct, in order to prevent himself becoming discouraged by errors:

‘So I’ve read that through now, and I know a few things are wrong, but it can flow reasonably well. When it doesn’t flow and you’re doing stupid things it’s- I think it’s so annoying actually, because you know it’s wrong, but somebody telling you, saying it, you bloody idiot . . .!’  
(Simon, training session 4).

In a subsequent session he seemed to be warming to ClaroRead™ yet more:

‘Actually it’s quite good because sometimes when you’ve done a sentence you think it sounds so bad it encourages you to think “Hang on, I’ve got to restructure that quite dramatically”, so then you can think “Start again or edit it”’ (Simon, training session 6).

#### *8.4.2b Navigation*

Navigation within the ClaroRead™ program was not always straightforward. Depending on the format of a document, there are different procedures to follow in order to listen back to written text: users are required to hover and highlight in a PDF, but click and highlight in Microsoft Word documents. This could be burdensome in terms of memory, and participants with more severe motor impairments such as Rohan also found clicking and dragging difficult to perform. The menu bar was felt to be visually distracting and appeared by default in the middle of the screen, though it could be dragged and fixed elsewhere; Karen explained:

‘When it comes up on the screen, it’s quite chunky? It doesn’t seem to like you going to the tool[bar], it just sort of sits in a big block’ (Karen, T3 interview).

She also found ClaroRead™ did not always function well when used for reading boxes or sections within a diagram. Peter recalled the potential for confusion when menu commands are read aloud, in addition to dictated text:

‘The trouble is, it’s something to do with ClaroRead™ and the Internet it gets- not confused but it gabs on and gabs on’ (Peter, T3 interview).

Again, this default setting could be changed, but procedurally this required several steps, and when the program was closed down and reopened it reverted to the default setting.

#### *8.4.2c Personal preference*

Despite the two areas of criticism above, ClaroRead™ was broadly regarded as beneficial by some members of the group. Karen was the most enthusiastic user, noting that Claro aided her concentration and absorption of information:

‘Oh, I love that, yeah. Once I’d started to use it I realised how much better it was to listen and then read, it was much easier, it seemed to stick?’ (Karen, T3 interview).

Like Simon, Dean made use of ClaroRead™ for editing his work: ‘I do a letter then I’ll go to Claro to see what it sounds like, if I’ve done any mistakes or anything.’ When asked if he thought he noticed more errors when using ClaroRead™ he replied: ‘Definitely.’ He also remarked on how much more relaxing both writing and reading are with the support of the software: ‘I don’t have to read it now, I can just sit back and listen to it. And then I can put it [the microphone] on and say “I don’t like what you sent!”’ (Dean, T3 interview). However, some participants with less impaired reading did not rate ClaroRead™ as useful: William said that he found

enabling the predictive text function on his laptop to be more helpful, while Albert and Janet found listening was such a distractor that they actively preferred to read conventionally from the screen.

## **8.5 Written outputs**

### *8.5.1 Genres and activities*

Written outputs were categorised into those which were purely for personal use (reflective writing, reviews, online shopping/searching the web and making lists) and those which were designed to be shared with an audience and to receive a response (email, forms and applications, letters/notes and social media use). The activities pursued by each participant over the course of their training period are indicated in Table 8.2. Seven of the ten participants (Peter, Sarah, Albert, Dean, William, Janet and Simon) produced a substantial body of work, and six (all but William) were broadly satisfied with the accuracy and performance of the software they used. Detailed descriptions of the processes used by these six participants, and samples of their completed writing tasks, are given below, but to summarise: an email account was created with Peter in an early training session, and over the course of his training he emailed all of his children, an old friend and a researcher at City University London in whose project he had previously participated. He received responses to many of these, and ongoing email conversations ensued. Peter also frequently practised using the software independently, composing a total of seven documents at home. He enjoyed 'window shopping' for a cordless microphone headset in a later session, and subsequently bought one online with his wife's help. Sarah wrote about her early work life and her son's school life. She emailed a friend, wrote a shopping list, browsed department store websites, and researched shopping and sightseeing opportunities to prepare for her forthcoming holiday. True to his plan, Albert wrote a series of humorous stories about his career, linking them all with the coda: 'The moral of this story is...' He did some of this writing independently at home and by the end of his training sessions had written

	Personal				Reciprocal				
	Reflective writing	Review	Online shop/search	Lists	Email	Forms and applications	Formal Letter	Informal note	Social media
Peter	✓		✓		✓			✓	
Rohan	✓				✓				
Sarah	✓		✓	✓	✓				
Karen	No new or spontaneous compositions produced								
Albert	✓				✓				
Dean		✓			✓	✓	✓	✓	✓
William	✓					✓			
Janet	✓	✓		✓	✓		✓		✓
Doreen	✓		✓					✓	✓
Simon	✓								

**Table 8.2:** Written outputs

seven documents. He also experimented with email but felt that he would prefer to keep this correspondence brief and consequently did not need AT to support it. Dean applied for a Freedom Pass (entitling people with disabilities to free public transport in London), wrote a review of his football team's recent form, and set up email accounts for himself and his daughter then dictated an email to his partner. Besides these tasks, the main project activity for Dean was appealing against a decision to reduce his Disability Allowance, also likely to result in the loss of his car, an issue which had been troubling him for several months. Janet produced lengthy emails to two friends over the course of several weeks, besides a film review, a reminder note of work activities she had planned, and a letter of complaint. As planned, Simon wrote an autobiographical account of his life before and since stroke. Keen to practise his skills independently, he spent a good deal of time at home editing and adding to the document, and by the end of his training it was over 2,000 words long.

For the remaining four participants (Rohan, Karen, William and Doreen), progress was somewhat less straightforward. All were able to produce some writing, but were either less satisfied with the written outcomes produced, or faced other challenges. Again the processes they adopted and writing samples they produced are explored in detail below, but in brief:

Rohan had a distinct Sri Lankan accent, and it proved very difficult for Dragon NaturallySpeaking™ to reproduce his speech accurately. This in turn compounded Rohan's struggle, described above, to speak in a smooth, even manner, and his loud, staccato delivery caused the software to perform even more poorly. Karen favoured using ClaroRead™ to listen to the long written documents she received as part of her gym instructor qualification coursework, then to write conventionally using her preserved touch-typing skills, and consequently she did not dictate any written work of her own. Nevertheless she was very enthusiastic about ClaroRead™ and independently requested that her tutors provide all written materials as PDFs in order that she could access them using the software, which they did; she passed her examinations. William was disappointed by the level of inaccuracy in the dictated speech he produced using Dragon NaturallySpeaking™. Though generally mild, his dyspraxia of speech was more marked when he attempted complex sentence structures or polysyllabic words – including software commands – and he did not always wish to rephrase with simpler or shorter alternatives. Always softly spoken, he struggled more than usual with projecting his voice for dictation, saying: 'I think it's hate the- my erm mumbling, and the worse thing, I always mumbling, but erm it's worse with the er software' (William, T3 interview). Many of the writing samples William produced were well constructed, but the standards he set himself were very high, and he often felt he had not met them. Finally, Doreen had ambitious writing plans at the outset of the project, but bringing these to fruition was challenging owing to frequent episodes of distress and frustration, and particular difficulties with translating abstract ideas into concrete words for the page.

#### *8.5.2 Writing samples with observation notes on editing*

A large number of verbatim examples of participants using a combination of dictation, commands and keyboard use were collected. A brief selection is given here in order to illustrate the barriers encountered by some individuals, and the strategies used to remediate them. Dictation errors are shown in bold font, correct commands appear in square brackets.

### Sample 1: Simon, training session 3

I have included photographs of the property on the slides which you may wish to look at [.] The property was in the Kissimmee area of Florida very close to Disney [.] in fact we could see the fireworks from Disney's Magic Kingdom from outside the house [.] We could also see Animal Kingdom from outside the house [.]

[new paragraph]

With minimal training, Simon was able to accurately dictate long, fluent sentences and insert commands in appropriate places, as demonstrated above. Proper nouns were recognised accurately, and there were no errors requiring correction in this sample.

### Sample 2: Janet, training session 3

Hi Sally how lovely to see you [.] wow you're in New York **at that** you're very happy [.] **House your house** in LA have you got two properties [?] Anyway I bet you have such a lovely time [.] yes I would love to see you in New York but I would love to see you in Paris **sleep**

Janet was also able to dictate accurately from an early stage of her training. There were three dictation errors in this text: 'At that' (line 1) was produced in place of 'I bet', an inaccurate interpretation on the part of the software rather than a speech production error by Janet. Likewise, 'house your house' (line 2) was originally dictated as 'how's your house'. 'Sleep' (line 4) was an incomplete production of the command 'go to sleep' which would have deactivated the microphone. Janet proofread her text from the screen, without using ClaroRead™, and noticed the second and third errors on this occasion. She corrected 'house your house' by deleting the first two words using the cursor and delete key, then voice to dictate the amendment. She also asked me to make a note of the 'Go to sleep' command for her. She did not notice the first error and this remained in the text. Capital letters automatically appear following punctuation commands requiring them in conventional writing – full stop and question

mark in this example – and in proper nouns such as city names, so Janet did not need to use commands to produce these.

#### Sample 3: Dean, training session 3

Dear sir or madam I am writing you to say I am very disappointed with the letter I received about my Disability Allowance I am very concerned about the letter **sleep wake up** I am concerned that you haven't made the right decision about my Disability Allowance I think you may need to look at it again and give me another decision **sleep**

As in sample 2, 'sleep wake up' in line 2 and 'sleep' (line 4) were intended as commands to deactivate and reactivate the microphone. These were the only dictation errors in this sample, and the same correction procedure as above was followed. The more fundamental issue in this example was that Dean found it challenging to create a compelling argument for why his higher level Disability Allowance should be reinstated, and consequently his text is rather 'empty' despite its surface accuracy; this is returned to in section 8.6.2 below.

#### Sample 4: William, training session 5

I must to go to the shops to buy food for the children [.] **nobody** I go in the shopping on Thursday but I was busy and decide to go in the shops on Friday [.] Tesco was very busy and the shelves was empty and all the normal things was missing like orange juice [.] **mints** and chicken and milk [.] I decide to go back home **half to** buying pizza and steak and **carry**

There were four dictation errors in this example: 'Nobody I' (line 1) was originally dictated as 'normally I.' William noticed this immediately and repeated the phrase, which was then produced correctly, then deleted the original version using the cursor and delete key. 'Half to' (line 5) was originally 'after'; William did not notice this error. For the remaining two errors ('mints' in place of 'mince' in line four and 'carry' in place of 'curry' in line five), William employed a more creative strategy, by thinking of a replacement word or phrase which he correctly assessed Dragon



NaturallySpeaking™ would be more likely to produce accurately: ‘meat’ and ‘curry and rice’ respectively.

William also made some minor aphasic speech production errors. When he proofread from the screen he noticed one such error, changing ‘go in the shopping’ to ‘do the shopping’, using conventional keyboard typing rather than dictation.

Sample 5: Rohan, training session 5

Dear Steve <b>whose feel</b> have <b>a lot looking that obligation</b> for <b>may</b> pay please <b>delete</b> the next time you come here
--------------------------------------------------------------------------------------------------------------------------------------------

Unfortunately, almost half of Rohan’s dictation is inaccurately produced here (9 incorrect words of 21 in total) and his original sentence was rendered unintelligible. He dictated: ‘Dear Steve you still have not written the application for my pay please do it the next time you come here.’ He was unable to correct errors in this text with either the keyboard or further dictation attempts.

### *8.5.3 Completed writing samples*

Samples of completed writing tasks from each participant can be found in Appendix 8.3, along with brief notes as to how they originated. All of the excerpts in this section appear with participants’ permission, and their original structure, layout and font sizes are preserved; errors and omissions which participants overlooked, or chose not to correct, are unchanged.

## **8.6 Further observations from training sessions**

### *8.6.1 Software, hardware and technical support*

Participants were encouraged to use their own, familiar computer hardware, in order to limit the additional cognitive burden of learning to operate a new machine. This was not always possible however: Simon and Doreen were loaned laptops for the project as their own were too old and slow to support the software packages. Rather than PCs, Janet and Sarah owned tablets, which supported dictation but were not compatible with the specific AT software packages used in the study, therefore Janet used

her partner's Apple Mac for training sessions, and Sarah used my Microsoft laptop; both practised independent dictation on their tablets.

Many other technical challenges arose during training. On Albert's PC, the Dragon NaturallySpeaking™ package became corrupted and had to be deleted and reinstalled, requiring him to conduct voice training for a second time. William had to purchase more memory space for his laptop, and Karen was required to upgrade the operating system on hers. These challenges were all ultimately resolved but required significant researcher input to consult with software support helplines and respond to technical questions in complex language; on one occasion Peter's wife tried to help him troubleshoot a problem at home and spent two hours on the telephone. After the training session in which Karen's operating system was upgraded, she noticed that the desktop icon linking to her email has disappeared. Keen to resolve this quickly, she searched for and called what she thought was the software helpline, resulting in a £300 purchase of bogus anti-virus software; thankfully she was able to obtain a refund.

Not surprisingly, for Karen and some other participants, software and other technical systems were sometimes treated as unpredictable and with a degree of mistrust; when asked to change her password – a routine event triggered by calendar date in order to maintain security – she was reluctant to do so. Peter was repeatedly alarmed by pop-up advertisements, despite reassurances they could be safely ignored or closed. Several participants appeared unfamiliar with navigating their own hardware and software even when they had owned them for a long period, and had developed idiosyncratic and time-consuming methods of achieving simple tasks, which were not always replicable.

#### *8.6.2 Additional writing and computing support requirements*

Dragon NaturallySpeaking™ and ClaroRead™ cannot operate in isolation, rather they are bolted onto other software packages in order to adjust the way in which those packages are accessed and used. As a result, a range of broader computing skills needed to be taught and reinforced for many

members of the group. On occasion these tasks were brief and straightforward to teach but made substantial, practical differences: for example, Dean was shown how to highlight and delete large passages rather than doing so manually with the cursor, and how to cut and paste so that he could quickly and easily change the order of paragraphs he had dictated. More often however, the process of teaching broader skills took longer and required the provision of detailed reminder instructions. For example, Sarah had never sent emails, therefore besides relatively straightforward instruction on their composition she also needed to be informed of the difference between opening a new and an existing email, the purposes of the inbox and outbox, how to reply to an email, where drafts are saved, the nature of a thread rather than a single item, and many other hidden features which more experienced users may have been able to take for granted.

Most of the participants were able to make and execute writing plans with little difficulty, though as described in Chapter 6 Rohan was far less clear, as was William initially, and Doreen's plans had to be reduced in scale and ambition owing to her unforeseen difficulties. Despite planning however, Janet remarked that in practice some dictation tasks were more difficult to fulfil than others, noting that friendly emails were easier to compose than her film review and letter of complaint, since the latter two required more expression of opinion or argument. In Dean's case, strong facts were at his disposal to help him construct a successful benefits appeal, but he was not able to marshal these to his best advantage and needed help to consider what might convince a panel. Conversely however, participants who were highly accomplished writers prior to stroke were able to express personality in their writing in a way they could not always achieve when faced with the additional challenges of managing turn-taking, word-finding difficulties and the pressures of time in every day conversation. Examples of this included Albert's carefully crafted stories, William's dry sense of humour which he maximised with judicious punctuation use, and Janet's warm, witty emails to her friends. Observing the production of these texts

offered insight into participants' characters, made training sessions a pleasant and collaborative experience, and facilitated rapport building.

#### *8.6.3 Independence versus support*

Some participants expressed reluctance to undertake independent work for fear that they may make a mistake which they would not be able to rectify without support. However, several of them embraced the opportunity to practice outside the training sessions, and reported that they found writing easier when alone. On one level this simply related to concentration and focus, or the intrusion of background noise: for example, Simon described choosing to write upstairs since seeing the words 'ninja warrior' in his document and realising it related to his grandchildren's television programme. For others, writing needed to be a solitary activity because it is so inherently personal, and they valued the escape it gave them. William, a former journalist said: 'The way to a story, it's a very private, private place, and suddenly it was gone.' Reflecting this outlook, William twice requested a training session via Skype rather than in person; on these occasions his mood was noticeably improved.

#### *8.6.4 Potential for benefit to participants*

Successful AT software use was not simply related to prior computer experience; Rohan, a former computer science lecturer fared very poorly while Sarah, who had limited experience and low confidence in her skills, went on to manage the software with ease. Having used speech for dictation, or given frequent oral presentations, was one element of prior experience which did appear to influence the speed with which skills were acquired during training, as noted in relation to Karen's swift mastery of Dragon NaturallySpeaking™ commands, and Peter and Albert's relaxed dictation delivery. By contrast, Sarah persisted with an idiosyncratic dictation habit of addressing the computer as though it were a sentient person for a significant proportion of her training, for example: 'What are you doing? You are teaching me the computer' (Sarah, training session 2) and: 'I want to talk to you about memories' (Sarah, training session 6). However, it is possible that this tendency may have been compounded by

the presence of a researcher, and may therefore have resolved sooner with solo use.

One attitudinal factor influencing satisfaction and success appeared to be individuals' responses to setbacks. For example, Peter spoke of regarding training as a scientific experiment, and this appeared to allow him to appraise challenges dispassionately and respond to them calmly. Likewise, at a time when there were difficulties with software compatibility on his laptop, Albert was able to make a clear distinction between his own dictation strengths and the shortcomings he perceived in AT. He reported that his son-in-law had light-heartedly asked him when he could expect some correspondence, and said that he intended to send him a 'totally unedited' email so that he could see 'what we have been up against' (Albert, training session 6). William was frequently frustrated when polysyllabic words were inaccurately produced on the screen, expressing surprise that the technology was not sophisticated enough to manage them. While this may have appeared to be a lack of insight into the contribution of his dyspraxia of speech, it also protected him from the sense of personal failure and distress felt so keenly by Doreen. William's robust outlook was illustrated by another of his key skills: the ability and willingness to rephrase when faced with repeated errors. Recounting the trip to the supermarket, he was unable to dictate the word 'poppadoms' accurately; after several attempts he changed tack and deadpanned 'rice' in its place. Peter adopted this strategy consistently from the beginning of his training, and as noted he also seemed to reduce circumlocution when speaking for writing rather than for conversation.

### ***8.7 Summary of barriers and facilitators, strategies and support***

Participants experienced both barriers and facilitators when using Dragon NaturallySpeaking™. Barriers included the complexity of the interactive tutorial; difficulties with dictation, such as maintaining a natural speaking style, tolerating inaccuracy and managing word-finding difficulties; challenges with commands, such as polysyllabic punctuation; and editing by later reviewing (rather than 'on-line') which made errors difficult to

locate and correct. Facilitators included the ease and versatility with which initial voice training could be achieved, either through reading or simply producing connected speech; learning to adopt a clear dictation style and managing circumlocution; supporting command use with a prompt sheet, manual operation of the microphone and insertion of punctuation using the keyboard; editing online as an integral part of dictation.

Participants were more divided regarding ClaroRead™. For some of the group, barriers included its unnatural prosody, its challenging navigation system and, for those with relatively intact reading skills, the additional cognitive load of auditory processing. For others, the bland prosodic style was considered beneficial as it made errors more noticeable, and the comprehension benefits of auditory processing outweighed its potential as a distractor.

Owing to the way the two AT packages are used in tandem with others, there were also more wide-ranging technological barriers and facilitators. One issue was with unreliable or slow equipment, though this was remediated with support from the AT software providers and City, University of London's hardware loan. Lack of computer experience and/or confidence was problematic for some, but additional written and verbal instructions were provided, along with encouragement and advice.

Finally, some personal attributes were also observed to help or hinder on an individual level, including reactions to setbacks, previous dictation or oral presentation experience and skill, willingness to dictate in the presence of an audience, and being inclined to attempt independent practice of skills taught in the training sessions.

### ***8.8 Summary of Chapter 8***

Chapter 8 focused on the qualitative data gathered by in-depth semi-structured interviewing and training session observations. It described how the data were collected, followed by a list of the seven main themes that emerged. It then described in detail the group's former and current writing, reading and computer use, with particular reference to changes which had

occurred since the onset of stroke and aphasia. The chapter went on to outline information the participants gave regarding their levels of social participation and mood, and how they regarded their quality of life. Next it described the participants' evaluations of the two AT, including information on the interactive tutorial, initial voice training, dictation, commands and editing with Dragon NaturallySpeaking™, and on prosody, navigation and user preference relating to ClaroRead™. The chapter then described the writing activities undertaken by the group during training, including the genres and activities covered. Substantial space was then devoted to writing samples; those with observation notes on editing appeared within the main body of the chapter while completed samples appear in Appendix 8.3, with brief notes as to how they originated. The chapter ended with a description of further observations made in the course of AT training.





## **Chapter 9: A discussion of study findings**

This chapter begins by returning to the research questions specified for the thesis as a whole, and describing the findings related to these. It continues with a description of the differences between the participants in this study and a more typical stroke population. It then gives a summary of findings from each group outcome measure, first the two assessments of narrative writing and the reading comprehension assessment, then the measures of social participation, mood and quality of life, and proposes explanations for why some outcome measures had significant results while others did not. The group's progress in relation to other reported AT users, both from the non-impaired population and those with disabilities other than aphasia, is then considered, and the findings of this study are then compared with those of the small set of single case studies of PWA trained to use AT. The chapter moves on to explore what factors may have influenced AT training success and satisfaction for this group, and this is followed by reflections on candidacy, and on how modifications in AT design could influence successful training for PWA. Strengths and limitations of the current study are considered, as well as its clinical implications. Finally, directions for future research arising from this study are suggested, and a conclusion is offered.

### ***9.1 Returning to the research questions of this thesis***

1. What is the current evidence for the effectiveness of writing interventions for people with aphasia?

The systematic literature review reported in Chapter 3 indicated that although the body of work on writing treatment for PWA was relatively small, it offered strong evidence of effectiveness; where maintenance and generalisation were tested there was also encouraging evidence. However, it was noted that generalisation was more often made to untrained words, and extended to functional writing activities rather less frequently. Further, treatment was most often at single word rather than sentence or narrative level; the small number of studies which did focus on narrative writing production all used technology to support this aim. Most writing

interventions to date have had remediatary rather than compensatory goals, and there has been a lack of group studies, with many more single case and small case series appearing in the literature. Again, almost all compensatory studies made use of technology. Very few writing interventions were seen to consider the role reading plays in functional writing, and qualitative research methods were hardly ever employed. These findings suggested several gaps in the literature. This thesis has attempted to address some of these, namely by focusing on narrative written production, by measuring group outcomes, including functional carryover, and by employing qualitative methods besides qualitative outcomes.

## 2. What is the evidence for using technology to deliver writing interventions for people with aphasia?

The descriptive review of literature on using AAC with PWA, reported in Chapter 2, revealed that specialist AAC technology was not always acceptable to PWA. There were a range of reasons for this, including: negative responses of other communication partners to AAC devices; wide variation in speech and language therapists' knowledge of devices and skills facilitating their use; the barriers associated with impaired language and, at least in some cases, executive functioning skills; and the functional challenge presented by devices not being able to keep pace with natural conversation. The review also highlighted that a small number of studies using mainstream AT software with PWA had reported positive findings, and that these were all studies with compensatory, functional aims which focused on promoting social participation.

## 3. Can an effective voice recognition software technology intervention, to support narrative writing, be designed and delivered in a way which is acceptable to people with aphasia?

The pilot study reported in Chapter 4 found that the intervention to be delivered in the empirical study was acceptable to two participants with aphasia, and allowed it to be refined before the main study took place. The main intervention described in Chapter 6, and statistically analysed in

Chapter 7, successfully achieved its aim of compensating for narrative writing difficulties and promoting social participation for the group as a whole.

4. How can the intervention be customised and personalised to suit the functional and participatory goals of individual participants?

Chapter 6 reported a range of ways in which the intervention was successfully customised in response to participants' previous computer and technology experience and confidence, their aphasic strengths and deficits, their writing goals and the ways in which they wanted to use AT to achieve these specific tasks, and their preferred learning styles. It described the various scaffolded support training techniques employed, with particular reference to three prognostic indicators to successful AT use: preparing and producing speech for dictation; flexibility and perseverance; and self-talk rather than on-task talk.

5. Can AT training compensate for writing and/or reading impairments and impact participation and/or mood, and can barriers to successful training be identified and overcome?; and
6. Does diagnostic assessment data, participant observation or any other measure offer insights as to candidacy for future intervention?

This final research question was addressed in Chapters 6, 7 and 8, which set out individual case profiles, the ways in which the intervention was customised to reflect these profiles, the group outcome measure results and detailed examples of participant observation which further illuminated the group outcome measure results. Question 6 is further discussed in substantial detail in sections 9.7.1 to 9.7.7 below, with reference to candidacy criteria.

## ***9.2 How do this study's participants compare with a 'typical' stroke population?***

The group of individuals who took part in this study were rather atypical of the wider stroke population, both in terms of age and education levels. As described in Chapter 1, the average age of first stroke in the UK is 71 for

men and 77 for women, while the age range of this group was 44 – 75, with a mean age of 58.2. Furthermore, stroke is more likely to affect people with lower incomes. While income data were not collected from participants in this study, they were a highly educated group. It is likely that this user profile influenced the motivations, expectations and goals of the group.

However, a brief examination of the participants of writing therapy studies included in this study's systematic literature review, relating both to conventional and technological therapies, revealed that while the current group may have been unusual in relation to the wider stroke population, they were similar to one sub-group of PWA who have engaged in therapy specifically for dysgraphia. Some individuals who received writing therapy did so owing to the severity of their aphasia, which limited their ability to communicate via other modalities; these individuals tended either to have undifferentiated jargon aphasia, or marked non-fluent aphasia, with both populations focusing on single word or short sentence production to support functional messages. A small group of individuals with severe dysarthria or dyspraxia of speech also received writing therapy for this purpose. Besides these groups though, recipients of writing therapy tended, like the participants in the current study, to be highly educated and keen writers pre-stroke, and still of working age; some were still in employment. Examples in the literature included: a sports writer who had retained his job with some modifications [127], six 'highly educated' PWA (page 356) [160], an engineering executive with 18+ years of education [128], a further education lecturer and political counsellor, educated to Masters level and still employed [29], a young man aged 19 at onset of stroke and keen to obtain employment [139], two office workers and a school teacher, all still of working age [157], a secondary school head teacher and consultant, who had retired with great sadness owing to stroke and was still of working age [115], two individuals, one a military instructor highly proficient with computers, the other a manager of an IT

department, who undertook a technological writing intervention [155], and a 50 year old accountant [135].

These were people, like the majority of the current group, for whom loss of functional writing had the potential to cause major and wide-ranging changes in their every-day lives and circumstances. Adopting Parr's social model of literacy [52], it seems entirely reasonable and appropriate that this group would self-select as candidates for writing therapy. Yet it is worth considering whether the AT compensatory model described here would generalise to a more typical client group. The candidate in the current study who most closely fitted this profile was Dean. Of Afro-Caribbean descent, Dean had been warned by doctors prior to his stroke that his high blood pressure and lifestyle choices were placing him in a higher risk group. He was less highly educated than the rest of the group; writing had not been a daily activity for him, nor something he felt passionately about, and it had fulfilled practical rather than cerebral purposes. Nevertheless, in the AT program, Dean was very capable of producing a wide range of written texts, and mastered many technological procedures with ease. He needed more support than some other members of the group in order to perform tasks such as creating a strong written argument, but was quick to adopt these skills once they were modelled and reinforced, and was highly motivated. Therefore, while user profile may influence choice of writing activities and level of additional support required, there does not appear to be a compelling case that a more typical stroke patient could not benefit equally from the AT program as did the current group. A further indicator of the wider potential of the program might be that the recruitment target of ten participants was reached by screening sixteen individuals, suggesting that candidacy criteria were not unduly narrow and could have attracted a larger sample if required.

### ***9.3 Group outcome measures of narrative writing and reading comprehension***

#### ***9.3.1 Writing***

##### ***9.3.1.a CAT written picture description***

As shown in chapter 7, there was a significant improvement in group writing performance on the CAT written picture description assessment when the use of AT was permitted at T3, compared to conventional typing at repeated baseline. The effect of training was maintained at three month follow up, indicating participants were able to continue with independent use beyond the training program. No such improvement was seen for the group over time in the pen and paper version of this task. These results suggest that AT had a compensatory, but not remeditory, effect on narrative writing, a similar finding to the four other studies [115], [117], [139], [118] which tested this.

##### ***9.3.1b Constrained writing task***

The group did not produce significantly more tokens with pen and paper after AT training, supporting the above finding that AT training had no significant remeditory effect on narrative writing. In the keyboard condition, significantly more tokens were produced after training. Again, this suggests a compensatory effect of AT training, as in the four studies above, and there was a further increase at T4, indicating that successful independent AT use continued after training had ended, as seen by Cauter and Woolf [115] and Bruce et al [118].

Yet despite the increase in tokens produced, there was not a significant improvement in lexical variety. This is perhaps less surprising than it first appears. To illustrate, two portions of this thesis were randomly selected and analysed using the same calculation method and tool as for the participants' constrained writing task data. The first portion was the opening paragraph of section 8.3.1 (page 153) while the second was the whole of the same section. For the first, the type-token ratio yields a lexical variety score of 63.2%, while for the second, longer section the lexical variety score drops to 50.4%. As both were written by the same author, on

the same day, regarding the same topic, it is reasonable to state that this reduction is attributable to increased length. In view of this, since group keyboard use produced longer texts, no significant reduction in their lexical variety may arguably be regarded in a more positive light.

As described in Chapter 7, five independent raters, blinded to time point and pen and paper/keyboard condition, were asked to give social validity judgements of the constrained writing task outputs of the ten study participants. There was no significant improvement in mean group ratings for either condition over time, neither in any sub-measure (effectiveness, informativeness, grammaticality, comfort) nor in the mean total score. Therefore, use of AT software appeared to have no impact on how the group of participants' narrative compositions were judged by independent raters. This was a disappointing finding given that the participants themselves gave positive qualitative assessments of their written output when supported with AT. Lustig and Tompkins [122] reported a similar finding in their writing intervention designed to avoid prolonged articulatory struggle for their participant with dyspraxia of speech, whereby only shorter utterances received higher ratings for communicative efficiency and comprehensibility after training: in the current study it is possible that, in a similar pattern to the lexical variability scores described above, the length of texts may have had a confounding effect on these ratings. Indeed, one rater described this anecdotally, remarking that even though the shorter messages were telegraphic and contained less informative content, they were clearer in form and therefore more comfortable to read (rater 4, personal communication). To a degree this may be because the likelihood of error naturally increases with text length, even for non-impaired writers. Examples of relatively shorter and longer texts may illustrate this further; the samples below were produced by the same participant, the first with keyboard at T2 therefore conventionally typed, the second at T3 therefore dictated:

Hi caroline,

Wonderful news, ~~on and~~ another son!! congatulation, well done. In st. geages or chelsea?

The sample above was given mean ratings of: effectiveness = 8.0, informativeness = 7.6, grammaticality = 6.6 and comfort = 6.2, where the scale score range = 0 – 10.

Sometimes my speech drawn up dried up, completely. I don't know why but it was so awful. Is it it my processing of speech or the speech therapy with Dragon software? Which is it?

New paragraph

Best time doing anything about talking is morning. I'm rested and ready beginning a new day. Between two and three was worse I think is because I have food. My body is concentrating for absorbed nutrients not talking. On the younger I have a rest in the afternoon; eating is tiring!

Around 4 or 5 my speech improved and until about 10 or 11. Curiously it's the effort of talking about one hour was hard when I was talking with my son my daughter. I think it's because they are young and old also teenagers have a different level of speech - actually is a grunt. They are not good speech therapy!

This second sample was given lower mean score ratings in every sub-domain: effectiveness = 6.4, informativeness = 6.0, grammaticality = 5.0, comfort = 5.4.

This was a training program designed to improve and generalise functional writing, which could include the ability to produce a greater volume of written narrative. On reflection, instructions to raters could have more explicitly indicated that they were primarily being asked to assess ability to compose novel spontaneous written output.

Furthermore, aphasic idiosyncracies may also be more apparent in longer, more expressive passages of text, and given that, as described in Chapter 1, it is rare to see uncorrected samples of aphasic writing, limited exposure to this kind of non-standard writing may have influenced raters' views of its acceptability. Finally, as participants became familiar with using AT the



writing tasks they attempted became more complex and ambitious, and it may be that the trade-off for this group was accepting imperfect but broadly comprehensible text. This was more acceptable to some participants than others, which will be returned to in section 9.7.1. Additional research or modifications to the use of social validity judgements may therefore be useful, with specific reference to aphasic rather than standard writing.

### *9.3.2 Reading*

In the keyboard condition, there was a significant improvement in group performance on the GORT-4 reading comprehension test over time. As with the constrained writing assessment above, scores at T4 three month follow up had risen, again suggesting that independent use of the AT was possible. No such improvement was apparent over time when participants undertook paper version of the GORT-4 without AT, suggesting AT training had no significant remedial impact on conventional reading comprehension at the narrative level. However, this result needs to be interpreted with caution, as there was also a group improvement between the first and second baselines. This may be attributable to the fact that adjusting to the unfamiliar synthesised speech output resulted in suppressed scores at T1, confounding the main effect of time. Use of AT to compensate for reading impairments in aphasia warrants further investigation: Cate et al [114] saw improvements in confidence, enjoyment and participation, though not in comprehension; Cate and Woolf's [115] findings suggested it was useful but its impact was not specifically measured, while Adams [112] and Harvey et al's [113] were more equivocal, observing increases in reading rate but not in comprehension.

## ***9.4 Group outcome measures of social participation, mood and quality of life***

### *9.4.1 Social participation*

Mean group social network size increased significantly after AT training, and no participant in the study described a decline in the number of

individuals in their social network. The single case study participant who worked with Cate and Woolf [115] saw a dramatic rise in the number of ex-colleagues in his network after AT training; Social Network Analysis [196] revealed the number of individuals in Stephen's network had more than doubled after their therapeutic intervention, and this expansion was particularly marked in the outermost circle. In particular, ex-colleagues had been entirely absent in his pre-treatment social network and featured prominently post-treatment. This was an important development: he had been unable to return to work after stroke, and reported missing his former occupation a great deal. In the light of Cruice, Worrall and Hickson's [236] finding that, compared to their non-aphasic counterparts, PWA were likely to have a higher concentration of network members in their innermost circles and lower numbers further out, one could argue this suggested Cate and Woolf's participant's network had begun to return to its pre-morbid state - though of course this could only be a tentative conclusion given the lack of a pre-morbid baseline measurement of his social network. Similarly, in this study Janet added several work contacts to her network as she built or restored relationships with freelance colleagues, partly via the use of email.

Changes to social networks in this study did not generally appear to be driven by one particular sub-group of a network expanding, however. Three people said their social network was unchanged (Sarah, William and Doreen), while the other seven described small increases – for Karen and Albert there was only one additional individual at T4; the maximum increase was six individuals. This may reflect the length of time since onset of stroke and aphasia for the participants in this study, and the resultant adjustment to a chronic condition; nevertheless, it is a promising finding given that the literature reports social networks tend to be negatively affected by stroke, and particularly aphasia, even at the chronic stage of illness [80], [81], [82].

#### *9.4.2 Mood and Quality of Life*

Lowered mood (referred to variously as depression, low mood, psychological distress or emotional distress in the literature) is known to be common following stroke [237], and a range of factors may predict it, including stroke severity [228], [238] cognitive impairment [239], [238], physical impairment [238], [240] poor social support, loneliness and low satisfaction with social network [228] and aphasia [228], [240]. Reduced quality of life is also frequently reported, and again is influenced by a wide range of factors including reduced activities [241], [242], communication impairment [241], [242], social contact with others [241], body functioning [241], comorbid conditions [242], emotional distress [242] and cognition [243].

Little is known about precisely which treatments for people with stroke and aphasia produce measurable effects on mood or quality of life. Compensating for writing impairments may both encourage functional written communication with others, and allow people to forge connections which strengthen or expand their social networks. Since it is known that both communication impairments and social isolation are predictors of low mood and poor quality of life, it was anticipated that changes in access to writing may affect these psychological factors, therefore measures of both were included in this study.

Ultimately, there was no significant group change in either mood or quality of life ratings after the AT training program, despite encouraging positive trends in both assessments over time. A number of qualitative findings indicated the quality of social contact was bolstered by writing treatment, and these revealed a positive psychological impact not only on the aphasic writers themselves, but also on the recipients of their correspondence (for example as shown by the emails between Peter, his son and his friend, see page 326). However, this was a small group, with a wide degree of variability within the sample, which reduced the power of the analysis. It may be that with a larger sample these trends could have reached significant levels. Alternatively, an increased treatment dose, with a more

intensive or longer program, could have made more difference to these scores.

For a breakdown of individual scores in all of the group outcome measure assessments, see Appendices 7.1 – 7.10.

### ***9.5 How do participants' responses to AT software compare to those of non-impaired users and those with disabilities other than aphasia?***

#### ***9.5.1 Non-impaired users***

The responses to AT of the PWA in this study showed a number of similarities with non-impaired participants in other AT studies. Two of Rae-Dupree's [103] observations were replicated: firstly, using VRS for dictation was more straightforward than using it to issue commands. Secondly, several of the participants in this study concurred that thinking for dictation required different skills than either thinking for conversation or planning for written production. However, for some of the current aphasic group, AT could be seen to reduce rather than increase these cognitive demands: Peter found dictation helped him to avoid circumlocution, and Dean regarded software use as less onerous. Even Karen, whose preserved touch typing skills allowed her to produce large volumes of type-written text, reported that dictation required less concentration and reduced her fatigue; this reflects Zumalt's [105] observation that while able typists may produce a high WPM rate, they are unlikely to sustain this for as long with the keyboard as they may with voice.

As described in Chapter 8, during training Janet noted that producing dictation was easier when fulfilling tasks such as informal email composition, and comparatively difficult when constructing an opinion or argument, such as when she wrote her film reviews and letter of complaint. Studies of non-impaired samples also appeared to focus on relatively simple tasks such as transcription and data entry [100], [101], [102]. It was also the experience of the student researcher, as a non-impaired AT user, that these rather mundane tasks were far easier than more reflective, sophisticated ones, both in their processing and planning

demands and also in terms of navigation through a document, where changes to the order of an argument can result in tedious formatting tasks which are quicker and easier to achieve with a keyboard.

### *9.5.2 Users with other disabilities*

In his study of 12 adolescents with learning impairments, Roberts [106] found that while the six slower typists produced more output with voice, the six faster typists among his cohort wrote less when using VRS. By contrast, in the current study, only Doreen was able to produce less spontaneous written output with VRS than with conventional typing, and she was nevertheless able to produce more narrative with the keyboard in the picture description task. The other nine participants all produced a great deal more constrained writing output in the keyboard condition – this was true even of accomplished typist Karen: her typed total token range of 139 – 174 was the highest of the group, yet her dictated total token range of 219 – 231 was even greater. Therefore AT appears to have a more robustly positive influence on volume of output for the individuals with acquired specific spelling and writing impairments in the current study.

Roberts and Stodden [107] found that, regardless of whether objective writing speed was improved by its use, a majority of learning impaired users expressed a preference for AT over conventional hand-writing or typing. Use of mainstream AT also appeared acceptable in this study, both to the participants themselves, and to their families and peers. Several participants' partners, including Janet's, Simon's and Peter's, expressed an interest in the wider study and observed AT installation and voice profile set up with curiosity. Dean's eleven year old daughter asked him to set up a voice profile for her on his laptop so that she could use VRS to complete her homework, Albert recommended AT to a friend who had early symptoms of dementia, and William was impressed by how competently his young niece, who had developmental dyslexia, was able to use dictation. This is promising given that family/peer reluctance - besides cognitive and linguistic burden – has been cited as a barrier to specialist AAC use by PWA, as described in Chapter 2, and suggests mainstream

technologies may be met with a more favourable response. Notably though, Dean refused permission for his daughter to use VRS as he felt it might inhibit her conventional spelling skills from developing further, echoing to a degree the fears of relatives when their partners were offered AAC support post-stroke.

As with non-impaired users, and those with aphasia in this study, the concept of thinking for writing was also commented on by one of Roberts and Stodden's [107] participants with learning disabilities, who observed that AT software could not resolve her primary difficulty with organising her thoughts. Roberts and Stodden further observed that the presence or absence of other compensatory writing strategies influenced whether users persisted with AT use. As described in Chapter 4, in the pilot study this was a significant difference between Ella, who lived with her mother and was willing to allow either her or her college support worker to help redraft her writing, and Claire, who lived alone and did not have an alternative strategy in place. Ella reported she was unlikely to continue using Dragon NaturallySpeaking™ beyond the training program, whereas Claire had made further plans for independent AT use. As noted in Chapter 8, there was also some variation within the ten participants in the main study in terms of willingness to seek and accept writing support from others. Participants with younger relatives appeared to be comfortable with asking children or grandchildren for help, and those with peers who worked in IT or computing were also happy to seek their advice. However, other than Doreen, the rest of the group preferred not to ask a spouse for assistance, as they wanted to avoid disagreements and did not wish to further burden busy partners: this subgroup appeared to pursue independent AT use most enthusiastically. This is a promising finding given that burden to caregivers after stroke is known to be potentially high, even in the chronic phase of illness [244], [245] and particularly when stroke has resulted in aphasia [246].

### ***9.6 How do the gains made by this group compare with other AT users with aphasia?***

As described in Chapters 2 and 3, there are only a small number of studies relating to AT users with aphasia, all of which are either single cases or case series involving two participants. There are three single case studies which used Dragon NaturallySpeaking™ to facilitate functional writing for PWA. In the first [117], a naïve computer user successfully mastered operation of AT, but appeared unable to apply the skills she had learnt to independent work, and her performance in story retelling tasks was markedly superior to spontaneous message production, suggesting limited generalisation. This was a similar picture to that presented by two individuals in the current study, Doreen and Rohan.

Bruce, Edmundson and Coleman [118] and Caute and Woolf [115] had more positive findings: both of their participants successfully learned how to use dictation for email writing, and also produced a wide range of additional outputs including shopping lists, diary entries and letters lobbying a local MP. Findings with the remaining eight participants in the current study align with this, and an even wider range of tasks were accomplished, partly owing to the size of the group, and partly because participants were actively encouraged to select their own writing genres, and most individuals expressed a desire to experiment with many of these. Like Caute and Woolf's participant, several people in the current study also explicitly stated that re-engaging with writing allowed them to express elements of their identity which they had been unable to access since stroke.

As part of their writing therapy study, Caute and Woolf also used a text-to-speech package, Read&Write Gold, to support their participant's reading, and this had a positive impact on his reading comprehension. While, as detailed in Chapter 8, using both AT packages in tandem was a challenge for some, the current study also observed a significant improvement in comprehension when ClaroRead™ was used. These findings are more positive than those of Adams [112], whose two participants with aphasia

saw no improvement in comprehension, though one did increase their reading rate, as did Harvey, Hux and Snell's [113] single case study participant.

### ***9.7 What factors may have influenced AT training success and satisfaction for this group?***

Roberts and Stodden stated that the profile of a user with learning impairments most likely to engage with AT included: motivation, disposition to tolerate high levels of ambiguity and frustration, limited alternative strategies and ability to speak standard English. The findings of the current study are in broad agreement with this profile, but can offer additional guidelines specific to the nature of aphasia. Since this was a small sample, findings here are necessarily tentative and should be explored further with a wider group study.

#### ***9.7.1 Personal attitude and approach***

A major factor in satisfaction with both the training procedure and written outputs appeared to be participant response to error. As described in Chapters 4 and 8, for both pilot and main study participants, responses were varied. Those who were able to adopt a 'good enough' approach appeared to enjoy AT use more than those who aimed for perfection. This was particularly evident for individuals who felt personally responsible for, and distressed by, failures which they attributed to their aphasia, rather than those who tended to find fault with the software.

Two participants expressed an explicit preference for writing alone instead of with an audience, and while a third did not state this, her dictation style was overtly influenced by researcher presence nonetheless. Future versions of the AT program may consider more creative solutions for participants who prefer to write without the presence of an audience, such as using clinic rooms with one way mirrors, more extensive video recording supplemented with feedback sessions, or even remote delivery via Skype. This could eventually reduce travel costs and time, and allow more physically impaired or geographically isolated individuals to participate.



### *9.7.2 Ideas and creativity*

Most participants in the main study did not find it difficult to think of appropriate writing subject matter. This was possibly a result of changes made on the recommendation of the two pilot study participants, including the introduction of a power-point presentation which made specific topic suggestions (Appendix 4.3). Allowance should of course be made for the fact that for many PWA who struggle with writing, it can be more readily dropped from their communicative repertoire than can speaking or listening; consequently, it may take time and patience to re-engage with it effectively. Despite suggestions and encouragement, some PWA may continue to struggle for ideas, an issue illustrated by Rohan's case in this study. For these candidates, additional time and resource may be required in order to develop supporting materials. These could be prompt sheets for reading or auditory processing, picture prompts, or simple structural guides for various genres, depending on individual client needs and goals.

### *9.7.3 Dysgraphia and dyslexia diagnosis and other aphasic traits*

As described in Chapter 6, a number of PALPA subtests of single word writing and reading were used to determine individual diagnostic profiles. These profiles have been examined to check whether they yield any consistent prognostic indicators of success with AT use for reading and writing, and the following observations were made.

Among this small group, severity of dysgraphia alone did not predict success: Peter was the most severely impaired by a considerable margin, yet managed to produce a substantial volume of dictated writing independently and with an acceptable degree of accuracy.

In terms of dyslexia, most of the group had relatively mild impairments, and in particular had largely intact lexical decision making (evidenced by high scores in PALPA 24 Visual lexical decision with 'illegal' non-words), useful for proofreading written work. Most also had reasonable auditory processing, enabling successful use of ClaroRead™ to access written output.

It is difficult to draw any clear conclusion from such a small sample as to whether differential central dysgraphia diagnoses - for example, surface rather than phonological dysgraphia - have any impact. Nevertheless, a contrastive example between two participants may be illuminating. Peter and Doreen both presented with patterns of spelling deficit consistent with a diagnosis of deep dysgraphia, arguably the most complex writing impairment to address effectively. Peter was unable to spell even short, concrete words accurately, while Doreen could retrieve complete forms on occasion, but made frequent semantic errors and often could not produce more than the initial letter of a word. Yet despite their similar dysgraphia diagnoses, their training outcomes were very different. There appeared to be a number of reasons for this. Firstly, Peter's cognitive skills were largely intact: he received three ceiling composite severity scores of 4.0, and one of 3.6. Furthermore, Doreen's written comprehension was markedly more impaired than Peter's; she achieved a T-score of 51 on the relevant section of the CAT language battery, compared to Peter's 68. Additionally, Doreen presented with severe dyslexia according to a number of assessments: a reading T-score of 46 on the CAT language battery, single word reading synonym judgement between 41 and 50 out of 60 on the PALPA, and a repeated reading comprehension score of 1 out of 20 on the GORT-4. As noted, this is the lowest possible score, and was only improved to 2 out of 20 with auditory input from the reading AT software at T3 and T4, indicating her auditory comprehension and processing were also very impaired. Peter's reading T-score on the CAT was similar to Doreen's (48 versus her 46) as were his synonym judgements (range = 45 – 49 versus Doreen's = 41 - 50). However, his reading comprehension scores on the GORT-4 were superior. He scored 3 out of 20 when reading conventionally, and this rose to 6 out of 20 when using AT reading software, suggesting Peter was more able to use auditory processing to compensate for his dyslexia than was Doreen. This finding suggests that more detailed profiling of auditory comprehension and spoken output could be prognostic for this type of intervention, and would be recommended in any future study using a similar training method.

This observation mirrors Caute and Woolf's finding: their participant also had some difficulty with auditory processing as measured on the CAT language battery, yet coped well with both VRS and reading AT. A factor their participant, Stephen, had in common with Peter was a tendency towards circumlocutory and longwinded contributions in conversation, indicative of fluent aphasia, which reduced noticeably when speaking for dictation. In this study, the positive influence of dictation Peter experienced was in sharp contrast with that of Doreen, whose difficulties appeared to be exacerbated by the pressure of a blank screen during AT training. For candidates facing similar challenges, additional pictorial prompting material may be useful, as it was for Doreen.

The contrasting patterns of success described here for the two candidates in the current study echo those of Beeson, Rising and Volk [173], who case series study aimed to identify predictive factors for poor outcomes from their writing treatment protocol. They found that, among their eight participants, the four who made the smallest gains had more marked semantic impairments, as measured using Pyramids and Palm Trees [247], yet that overall severity of aphasia, as measured on the Western Aphasia Battery [176], was not predictive of poorer success rates.

One further tentative observation with regards to differential central dysgraphia diagnosis was that, as described in Chapter 6, Simon performed comparatively well on the PALPA sub-test of non-word spelling, achieving a score of 54.2%, the second highest non-word spelling score in the group (only Albert scored more, and the remaining eight participants scored 30% or less). This suggested that from the outset of the study he was able to exploit the phoneme to grapheme conversion route with more success than the rest of the group. Over time Simon showed improvement in both the pen and paper and keyboard conditions for the CAT written picture description. This is of particular note since he was one of three participants, along with Albert and Peter, who engaged in a great deal of independent AT use. Since Peter's severe deep dysgraphia was intractable, writing remediation would have been an unrealistic aim for him, and as

noted, Albert's performance was already superior to the rest of the group, with little room for measurable improvement. There may be a case to suggest that for participants such as Simon, highly motivated and confident and with relatively mild impairments, AT training may offer a degree of narrative writing remediation, besides its compensatory effects, though clearly this would need testing with a much larger group. Simon himself certainly considered that his written spelling without AT had improved, saying:

'It's amazing how much, how different now the spelling is; better. I think my spelling is improved, I don't know whether it is- whether it's just because the aphasia is getting better, I don't know, but I think my spelling is better than it was and I'm more confident now in writing something and therefore I use the ordinary email [meaning without AT], don't have to do the spellcheck quite so often' (Simon, T3 interview).

Finally, Karen, the only participant in this study with a peripheral rather than central dysgraphia, did extremely well with the AT training, and it would be useful to explore this finding further, with more participants with a similar diagnostic profile.

#### *9.7.4 Speech production*

In Roberts and Stodden's [107] study, two participants with distinctive accents – Hawaiian pidgin/creole in their case – found enabling VRS to recognise their output particularly difficult; in the current study, this was problematic for Rohan, who had a pronounced Sri Lankan accent. Until forthcoming iterations of Dragon NaturallySpeaking™ have addressed the potential for greater dictation inaccuracy with this group, participants with accents outside the software's standard range should be offered compatibility testing at the outset of training, in order to ensure they are given alternative writing therapy if this appears more feasible.

A further challenge for Rohan was managing to speak in a smooth, relaxed manner, despite repeated prompting and despite his ability to do so in conversation, and it appears his problems with attention and memory may have played an additional role. Both Albert and Sarah experienced similar difficulties at first, but were able to reflect on them and find strategies to overcome their nervousness and sense of unnaturalness. Future participants who feel anxious may benefit from additional time to rehearse speaking for dictation, possibly including a short 'warm up' period at the beginning of each training session before the software is activated; Albert in particular found this very beneficial. He enjoyed rehearsing speaking for dictation in private at home, which may also benefit future participants.

William's success in this study provides an indication that mild dyspraxia of speech need not impact candidacy. This was in part due to his ability to flexibly rephrase problematic words and phrases to improve dictation accuracy; other PWA may need to be provided with additional support and prompt materials in order to adopt this technique.

#### *9.7.5 Therapeutic goals*

An additional issue for this population may be an ongoing desire to remediate, rather than compensate for, spelling and writing impairments; illustrated by Doreen's case in this study. This will naturally require skilful management and goal setting by therapists, but in a larger scale study it may be feasible to introduce elements of both remediation and compensation in tandem (see section 9.11 on further research below), thereby reducing this challenge.

#### *9.7.6 Degree of cognitive impairment*

In this study a clear-cut, measurable trait which appeared to influence training outcome was cognitive impairment. The original eligibility criteria for inclusion in this AT training program stated that participants should have no significant cognitive impairment - as this may limit their ability to engage with AT - which was to be defined by a raw score below cut off point for four or more of the ten CLQT tasks. Examination of individual

outcomes suggested this criterion may not have been sufficiently stringent, and that it would have been advisable to examine composite severity rating scores. The CLQT yields five cognitive domain scores: attention, memory, executive functioning, language and visuospatial skills. These scores in turn yield severity ratings for each domain and a total composite severity rating, with a range of 0 – 4, where lower scores indicate greater impairment (0 - 1 = severe, 1 - 2 = moderate, 2 - 3 = mild, 3 – 4 = within normal limits). Scrutiny of each participant's composite severity ratings across the four time points revealed that seven of the group did not score below 3.6 at any point. Janet received scores of 3.2 (T2) and 3.4 (T3); these were both still within normal limits. However, Rohan received composite scores indicating mild cognitive impairment at three of the four CLQT battery assessment points (2.8, 2.6, 2.6), and Doreen recorded one mild cognitive impairment score (2.6) in addition to two borderline scores (both 3.0). Closer inspection of their domain scores revealed Rohan's were poorest for attention and memory, and Doreen's for language and memory. Though still relatively mild, these difficulties made AT training both challenging and of limited usefulness for these two candidates; for one of them it was also a distressing experience. In future, users with similar profiles may enjoy, and benefit from, a scaled back version of the current AT training, with a slower pace, more extensive supporting materials, and carefully planned, achievable functional goals.

To summarise, good prognostic indicators for compensatory AT training appear to be: unimpaired cognition; sufficient monitoring skills to ensure natural dictation; ability to speak relatively standard English, with no more than mild dyspraxia of speech and sufficiently flexible spoken output to accommodate this; drive to pursue independent writing rather than rely on other strategies; ability to creatively produce ideas and set realistic goals with support; acceptance of compensatory rather than remedial therapy; ability to tolerate inaccuracy and engage in correction procedures; willingness to write in the presence of a therapist until independent skills are in place. However, within the group of ten participants in this study,

levels of progress and satisfaction were generally high, and suggest that AT can provide at least a degree of compensation for any user with aphasia who is able to produce connected spoken output.

#### *9.7.7. Further reflections on candidacy*

Sections 9.7.1 – 9.7.6 highlighted a number of factors than can be identified at baseline which may be positive prognosticators for this intervention approach. The observations of participants' responses identified further markers of candidacy which may emerge during the early intervention sessions. To expand this: the third training session was typically the first in which participants were able to experiment with using Dragon NaturallySpeaking™ for spontaneous dictation activities, since the first two sessions were largely spent installing the two AT packages and training Dragon NaturallySpeaking™ to recognise a participant's voice. Some individual traits were almost instantly clear at this stage, for example responses to and tolerance of errors, ability to speak smoothly and calmly for dictation, ability to remember and follow procedural steps, and capacity to produce and execute creative ideas. During the course of training, this finding was most useful as an indicator of how much and what type of supporting material and instruction might be required since, as described, several participants who faced challenges at first went on to benefit a great deal from training. However, for the poorest responders in this study, the difficulties which proved to be most difficult to resolve, such as staccato, unnatural delivery or intractable problems with memory also manifested themselves very clearly from this point onwards. In future studies, these issues may serve as a signal to therapists to focus either on finding a resolution at an early stage, or on formulating an alternative therapeutic writing plan with their client, perhaps by conducting an informal dynamic assessment of dictation skills, to see whether this can be mastered and adapted at least to some extent.

## ***9.8 How could improvements in mainstream AT design improve its usability for PWA?***

### ***9.8.1 Dragon NaturallySpeaking™***

The majority of the group managed the standard voice training procedure of reading a passage of text aloud, and those who could not do so were able to train the software with spontaneous speech. However, the software would perhaps benefit from clearer and more explicit on-screen explanation of this alternative, in order to ensure that it is presented as an equally viable training method rather than a less preferable option.

The standard Dragon NaturallySpeaking™ interactive tutorial was challenging for most of this group, and integrating a simplified or customisable version would be a useful addition. It would then be more straightforward for clinicians to substitute names and sentences to make them personally relevant and reduce confusion, and to adapt the pace and content of the tutorial to individual needs.

The group found dictation easier than either issuing commands or editing their own work with Dragon NaturallySpeaking™. Simon suggested making a recommendation to AT designers that they should invent a number system with corresponding punctuation symbols for those whose mobility issues prevented them from using the keyboard at all; this would also support individuals who found polysyllabic punctuation commands difficult to produce. This was a useful insight and will be passed on to software designers; however it would in itself require detailed instructions and reinforcement and may represent an additional cognitive burden for all but the most able and confident users.

Most importantly, use of Dragon NaturallySpeaking™ would categorically be improved by modifications to enable a wider range of regional and national accents to be recognised accurately.

### ***9.8.2 ClaroRead™***

The aspect of ClaroRead™ responded to most negatively by this group was the automated ‘voice.’ Mainstream technology devices such as satellite



navigation and Siri for mobile phones continue to make increasing use of this type of synthetic output, and while it is undoubtedly jarring, many non-impaired users find it acceptable. However, Pisoni [248] showed that synthetic speech processing placed a higher cognitive load on unimpaired users than natural speech, and this effect is likely to be exaggerated for PWA owing to the possibility of additional auditory processing deficits. For these users a judgement will be required regarding whether the potential benefits to comprehension outweigh the distraction, irritation and extra cognitive burden. This may not always be straightforward, because personal preference may not directly relate to performance on speech and language assessments. Furthermore, problems of written production are more self-evident than those of auditory or reading comprehension, so it is possible that PWA may have less insight into the extent of their difficulties with the latter.

However, it is likely that in future iterations the voice output of this type of software will continue to be refined. In the pilot study, Ella's playful engagement with the software was also encouraging, and particularly given that she was the youngest participant may indicate that future generations respond more positively to automated voice output. This is supported by the findings of Smither [249], where although all users found synthetic speech more difficult to process than natural speech, the effect was significantly more pronounced for older participants. This may be partly owing to the fact that synthetic speech is less acoustically variable [250] and its perception may therefore be compromised by mild, uncorrected hearing loss, common in the older population.

## ***9.9 Strengths of the study***

### ***9.9.1 Methodology***

The small group, repeated measures design adopted by this study allowed emerging patterns of group performance to be observed, strengthening the evidence base for the AT's usefulness. The use of mixed methods allowed both for statistical data to be gathered and analysed, then for this to be further illuminated by detailed examples from qualitative interview

and observation data. The qualitative data also served to describe why some outcomes, such as measures of mood and quality of life, did not reach statistical significance but may still be useful in future.

The close observation of micro-level, procedural behaviours which took place during AT training, including how and why problems arose and how they were resolved, will be highly relevant for future research in this area. In particular, the spontaneous strategies employed by participants could be readily taught to others, and tools could also be designed to assess them, in order to check whether future candidates were likely to be sufficiently flexible to adopt them successfully.

### *9.9.2 Sample*

This was a small group scoping study, in order that detailed qualitative data could be gathered, and intensive training and assessment sessions could be conducted. The broad eligibility criteria permitted a range of aphasic profiles to be scrutinised, and the group varied in terms of dysgraphia diagnosis and severity, degree of dyslexia, cognitive ability, physical and motor impairments, computer experience, age and many other factors, thus enabling the study to begin unravelling which factors may influence success. The study also represents a significant broadening of the literature beyond the single case studies which have been reported up to now.

### *9.9.3 Program content*

Surprisingly few studies in the literature have examined the use of reading and writing in tandem (see Chapter 3, page 75), yet arguably functional writing rarely occurs in isolation from reading, and in a social model of literacy, regaining the use of functional writing can only be truly useful if participants are able to read their output and check it for sense and content; likewise written communication received from others is only relevant if its content can be accessed. One strength of this study was the explicit acknowledgement of the role reading plays in writing, and the integration of a reading AT besides a VRS in order to provide practical

support and to test whether auditory processing could promote reading comprehension for PWA who had dyslexia and/or dysgraphia.

A further strength relating to training program content was that the focus and range of writing activities undertaken during AT training were selected by participants themselves. As a result, each received a highly personalised program which corresponded to the goals they had set at the outset of training. This personalisation was not unduly burdensome in terms of clinical time, and has resulted in a set of supporting materials which can be used as stand-alone guides or combined into bespoke training manuals for individual participants. It is hoped this personalisation will have maximised the functional usefulness of the AT training, thereby increasing the prospect that independent use will continue beyond the teaching period. In the current study, this did appear to be the case, with improvements maintained at T4 on the CAT written picture description task with AT, and further increased at T4 in both the constrained writing task and the GORT-4 reading comprehension test with AT.

### ***9.10 Limitations of the study***

#### ***9.10.1 Data collection***

Owing to constraints of budget and time, the AT training in the study was conducted by the same researcher who carried out both the quantitative participant assessments, and the qualitative in-depth interviews and observations. It would have been preferable for an independent researcher to collect data which were to be reported as outcome measures, in order to eliminate potential bias and ensure participants were able to be as frank as they wished in their interview responses regarding the AT training. Nevertheless, all raw data scores for the quantitative assessments used were obtained by transparent and replicable scoring methods, and the data are held on file to be crosschecked for assessor agreement if required. For the constrained writing task, the only assessment in which it was theoretically possible for there to be a degree of subjective interpretation, this was controlled for with the assistance of five independent raters, blinded to time point and narrative writing condition. Likewise, all in-depth,

semi-structured qualitative interviews were audio-recorded and both the original sound files and the transcribed data have been stored. Approximately two thirds of the training sessions (58 out of 90) were video-recorded, and these recordings are also on file. Observation notes were also made following each of the 90 training sessions. An independent rater examined 30% of the qualitative data, including interview topic guides and transcripts, observation notes, thematic index, theme and sub-theme matrices and preliminary data analysis, in order to verify that the principles and procedures of Framework analysis had been accurately and comprehensively followed. Qualitative evidence was also triangulated by the use of both interviewing and observation techniques to gather data: even participants who felt obliged to respond positively to questions and probes during interviews would arguably have found this difficult to sustain over the course of a ten week training program, were it not genuine.

#### *9.10.2 Dosage, experience and AT access*

For a number of reasons, ensuring equitable training dose was challenging. Some participants had chronic physical impairments and/or experienced periods of ill-health which impacted their involvement and commitment. Furthermore, in common with many individuals with brain injuries, lowered mood [251], poor memory [252] resulting in difficulties with organisation and time-keeping, and varying motivation levels [253] were sometimes evident, and were problematic for some participants to a far greater degree than others.

Independent AT use was also difficult to monitor and relied largely on self-report. Those who did engage in substantial independent use were keen to bring evidence to training sessions, which allowed successes and challenges to be documented. Simon, Peter and Albert were noted to be particularly and consistently proactive independent users; William, Sarah, Karen, Dean and Janet also undertook some limited independent practice, though their commitment and enthusiasm for this varied across time and between participants. Additionally, those who felt some reluctance to practice AT use alone were honest about their fears and rationale, and this

information in itself will allow adaptations to be made to future versions of the training program. Rohan and Doreen, the two poorest responders, preferred not to use the software outside training sessions.

Previous computer use and experience were also difficult to assess formally, and again relied on self-report, besides observation; these factors were in some cases also confounded by cognitive impairment, memory decline or aphasia. Again, valuable learning took place regarding what additional background knowledge could be screened for and what technical skills may need to be taught before embarking on a larger scale study.

Independent access to technical equipment was important in this study given that participants needed to be able to use it outside training sessions. Owing to the budget constraints of a small scale project, most participants used whichever hardware and software they already owned, and some had far more modern and powerful tools than others. However, where out of date equipment was clearly impeding progress, as was the case for two participants (Doreen and Simon), they benefitted from the generosity of another project at City University London, which granted the long-term loan of laptops.

Half of the group elected to train at home while the other half travelled to the university, a decision based on their personal preference, sometimes relating to difficulties with travel owing to mobility issues or reduced confidence, sometimes for reasons unspecified. Since this was a project requiring long-term commitment, every effort was made to accommodate participants' wishes and ensure their continued engagement. No objective measure of the influence of training location was taken, however some anecdotal observations may be of interest. Firstly, the presence of third parties was more difficult to control for in participants' homes, which sometimes created distractions and interruptions, but more positively allowed family members to offer additional insights and background information. Secondly, training sessions off campus tended to have a more

fluid and relaxed feel, since room bookings did not limit conversation time, and being at home allowed participants to fulfil the role of host rather than simply research subject, for example by offering lifts to the railway station or refreshments. This generally encouraged an egalitarian and friendly relationship to develop more rapidly. Lastly, useful research evidence was gained through home visits, by observing factors such as participants' personal circumstances, and specifically the relative prominence given to computer equipment in the home, and how readily and comfortably it could be accessed.

#### *9.10.3 Sample size*

A larger sample would potentially have enabled clearer patterns to emerge from the data. This will be returned to in section 9.11.1 below, relating to future research.

### ***9.11 Clinical implications of the study***

In the terminology of the social model of disability: for the participants in this study the individual locus of their impairment is dysgraphia, sometimes with dyslexia, and the resultant loss of writing and reading. Their impairment is overlaid by the socially imposed disabling barrier of inaccessible written material, and the way in which many forms of personal and public communication of information are conducted via writing and reading, which do not account for people with impairments and thus restrict their participation. Since AT software allows an alternative route of access to writing and reading, it represents a means by which this disabling barrier could be dismantled. This thesis has argued for an integration of the medical and social models: since impairments and disabling barriers typically co-exist, an approach which tackles both can maximise benefits for PWA. A majority of participants in this study had received very little direct remediation of their writing impairments and regretted this, with some undertaking self-directed spelling and hand-writing activities. AT programs such as this one will present speech and language therapists with a practical, pragmatic adjunct to writing or typing therapy, particularly for clients with chronic, intractable impairments.

It will now be possible to prepare the program for dissemination by writing a training manual for speech and language therapists. The following is not an exhaustive list, and such a manual would be put together with input from both an advisory group of PWA and from potential clinical trainers. However, it could include, amongst other things:

- A suggested assessment protocol based on those used in this study, to enable clinicians to identify those most likely to benefit from software training and exclude unsuitable candidates;
- Examples of topic and writing genre prompts which were found useful for goalsetting by participants in this study (Appendix 4.3);
- A selection of supporting materials which may be adapted to suit individual client needs, such as the prompt sheet for frequent commands (Appendix 8.2);
- Troubleshooting suggestions for frequent AT challenges, for both software packages;
- An outline of additional support needs some clients may have, relating to technical support, background computer knowledge, further assistance with the skills required for composing narrative writing;
- Observations on how different AT learning styles and preferences may best be supported;
- Samples of written texts and explanations of how these were constructed.

Reaching the end of remedial speech and language therapy can be a challenging time for people with aphasia and their families, and discharging clients can also be difficult for therapists themselves. A compensatory AT program offers one practical tool for supporting this transitional stage, and will provide clients with the opportunity to continue using the skills they have developed once training ends. Therapeutic programs which focus on harnessing preserved strengths, and building positively upon them, promote competence and independence. This in turn encourages progress towards acceptance and accommodation of chronic impairments, and

enables people with aphasia to resume being active and positive contributors to their wider domestic, social and professional lives.

As with all person-centred therapeutic interventions, in order to deliver an effective compensatory AT training program, clinicians will first need to establish clients' priorities regarding the type(s) of writing they wish to undertake, and the goals they hope writing may help them achieve. For example, returning to Barton's [61] notion of writing as a means of achieving social inclusion, several goals emerged among the current group. For many, writing clearly represented a way of achieving certain domestic or social ends, such as Dean's wish to undertake his own administrative tasks, Peter's affectionate emails to his son, and Janet's letter of complaint. This last was a particularly compelling example, as Janet was enabled to take back agency in writing from a situation in which she had felt too flustered and angry to do so verbally.

An unexpected use of writing to fulfil social roles emerged from the current study: both Peter and Dean spontaneously wrote thank you letters to me during training or assessment sessions. All of the participants had already expressed gratitude verbally on many occasions during the program, yet these notes appeared to fulfil a function beyond that, and perhaps spoke to the social convention of formalising thanks by putting them 'on record.' Dean dictated a note when I briefly left the room to print his written work at the end of a training session:

'It's just a quick letter to say thank you to Becky for helping me and putting this programme on my computer she has been very helpful filling out application forms for me I am truly grateful for her help' (Dean, session 6).

In his thank you note, Peter explicitly described how the AT training would help him perform his social roles henceforth, to create a legacy for future generations of his family:



'I shall be always grateful to you for doing something for me that is marvellous and I thank you. I shall be able to write to my children my nephews and nieces and I will also be using the computer to say things to the papers. I can always then be chatting to everybody as a result of the way that I can get my words out.

I am going to write up my childhood and in fact my mothers and fathers childhood, so that my children's can see it. I will be able to tell them all about our ancestors and mine so that they can remember how they are there' (Peter, independent email at T3).

For a subgroup of participants, writing was intrinsic to demonstrating the essence of who they were as individuals. Examples of this included Albert proving that he could still be a raconteur – albeit in writing rather than orally - and that he had had a rich and respected work life. Likewise, in her former work Doreen had coaxed information from troubled adolescents using non-verbal means such as writing, and then had represented their needs eloquently in case reports for court submission. Loss of these skills was a real blow to her self-esteem and identity. Finally, William's career had involved working rapidly to condense facts and make them clear and digestible, under the strict time constraints of breaking news stories. For these three individuals, writing had been a tool with which they had performed subtle and high level tasks, and demonstrated their professional prowess. There are established therapeutic approaches such as biographic narrative interventions [254], [255] which could potentially be augmented with the use of AT, and from which individuals with a sense of diminished identity and self-esteem may benefit.

## **9.12 Further research**

### **9.12.1 Conducting a larger scale feasibility study**

A natural next step following this study would be to conduct a larger scale well-powered study including a control group, which could evaluate the

outcomes of the training with more participants and also aim to elucidate with more confidence issues around candidacy such as whether specific dysgraphia diagnoses are influential. Such a study would provide more convincing evidence on the effectiveness of training people with aphasia to use AT software to compensate for their writing and reading difficulties.

Any future study would also aim to develop core principles for compensatory AT training for roll out by clinicians, and to ensure continuing technological advances could be accommodated.

#### *9.12.2 Maximising the impact of the study findings*

Besides a larger scale study, there are also a number of ways in which the impact of the findings may be maximised:

##### *9.12.2.a Development of screening and training materials for speech and language therapists*

As described in section 9.10 above, one element of further research arising from this study will be developing and testing an assessment battery and training program for clinicians to deliver. This is likely to involve testing the training manual and program in consultation with users and clinicians, then piloting the training program with a small number of speech and language therapists in order to scope its feasibility, to assess the training requirements of the trainers themselves, and to establish the costs and time needed for successful delivery.

##### *9.12.2.b Liaising with software developers and providers*

The AT packages used in this study were shared with participants without financial cost to them or the researcher, owing to the generosity of the two software providers. They also willingly offered impartial advice and technical support, and expressed an interest in the research outcomes. Both providers have stated they are keen to hear of ways in which the efficacy of their products could be extended, including for groups with additional communicative or motor requirements; the Dragon NaturallySpeaking™ team have had past links with a young man paralysed following a sports injury who has already successfully used their AT.

The findings of this study will be shared with both providers, and it is hoped that future collaborative discussions may be possible, with a long-term view to refinements which could benefit an extended user group of PWA, and ultimately users with a wider range of communication challenges. Users with aphasia would be involved as co-researchers in such a collaboration, adopting a participatory design model similar to that employed by Wilson and colleagues [256], [257] in order that their expertise could fine-tune both the software and subsequent training to best fit this user group.

#### *9.12.2.c Engaging PWA in long-term, independent writing projects*

As described in Chapter 1, first-hand written accounts of living with aphasia, and particularly those containing any visible evidence of dysgraphia, are rarely found in the literature. AT presents a real opportunity for hitherto unheard written narrative ‘voices’ to be placed on record and to reach wider audiences of academics, healthcare professionals and – perhaps even more importantly - fellow PWA. This type of writing could then complement the small but growing on-line literature by partners and carers of PWA [258], [259] which gives personal accounts of living with the impact of stroke and aphasia.

In the current study, Albert and Simon expressed an interest in writing larger scale texts and pursuing long-term projects in future, suggesting that this may also appeal to at least some of the next intake of candidates. Albert had a firm grasp of the challenges this would involve, having already co-authored a business text book and written his doctoral thesis, yet was both realistic and optimistic about the chances of bringing such a plan to fruition. With his keen insight into the need to counterbalance volume of output with accuracy of editing, Simon would also have been an ideal candidate for such an expanded writing program.

Corker [49] criticised a purely social model of disability because she believed it could marginalise groups for whom language and communication exert additional influence on mediating social inclusion.

This observation was reflected even by those participants with milder impairments in this study, who said that the relative invisibility of dysgraphia – in relation both to physical impairments and to other more obvious aphasic traits - meant that they could sometimes choose whether to reveal or conceal it. For example, Karen said she only disclosed her difficulties with writing to fellow PWA; otherwise she employed strategies such as pretending to have forgotten her diary so that someone else would jot down a date on a post-it note. The notion of revealing or concealing deficit is highly relevant to a study such as this one, and requires sensitive and careful handling. Unlike spoken conversation problems, which may be awkward but are ultimately transient, communicative breakdown in writing can represent a permanent record of ‘failure’: it was extremely distressing for Doreen to have the severity of her difficulties laid bare. To a lesser degree this was also the case for William, whose former career was heavily based on his writing flair. By contrast with Doreen and William, Peter was fascinated by the vagaries of AT, and was able to view both the software and his own written output with a scientific detachment. Like the minority of participants in Moss et al’s Internet study [74], Peter was happy for aphasic errors to remain unedited, and explained that this was partly because he felt it would benefit the wider research:

‘There are obvious mistakes in the paper. And I would normally try to get these away before going on. But I thought that you would like to be able to see the mistakes that I, and the computer, can make. I was going to get some of the paragraphs, above, cleaned up in this part. But I thought that it would be really better to leave the whole thing as something that is, so far, the best that I can do.’ (Peter, independent email correspondence between T3 and T4).

#### *9.12.2.d Peer support and participatory design*

In the current study, Peter raised an interesting possibility: he and his wife, who had worked together prior to his retirement teaching technical

computing skills to adults with dyslexia, ultimately hoped to co-present a similar AT training option to his peers at a weekly conversation group for PWA. Such a proactive approach by former participants would neatly encapsulate a model of literacy based squarely on the needs of PWA, and address one aspect of social participation which PWA sometimes feel is lost after stroke: that of reciprocity [77]. This would be an ambitious enterprise and would require careful organisation and clear structure, but could be piloted on a small scale with researcher support, following peer support models in the literature [260], [261].

#### *9.12.2.e Supporting self-directed attempts at remedial writing tasks*

Via personal communication after his involvement in the AT program, Peter reported that he had devised and begun experimenting with a means of using VRS to support independent remedial hand-writing and typing exercises, whereby he first produced a spoken version of a single word, then listened to it to check it was accurate, and finally spent time copying it, both by handwriting and with the keyboard. Though this sounded laborious, Peter was embracing it with great enthusiasm, and it may be feasible to adapt his procedure for other severely dysgraphic individuals who keenly wish to re-learn writing of certain key functional words such as the names of family members, in order that they may achieve personal and social literacy goals, such as writing greeting cards, without the need for AT.

### **9.13 Conclusion**

This thesis has provided evidence that, with adequate support, people with aphasia can be successfully trained to use two mainstream AT software packages, and that their use can significantly improve narrative writing and reading comprehension for PWA. It has also gathered rich data regarding individual differences between participants, in order to offer tentative predictions as to which candidates may benefit most from training in future. For the participants in this study, substantial time had passed since the onset of stroke. The majority were reconciled with their residual deficits and had made admirable progress in compensating for them. Yet

from the outset, it was clear that the loss of writing was still keenly felt, and continued to present them with both practical and emotional obstacles in their everyday lives. Writing and reading activities are increasingly intertwined with technological advances, and it is crucially important to ensure the right of all people to participate and engage with them. Aphasia is often referred to as an invisible disability, and it became apparent that in turn dysgraphia can all too easily become the least visible aspect of the communication challenges faced by people with aphasia, but one that has the power to reduce self-esteem and heighten a sense of isolation. An assistive technology training program has the potential to provide even severely dysgraphic individuals with access to writing and reading, and in turn increase social participation. For someone like Peter, who had been unable to email his children for ten years, the impact of training may be dramatic:

‘I wouldn’t be able to do anything like that by myself these days unless there was the microphone. When I come here, I am alive’ (Peter, training session 7).

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Appendix 3.1: Data extraction table for the systematic literature review

<b><i>Non technology-based interventions (N = 28)</i></b>						
<b>Author(s) &amp; year</b>	<b>Participants</b>	<b>Setting</b>	<b>Design</b>	<b>Intervention</b>	<b>Outcome measures</b>	<b>Main findings</b>
Ball, de Riesthal, Breeding & Mendoza 2011 [140]	Three adults with severe aphasia and apraxia of speech	University clinic, home practice with video	Case series	Therapy using the modified version of ACT and CART with spoken repetition (see Beeson & Egnor 2006 below) Participants selected 18 target items from a selection of noun and verb pictures 12 weekly ACT sessions and 6 days per week of CART and repetition homework	<u>Pre-treatment:</u> Western Aphasia Battery (WAB) John Hopkins University Dysgraphia Battery Cognitive Linguistic Quick Test (CLQT) Pyramids and Palm Trees  All repeated post-treatment and at follow up	All participants showed improvement in the written task, but none in the spoken task – authors conclude modified ACT and CART may not be suitable for individuals with severe aphasia couple with apraxia of speech
Beeke, Johnson, Beckley, Heilemann, Edwards, Maxim & Best 2014 [120]	Male with aphasia and non-aphasic conversation partner	Participant's home	Single case	Training designed to encourage participant with aphasia to increase use of writing in conversation, and to encourage partner to reduce corrective behaviours and increase facilitative behaviours	<u>Pre-treatment:</u> Verb and Sentence Test (VAST) Object and Action Naming Battery  <u>Treatment:</u> Conversation Analysis of 12 video recorded conversations between PWA and partner, six before therapy and six after, raters blinded to time point; barrier and facilitator behaviours counted  <u>Post treatment:</u> Semi-structured interview	PWA used writing to enable word-finding in order to complete his conversational turn. Pre-treatment, partner engaged in 'correct production sequences', ignoring written production until PWA had correctly spoken the target. Therapy involved examining video recordings of their conversation with a therapist and looking at conversational strategies they could adopt. Post-therapy, PWA significantly increased use of writing and partner significantly reduced correction sequences. No other strategies (gesture, keywords, paraphrasing etc) showed significant change for either of the pair.

						PWA's writing is dysgraphic but highly functional as a turn-taking resource to support his agrammatic speech.
Beeson 1999 [191]	75 year old man with severe Wernicke's aphasia	Assessments in university clinic, self-directed therapy at home	Single case	<p>Focused on strengthening graphemic representations so that single word writing would be available to support other modalities of communication, 1: Examine effectiveness of cueing hierarchy (2 sessions per week for 10 weeks) using Anagram &amp; Copy Treatment, 2: subsequent treatment to increase single word vocabulary 3: maximise writing use for conversation and 4. shift responsibility for rehabilitation from therapist to participant choosing words he wished to spell; 27 hours of therapy + 10 testing sessions over 16 month period</p>	<p><u>Pre-treatment:</u> WAB Portions of the John Hopkins University Dysgraphia Battery – to assess single word writing Wechsler Memory Scale - Revised Raven's Coloured Progressive Matrices</p> <p><u>Treatment:</u> Cueing hierarchy – anagram rearrangement followed by repeated copy of the target words (ACT); later with the inclusion of one foil vowel and one foil consonant in the anagram sequence, and writing the target from memory rather than copying</p> <p>Daily Copy And Recall Treatment (CART) homework</p> <p><u>Post-treatment:</u> WAB Portions of the John Hopkins University</p>	<p>The participant had severe impairment of written and spoken modalities but former was responsive to treatment while latter was resistant</p> <p>At end of treatment phase 1 spelling of targeted words had improved but there was no evidence of carryover to untrained items</p> <p>Phase 2 was CART at home only, no ACT with therapist; again item-specific improvement only, and no evidence of functional use of writing</p> <p>Phase 3 targeted 20 functionally useful nouns suggested by participant's wife, using them in natural conversation with coaching on selecting from range of options: successful use of three item sentences to convey novel messages</p> <p>Phase 4 –ambitious target of 40, 14 correctly spelled and misspellings were often recognisable or semantically related</p> <p>WAB and JHADB unchanged</p>



					Dysgraphia Battery – to assess single word writing PALPA 25, 47, 48	
Beeson, Hirsch, & Rewega 2002 [194]	Four individuals with aphasia and severe dysgraphia	University clinic treatment for two, home-based practice for all four participants	Case series	Single word writing treatment: two participants received therapist-led ACT and homework CART, other two received latter only Dose varied slightly: 3 participants twice a week, one once, and two worked on 35 words, the others 'a minimum of 20' in sets of five CART involved copying each word of a set at least 20 times, 6 days a week	<u>Pre-treatment:</u> PALPA subtests 53 written picture naming (except one participant received analogous task from JHADB) 31, 48 & 25 Wechsler Memory Scale - Revised Raven's Coloured Progressive Matrices Pyramids and Palm Trees	All four responded positively Three had severely limited spoken language and writing provided access to communication, the fourth employed his improved writing for messages such as email  Case 1 (global aphasia, ACT & CART): improvement in trained, none on untrained, but set himself targets for learning functionally useful words and used these to communicate Case 2 (Broca's aphasia, ACT & CART): improvement in trained, some partial knowledge (first few letters) of untrained, used writing for functional communication and continued to target new words Case 3 (severe Broca's aphasia, chiefly used gesture, CART only): improvement in trained, in testing no improvement in untrained however anecdotal evidence from group settings suggests some progress Case 4 (moderate-severe Broca's aphasia, CART only): improvement in trained, non-significant but adequate improvement in untrained, able to use email with support from family to write unfamiliar words for him to copy,

						<p>and enhanced social participation (no formal measure of this indicated); used writing in conversation and this sometimes cued oral output</p> <p>CART alone (i.e. independent work) is enough to improve single word spelling</p>
Beeson, Rising & Volk 2003 [173]	8 individuals with severe aphasia (1 Wernicke's, 7 Broca's)	2 university clinic sessions per week plus daily homework	Case series	CART therapy, to assess the nature and severity of cognitive and linguistic impairments of those who respond well versus those who do not	<p><u>Pre-treatment:</u>  PALPA subtests (numbers not given)  Pyramids and Palm Trees  Tapping Forwards subtest from the Weschler Memory Scale - Revised  Raven's Coloured Progressive Matrices  Oral language portions of the WAB</p>	<p>Of the 8 participants, 4 showed strong, positive responses to treatment, 3 others showed some response but failed to match criterion, one had a poor response.  Impressive response for severe aphasia – words of 2-9 letters – no generalisation to untrained, therefore CART is working to strengthen graphemic representations. All four went on to acquire new spellings for conversational use in a self-directed manner [reported in Clausen &amp; Beeson 2003 below]</p> <p>Factors limiting likelihood of success:  *cognitive-linguistic impairments – Pyramids and Palm Trees (i.e. semantic) test and PALPA 47 (spoken word-picture matching i.e. auditory processing and semantic) showed a significant positive correlation with treatment effect - unsurprising since written words need to be linked to their meaning in order to be useful</p>

						<p>One participant had particularly poor recall of copied words and performed the most poorly – authors suggest testing this might indicate someone unlikely to respond after one or two sessions</p> <p>*failure to accurately complete CART homework</p> <p>Aphasia severity on the WAB does not appear to be a predictive factor for success</p>
Bowes & Martin 2007 [127]	45 year old female with phonological dyslexia and phonological dysgraphia	Not stated	Single case	<p>Investigation of bigraph-biphone segment blending therapy on reading and writing abilities; 3 treatment programmes over 3 year period [dose and frequency/gaps not indicated]</p> <p>1<sup>st</sup>: focus on improving awareness of grapheme-phoneme correspondences and sound blending abilities for non-words</p> <p>2<sup>nd</sup> &amp; 3<sup>rd</sup>: extend these abilities to reading and writing two syllable words and phrase length material</p>	<p><u>Pre-test:</u></p> <p><i>Tests of semantic knowledge:</i></p> <p>Boston Naming Test</p> <p>Philadelphia Naming Test</p> <p>Peabody Picture Vocabulary Test</p> <p>Philadelphia Comprehension Battery</p> <p>Pyramids and Palm Trees test</p> <p>Short-term memory span</p> <p><i>Tests of phonological processing:</i></p> <p>Philadelphia Repetition Test</p> <p>Rhyme judgement, phoneme discrimination, auditory lexical decision</p> <p><i>Tests of reading and writing:</i></p> <p>PALPA subtests 22, 29,</p>	<p>Before treatment participant used lexical approach to reading which led to guessing incorrect words based on partial phonological information. This was remediated by using non-words to necessitate use of grapheme-phoneme conversion route; the approach was also successful for writing</p> <p>In all but one trained set of words, there was generalisation to controls and untrained words</p> <p>Further, improvements in reading generalised to ability to write those same words – suggests efficacious to train both together; also begs question of whether reading therapy alone also treats writing?</p> <p>Note that this was a very long term intervention</p> <p>Also note that this participant was working for the same employer as before stroke but with modified duties (she was previously a sports</p>

					30, 31, 32, 35, 37 Reading Comprehension Battery for Aphasia (RCBA) <u>Baseline:</u> As above <u>Post-test:</u> As above	reporter)
Carlomagno, Colombo, Casadio, Emmanueli & Razzano 1991 [160]	Six 'highly educated' PWA	Not stated	Group	All participants received two rehabilitation treatments based on dual route theory, where phonological treatment stimulated phoneme- grapheme conversion and visual-semantic treatment stimulated whole word retrieval	<u>Pre-treatment</u> 'Written naming and writing from dictation tasks' – test name not given 'Repeated assessment on reading and writing subset of standard aphasia test' (attributed to Pizzamiglio et al 1985) <u>During treatment:</u> Standard aphasia testing every three months Writing abilities 'evaluated by means of a modified version of a standardised battery for assessing reading and writing disturbances (attributed to Burani 1984 unpublished) – highly modified owing to 'orthographic peculiarities of written Italian.' <u>Post-treatment:</u> Writing assessments repeated at end of each	Both treatments had significant and maintained impact, but when single cases were considered three participants were found to respond to only phonological treatment, one only to lexical treatment, two to lexical with some residual impact of phonological.

					therapy and fifty days later	
Carlomagno et al 2001 [161]	Eight individuals with moderate aphasia, 6-12 months post-onset	Two ambulatory care units	Group	Testing two types of intensive writing intervention (each 20-24 one hour sessions over 5-6 weeks), with assessments of reading and writing before and after therapy, and one month later One 'lexical' therapy – whole word spelling in crossword format, one 'non-lexical' – repetition, phoneme discrimination and segmentation, letter-sound matching, syllable spelling, pronounceable nonsense strings Participants not randomly assigned	Communicative Abilities in Daily Living (CADL) Standardised aphasia assessment (Italian – BADA – said to be similar to PALPA) Psychosocial adjustment was assessed through unstructured interviews with relatives (but not the participants themselves)	Two interventions found to be equally effective across the group, with results as expected: lexical therapy led to changes in written naming and writing to dictation, while non-lexical led to improved nonsense strings and word writing but not written naming Individual effects analysed: for 2 patients both interventions effective, for the remaining six only one intervention was effective (three of each) 4 of the 8 regained employment which involved reading and writing after the intervention and for a 5 <sup>th</sup> better psychosocial adjustment was observed Two of the patients who responded to lexical therapy also showed generalisation to oral picture naming – they were observed to prime their oral response by writing down the first letter of the stimulus Note though that Italian, unlike English, is considered to have shallow orthography so that an acceptable level of accuracy can be achieved even when using only one of two routines
Clausen & Beeson 2003 [143]	Four individuals with chronic, severe aphasia and	University clinic or participants' homes	Case series [The 4 participants are all reported	Facilitating the use of writing in conversation for people with severe aphasia, using Copy And Recall Treatment (CART)	<u>Pre- and post-treatment:</u> PALPA visual lexical decision making subtests	All four were able to use telegraphic written in group setting (facilitated by two SLTs) and in communication with unfamiliar conversation partners,

	agraphia		elsewhere – DR, SL and WD in Beeson, Rising & Volk 2003[173], AD in Beeson, Hirsch & Rewega 2002 [194]]	to improve spelling of target words (bespoke, generated collaboratively by individual, spouse and clinician) in individual sessions, plus group work and unfamiliar partner work on single word writing for conversation, using loosely structured scripts	Pyramids and Palm Trees Raven's Coloured Progressive Matrices	<p>though the latter produced fewer words, and words learnt first (i.e. practised most) were used most, suggesting rehearsal with friends and family would be beneficial</p> <p>Word lists contained biographically useful information for group work: family, employment history, hobbies, favourite food/restaurants, plus words to facilitate requests for information from others e.g. name? Work? From? Eat out?</p> <p>Despite repetitive nature the groups are reported to have been conversational and 'genuine', also supportive thereby providing psychosocial benefit (not measured)</p> <p>The most independent participant used writing for functional communication the most – he had a part-time job and use public transport alone; at the start of treatment his preferred method was attempting speech so this was a trained and reinforced strategy</p>
Kiran 2005 [144]	Three male monolingual individuals with aphasia	Referral from regional speech pathologists and hospitals, setting not	Case series	Phoneme to grapheme training across writing to dictation, written naming, oral spelling and oral naming; hypothesis that training one modality will increase access to another i.e.	<u>Baseline:</u> WAB, Boston Naming Test, 19 PALPA subtests <u>Stimuli, tested pre-treatment in all four conditions:</u> 20 regular, imageable words that participant	<p>Writing to dictation improved for 2 of the 3 participants (trained and untrained words)</p> <p>Written naming and oral spelling of trained words improved</p> <p>Marginal effect seen on untrained</p>

		stated		looking for generalisation to untrained items on untrained tasks	could not write, spell or name (different for each participant), divided into trained and untrained sets <u>Post-treatment</u> : stimuli as at pre-treatment, plus all baseline assessments repeated	words for written naming, oral spelling, oral naming
Krajenbrink, Nickels & Kohnen 2016 [150]	Two males with acquired dysgraphia	University clinic	Case series	Two phase CART designed to strengthen graphemic buffer and test whether orthographic neighbourhood size impacted treatment effects and generalisation	<u>Diagnostic</u> : CAT, PALPA subtests Single word spelling treatment stimuli with no neighbours, many neighbours and control sets	Significant treatment effects for one participant; trend only for the other; no generalisation for either candidate
Lustig & Thompkins 2002 [122]	Female with aphasia and apraxia of speech	Three conversational settings: therapist and client in a) quiet, private room, b) café; client and unfamiliar conversational partner in quiet, private room (clinician present,	Single case	Training to encourage participant to substitute a self-initiated written word for protracted articulatory struggle, in three conversational settings (private, public, unfamiliar partner)	<u>Diagnostic</u> : Porch Index of Communicative Ability Western Aphasia Battery Apraxia Battery for Adult Progressive Coloured Matrices Revised Token Test <u>Pre &amp; post-treatment</u> : Communication Attitude Inventory Recovery Locus of Control Scale Rosenberg Self-Esteem Scale Social validity judgements	Participant adopted strategy and successfully used it in all three settings Social Validity Ratings increased for shorter video clips but not longer segments No change on CAI or Rosenberg, but locus of control on Rosenberg had shifted indicating increased willingness to allow conversation partners to share responsibility for communicative success

		observing)				
Mitchum, Haendiges & Berndt 1993 [200]	Adult male with chronic, severe non-fluent aphasia	Not stated	Single case	<p>Model guided treatment to improve written sentence production; hypothesised this would generalise to spoken sentences since they postulate impairments affecting sentence production affect processing components executed prior to modality 'split'</p> <p>Treatment 1: facilitation of written verb retrieval with 16 line drawn transitive verbs</p> <p>Treatment 2: facilitation of grammatical frame structure using past, present and future verb sentence structures</p>	<p><u>Diagnostic:</u> Boston Diagnostic Aphasia Examination (BDAA) Boston Naming Test</p> <p><u>Baseline:</u> 12 months of 2 hour weekly sessions (clearly part of a much bigger study) to explore difference between ability to use single words and inability to produce or understand sentences</p> <p><u>Stimuli:</u> 2 sets of 30 line drawings for single words, one nouns one verbs A set of 12 line drawings showing an animate agent engaged in a transitive activity i.e. SVO, for oral and written production of active and passive sentences Target words for use for formulating sentences containing the target word Cinderella picture book with no words, for spoken and written narrative elicitation</p>	<p>Prior to treatment participant had a clear and consistent pattern of poor main verb retrieval and impaired use of grammatical elements related to the verb; tests reveal fair auditory comprehension of single words but poor sentence comprehension.</p> <p>During long pre-treatment assessment phase: *unlike other participants in their larger scale study, this individual showed greater ease of output with written than verbal expression. His written object naming was superior to written action naming *all syntactically well-formed sentences were produced in response to noun rather than verb word targets *written sentences for narrative exercise used only non-lexical verbs</p> <p>Dramatic improvement in written picture description following two treatment phases, even in narrative task</p> <p>Notable that in this study the participant's reading was very impaired and he could not read the sentences he had produced – this intervention seems to be of limited practical use to him in</p>



						terms of functional writing – but he also showed remarkable changes in spoken sentence production i.e. evidence of generalisation
Murray, Timberlake & Eberle 2007 [129]	52 year old male with agrammatic Broca's aphasia	University clinic plus weekly homework assignments	Single case	Training with a modified version of Treatment of Underlying Forms targeting writing only Stimuli: 20 pairs of drawings depicting both versions of semantically reversible sentences e.g. artist chased thief, thief chased artist; ten used during treatment, ten untrained to allow experiment to be controlled Plus printed word and noun/verb phrase cards and additional sentence elements 'I know', 'who'	<u>Pre-treatment and during treatment:</u> Production of five sentence types (passive, object-extracted embedded, subject-extracted embedded, OE matrix, SE matrix) <u>Post-treatment:</u> Four discourse samples – procedural & descriptive, spoken and written <u>Follow up</u> at 4 weeks – as post-treatment	(TUF – hypothesis that training complex non-canonical sentences can concomitantly improve untrained syntactically related simpler structures)  Gains in complex structures resulted in gains in untrained, simpler, related structures, and generalised to spoken production of those structures
Orjada & Beeson 2005 [192]	Male individual with chronic aphasia, alexia and agraphia	Setting not stated; daily homework	Single case	Concurrent treatment of reading and writing impairments using Oral Reading Treatment (ORT) using seven personally relevant scripts (73-156 words long), and Copy and Recall Treatment (CART) to retrain 50 targeted words (10 each from the first three scripts, 5 each from the last four scripts), for ten weeks, two one hourly sessions per week	<u>Pre-treatment:</u> WAB First five levels of the Gray Oral Reading Test 3 (GORT-3) Single word reading and spelling assessed using: 120 item list balanced for frequency regularity and word length; 20 item functors list; 20 item non-word list  <u>During treatment:</u> At beginning of every	[Participant had received six weeks of successful ORT training prior to combined therapy]  Reading accuracy: pre-training average was 79.1%, errors were predominantly functor substitutions and visually similar words; post-intervention accuracy was 90% or higher  GORT-3 also indicated improved reading of functors, which were not specifically targeted

				<p>Reading was treated at sentence level during therapy sessions, with additional daily reading homework; writing was treated at word level – trained in sessions but completed at home</p>	<p>session, probes of reading accuracy, reading rate and spelling accuracy; each script had to 90% accurate before the next script and related spellings were introduced</p> <p><u>Post-treatment:</u> WAB First five levels of the GORT3</p>	<p>Reading rate: increased from average 43.7 WPM to average 61.5 WPM</p> <p>Spelling accuracy: improved over all seven sets; decline shown for earliest set at session 8 probe so maintenance homework was incorporated and follow up probe at session 16 indicated maintenance had now occurred</p> <p>Authors observed participants spoken language also appeared to improve</p>
Panton & Marshall 2008 [29]	Male participant with dysgraphia, hypothesis: at graphemic buffer level	NHS speech and language therapy clinic	Single case	<p>Treating spelling and every day writing (in this case, note taking for work) based on Duchan &amp; Black's (2001) 'life goals' model</p> <p>Intervention designed after pre-treatment testing: 1. increase capacity of orthographic buffer, with the aim of generalisable spelling benefits, and 2. Encourage compensatory strategies e.g. focusing on key words and abbreviation rather than spelling or verbatim transcription</p> <p>12 one hour sessions, spread over six weeks</p>	<p><u>Pre-treatment:</u> PALPA 40, 45 Assessments created by the authors: 1. note taking task using two fictitious messages and a short news story – listen three times then note down content, using any method available (i.e. compensatory strategies were permitted), 2. task testing influence of word length on spelling 3. task testing knowledge of germination (doubling of items e.g. broom, chatter)</p> <p><u>Post-treatment:</u></p>	<p>Participant worked as a political councillor and was using word prediction software on his computer and had a secretary, but had profound difficulty with all handwritten tasks and needed to take notes for work</p> <p>Two blind raters assessed Ray's notes and there was a highly significant effect for therapy on number of units understood</p> <p>Writing to dictation: trained words improved and maintained, untrained also improved but not maintained</p> <p>Qualitative analysis of note taking methods indicated: More whole words achieved post-therapy, including non-trained + more close approximations</p>

				plus independent work sheets	Repeat two phone messages note taking task – one using vocabulary practised, the other not (therefore also testing generalisation) Writing to dictation task, using long words related to participant's life <u>Follow up at 3 months:</u> As at post-treatment, plus news story note taking	More use of strategies (grouping words, abbreviations) + strategic word substitution for words participant knew he could access e.g. committee changed to meeting  Participant seemed able to switch between registers after therapy, focusing on perfect spelling when writing to dictation but on content with message taking
Rapp 2005 [148]	Three adults with acquired dysgraphia with either orthographic lexicon or graphemic buffer deficits	University clinic	Case series	Spell-study-spell protocol, bi-weekly sessions for 7-11 weeks with periodic follow up for 40-112 weeks	JHU Dysgraphia Battery	Significant remediation for all three participants; generalisation to untreated items for two individuals with GB deficit but not the individual with OOL deficit. Maintenance varied, authors consider cognition to be a factor here
Raymer, Cudworth & Haley 2003 [124]	Male with severe agraphia, diagnosed as impaired both at orthographic output lexicon and graphemic buffer	Not stated; daily homework	Single case	CART for two sets of words trained sequentially, and an examination of generalisation to untrained words with similar beginnings/endings, and non-words	<u>Diagnostic:</u> Western Aphasia Battery Boston Naming Test Johns Hopkins University Dysgraphia Battery <u>Post-intervention:</u> WAB writing subtest	Authors contend generalisation pattern post therapy indicates improvement in two stages of spelling, with improvements to untrained words with similar beginnings/endings indicating changes mediated by the OOL, and improvements to non-words and greater improvement for beginnings over endings indicating a strengthened graphemic buffer
Raymer, Strobel,	Four participants	Not stated	Case series	Errorless and errorful training of spelling to	Boston naming test, WAB, JHU Dysgraphia	Significant improvements in both conditions; little generalisation to

Prokup, Thomason & Reff 2010 [151]	with acquired dysgraphia (one male also took part in the single case study above)			dictation	Battery	untrained words (though better performance on WAB for three of four participants). Better results for errorful in terms of scores and maintenance, but participants preferred errorless condition
Robson, Pring, Marshall, Morrison & Chiat 1998 [125]	Female individual with severe undifferentiated jargon aphasia	Not stated	Single case	3 stage therapy programme devised to improve single word writing and encourage its use for functional communication. Stage 1 (14 x 45 minute sessions over 5 weeks): written picture naming, stage2 (15 sessions): written answers to spoken questions, stage 3 (16 sessions): making explicit link between items participant could write and messages they might convey by linking single words to complex concepts: 'message therapy'	<p>Acknowledge there should be a repeated baseline but state this would be too arduous for participant</p> <p><u>Stage 1: Pre-, post- and at six week follow up:</u> Core vocabulary of 74 words in six semantic classes collected in collaboration with participant's friends and divided into sets matched for word length and frequency – one set was treated and one used as a control</p> <p><u>Stage 2:</u> 18 words and pictures from above set based on good performance at stage 1; questionnaire designed to elicit the items in a functional way e.g. what might you order in a café?</p> <p><u>Stage 3:</u> word</p>	<p>Pre-testing indicated that participant is unable to monitor her speech despite good auditory comprehension, but is able to perceive her writing errors despite poor visual word recognition skills</p> <p>Stage 1: *Pre-treatment: spelling score was 0/74 Post- : 14/74, of which 12 were from the therapy set (significant effect of training); more partially correct items from trained set too *Decline seen at maintenance follow up, but still significantly better than pre-treatment *Failure to generalise to functional communicative settings</p> <p>Stage 2: *significant therapy effects *slight use in functional communication – adding markers to a map, writing therapy appointments in diary</p> <p>Stage 3: *Increased ability to associate single items with longer messages</p>

					association tasks, initially with a stimulus word and a set of choices, then just stimulus, then phrase rather than word: assessed with a written picture naming task and a message production task (message given to participant orally and in written form, required to produce a word to convey it	<p>*Items which had not been treated with message therapy were produced as responses</p> <p>*Friends indicate use of writing communicatively</p> <p>Participant remained unaware of the incomprehensibility of her jargon, was distressed by not being understood, and favoured oral output – but she had increased awareness that writing was of communicative value</p>
Robson, Marshall, Chiat and Pring 2001 [147]	Ten individuals with jargon aphasia who produced fluent neologistic speech and rarely monitored their output	Participant s referred from speech and language therapists; setting not stated	Case series	<p>1: anagram sorting, delayed copying, lexical decision tasks – 6 participants assessed as having residual orthographic knowledge</p> <p>2: These six received copying, word completion and picture naming tasks (selected based on diagnostic performance) with personally useful vocabularies (20 common, 20 proper nouns divided into ten of each treated and ten controls) – 12 sessions of 45-60 minutes delivered twice weekly</p> <p>3: Three of the participants (those who had a regular communication partner)</p>	<p><u>Diagnostic:</u></p> <p>Pyramids and Palm Trees</p> <p>PALPA subtests assessing spoken and written word comprehension</p> <p><u>Exclusion stage:</u></p> <p>Writing assessments: picture naming, anagram sorting, delayed copying, lexical decision tasks using 32 items</p> <p><u>Pre-therapy (6 participants):</u></p> <p>Writing personal vocabulary items, and writing an item which would convey a message related to it (but not containing it), where message read aloud and shown to</p>	<p>Before therapy, all ten participants were poor at naming, equally in both modalities, with no effects of frequency, length or regularity; however while speaking was fluent, writing was non-fluent with self-correction attempts</p> <p>All were more successful with anagrams than writing</p> <p>Copying performance ranged from near perfect for real words to very impaired</p> <p>Lexical decision surprisingly good: 9/10 scored 90%+</p> <p>Four were excluded owing to distress, ill health, poor attendance</p> <p>The six clients who received therapy made significant progress in written naming, with no gains on control items. They did not use writing for functional communication; only one showed</p>

				received 6x45 minute sessions of 'message therapy' – reinforcing how one word could relate to a phrase level complex message	participant by therapist <u>Post-therapy at stage 2</u> – as pre- Plus follow up one month later, for those who had shown significant gains post-therapy only <u>Post-therapy at stage 3:</u> Word and message related tasks repeated, plus conversations to assess functional communicative use	significant improvement on the message task  The three who received message therapy made progress on assessments and families reported functional use of writing, both of treated and untreated words; sometimes approximate or initial letters only, but communicatively useful, plus more creative uses such as combining words or using writing + drawing  'This approach to therapy rests on the finding that in some people with jargon aphasia, writing differs in character from speech, being more accurate and better monitored' page 484
Sage & Ellis 2006 [30]	Female individual with graphemic buffer impairment	Not stated	Single case	Priming study contrasting no primes, control primes and orthographic neighbour primes, followed by therapy with three word sets: one direct therapy, one no therapy, one with therapy to neighbours of words in set	<u>Pre-treatment:</u> Raven's Progressive Matrices National Adult Reading Test Boston Naming Test Graded Naming Test	Priming study indicated changes in accuracy when orthographic neighbours used. Therapy indicated improvements to both directly treated and neighbour set words, with no change in control word spelling
Salis & Edwards 2010 [130]	Female individual with moderate to severe aphasia and severe apraxia –	'The treatment was undertaken in the context of current UK clinical practice' –	Single case	Therapy treating verb and sentence production with ten weekly sessions, aiming to improve 1. Spelling of transitive and intransitive verbs 2. Written production of simple SV sentences 3.	<u>Pre-treatment assessments:</u> Raven's Standard Progressive Matrices <i>Word level:</i> PALPA subtests (47, 48) <i>Sentence level:</i> Verb And Sentence Test	Before treatment, only 4 intransitive and no transitive words were attempted  Intransitive and transitive verbs and SV improved and maintained; SVO sentences more challenging and decline at maintenance

	communicated mostly through writing	assume this means an NHS setting?		<p>Written production of SVO sentences</p> <p>Treatment of lexical items and sentences was simultaneous: asked to describe a picture with one word then write a sentence with that word in it</p>	<p>(VAST) [adapted for written rather than spoken use] Event Perception Test Written picture description: Cookie Theft</p> <p><u>Treatment stimuli:</u> Picture sets of 12 intransitive and 15 transitive verbs</p>	<p>Little evidence that strategy was used functionally</p>
Schwartz, Nemeroff & Reiss 1974 [165]	<p>Eight adult males with aphasia in the treatment group, six adult males with aphasia in the control group, matched for age, time post-onset, education and pre-therapy score on Porch Index of Communicative Ability</p>	Not stated	RCT	<p>Two language therapy programs delivered to treatment group. Hypotheses: there would be significant differences between the two groups: on the PICA post-therapy, in degree of improvement, and in daily average scores in various writing tasks</p> <p>Experimental subjects received 20 x 30 minute sessions comprised of: writing alphabet from memory, written picture naming, writing to dictation, writing words which were said, then placed in a sentence, then repeated</p> <p>Control subjects received 20 sessions of multi-modal language therapy using the same stimuli</p>	<p><u>Pre- and post-treatment:</u> Porch Index of Communicative Ability</p>	<p>There was no significant difference between the two groups on the post-treatment PICA, although it was approached, in favour of experimental group</p> <p>Significant difference in degree of improvement between the experimental group and controls</p> <p>But, 'the experimental group did not significantly respond in a differential manner to any of the five writing tasks' P283</p> <p>Authors note it would have been useful to include a control group who did not receive therapy of any kind</p>

Thiel & Conroy 2014 [145]	Four individuals with acquired dysgraphia	Recruited from two stroke support community groups; home setting	Case series	Investigation of whether errorless and errorful therapies would differ in their effects on spelling speed as well as accuracy, using matched sets of words plus a control set		Both approaches improved accuracy; for three participants the gains were equivalent, for the fourth improvements were significantly greater with errorless therapy. There was no significant difference in spelling speed between the two conditions
Thiel, Sage & Conroy 2016 [146]	Eight participants with dysgraphia	Not stated	Case series	Comparison of uni-modal with multi-modal therapy, crossover design whereby all participants received both types  Note that participants were excluded if they had severe reading impairment as assessed on the CAT	CAT PALPA spelling assessments (39, 40, 44, 45) Boston Diagnostic Aphasia Examination (short version) Pyramids and Palm Trees Test Picture matching	Authors say treatment is usually uni-modal – using either writing to dictation or copy and recall. Comparison of uni-modal with multi-modal revealed no significant differences between the two models – both improved accuracy of treated and controlled items, though not all improvements were maintained at follow up. They conclude outcomes depend on participant variables rather than uni/multi modal treatment model. All participants preferred the multi-modal therapy owing to greater variety of tasks
Thiel, Sage & Conroy 2016 [149]	Eight individuals with an acquired spelling impairment following stroke (same individuals as in the above 2016 study)	Not stated	Case series (generalisation measured as a group)	10 sessions of CART spelling to dictation of trained and untrained words; group generalisation to functional narrative and written picture description besides frequency of writing and perception of disability	<u>Diagnostic:</u> BDAE, PPT, PALPA <u>Outcomes:</u> Spelling to dictation of trained and untrained words, written picture description, spelling accuracy within emails, disability questionnaire, writing frequency diary	All made gains on treated words; six of eight on untreated. Group analyses showed significant improvements to written picture description, but not to functional emails, nor to writing frequency or disability perception
Tsapkini &	One with	Not stated	Case series	Sub-lexical route	<u>Pre- and post-therapy,</u>	30 sounds representing most



Hillis 2013 [126]	post-stroke aphasia, one with primary progressive aphasia – results for first participant only are reviewed here			treatment (phoneme-grapheme conversion training), 25 weekly, hour long sessions (this was the time the training took to complete rather than a fixed pre-determined intervention period)	<u>and at six month follow up:</u> WAB John Hopkins Dysgraphia Battery	common word-initial phonemes in English, with 30 words to anchor these sounds to graphemes  Participant was able to learn relationship between phonemes and graphemes and between phonemes and words, and there was generalisation to untrained words, both maintained at six month follow up
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<b>Technological interventions (N = 25)</b>						
<b>Author(s) &amp; year</b>	<b>Participants</b>	<b>Setting</b>	<b>Design</b>	<b>Intervention</b>	<b>Outcome measures</b>	<b>Main findings</b>
Al Mahmud & Martens 2013 [167]	12 PWA and family members interviewed, 8 PWA to give end user feedback	Recruitment via local rehabilitation centre, interviews in participants' homes	Qual Analysis of transcribed interview field notes and q'aires	Iterative design and exploratory evaluation of modified email tool ('Amail') for PWA; three stages of design and feedback	Video-recorded in depth interviews with PWA (N=12) and their family members (N=not given), plus field notes; questionnaire about computer and email use and barriers to use; triangulation of interview findings via interviews with two SLTs and one 'computer trainer.' Interviews analysed using procedures from Grounded Theory	<p>PWA reported:</p> <ul style="list-style-type: none"> <li>*Reading emails is comparatively easy but composing responses is challenging</li> <li>*Interface needs to be simple to use independently, particularly most common functions (new message, respond to message)</li> <li>*Limit number of options to minimise confusion</li> <li>*Support with composition at word or phrase level combined with pictures/icons would be helpful</li> </ul> <p>Therapists reported:</p> <ul style="list-style-type: none"> <li>*Email is a potentially useful way for PWA to increase social and therapeutic contact</li> <li>*Supplying standard sentences for insertion, and step by step written guidelines, would be useful</li> </ul> <p>End user testing with 8 PWA found:</p> <ul style="list-style-type: none"> <li>*Preference for pasting from received email/dictionary rather than writing new words</li> <li>*Recommended a text to speech function to assist with reading incoming emails</li> <li>*Minimise visual components and navigation steps</li> </ul>
Armstrong & MacDonald 2000 [139]	Male adult with aphasia, 9 years post onset	Speech and language therapy clinic (unclear whether university or	Single case	Two compensatory interventions. First physical: splint to enable writing directly onto computer screen	<u>Baseline assessments:</u> 1. 'Sentence level material analysed for graphemic and linguistic (syntactic and semantic) effects'	<ul style="list-style-type: none"> <li>*Quality of written production improved when using dominant hand – more flexibility of expression, more abstract verbs, fewer spelling errors</li> <li>*By third session of technology</li> </ul>

		NHS)		<p>using a Mousepen with dominant (hemiplegic) hand – 12 sessions;</p> <p>Second technological: word processing programme with auditory feedback and lexical and grammatical prediction (Write:OutLoud® and Co:Writer®) – 12 sessions after first intervention completed</p>	<p>2. Single word writing to dictation of five words from the Test of Word Knowledge (TOWK)</p> <p>3. Written picture description using the Western Aphasia Battery (WAB)</p> <p>4. PALPA subtest 44 to evaluate regular and exception word spelling</p> <p><u>Post-physical intervention:</u> 2, 3 and 4 repeated and pre- and post-differences descriptively analysed</p> <p><u>Post-technological intervention:</u> 2, 3 and 4 repeated and pre- and post-differences descriptively analysed, and qualitative descriptions of participant's continued functional use</p>	<p>intervention sentence content and construction in written picture description appeared normal</p> <p>*Slow but accurate selection of target from predicted list, provided he got first letter correct (otherwise an unrelated list may be generated)</p> <p>*Both interventions had a positive impact on regular word spelling. Prosthesis had negligible effect on exception word spelling; computer did in that participant could recognise and select a predictive target even if he could not spell the whole item</p> <p>*At sentence level, higher volume and more complex output, though the complexity resulted in greater number of grammatical and semantic errors</p> <p>Long term: participant bought a PC and used it to write letters independently 4 times a week</p>
Beeson, Rewega, Vail & Rapsack 2000 [71]	Two individuals with acquired spelling impairments one post-stroke, one post-TBI – data extracted for first individual only	Setting not stated; additional homework	Case series	Homework based ten-month intervention to improve spelling, based on observation that participants produced phonologically	<p><u>Pre-treatment:</u></p> <p>WAB</p> <p>Boston Naming test</p> <p>Weschler memory Scale-Revised</p> <p>Johns Hopkins University Dysgraphia Battery</p>	<p>Spelling improved for both participants and showed 'interactive' use of partially preserved lexical, and sub-lexical routes</p> <p>Participant also wrote an essay describing her spelling strategies. Regarded both her spelling and her</p>

				plausible spelling errors based on sound to letter correspondences, using this plus self-correction plus an electronic spellchecker		error detection as improved  Highly educated and literate participant; three degrees and an amateur fiction writer
Beeson & Egnor 2006 [152]	Two adults with moderate aphasia and severe spelling impairment	Home or university clinic plus daily homework	Case	Twice weekly sessions for ten weeks (5 for each type of treatment) plus 30-60 minutes homework daily Combining treatment for written and spoken naming using Copy and Recall Treatment (CART) writing treatment with verbal repetition treatment of target words; and comparing this to repetition only i.e. oral naming without written spelling AAC device used – names audio-recorded and labels representing items affixed to buttons, one side for CART, one side for repetition only	<u>Pre-treatment:</u> WAB Pyramids and Palm Trees Raven's Coloured Progressive Matrices PALPA subtests 47, 48, 25, 53, 22 <u>Treatment stimuli:</u> 50 common and 50 proper nouns selected for each participant based on relevance to communicative needs – oral and written performance probed and 40 selected based on no more than one correct attempt over three trials; 20 words assigned to each category (CART + Rep or Rep only) <u>Post-treatment:</u> PALPA 53 (i.e. untreated word spelling 40 stimuli words <u>6 week follow up:</u> 40 stimuli words	Both participants improved in written spelling, but improvements in oral naming were marked for one individual in the CART + repetition task, suggesting that strengthening orthographic representations provided additional support to access phonology. Pre-treatment, performance on writing to dictation was superior to written picture naming, often knew initial letters, and made phonologically plausible errors i.e. there was already some evidence of taking advantage of the links between phonology and orthography  For the other participant there were more gains in writing than speaking regardless of task. She performed equally poorly on dictation and picture naming and attempts bore little resemblance to targets; unable to derive phonology for self-cueing  At follow up performance declined for both participants suggesting longer or more intensive therapy might be beneficial

Beeson, Rising, Kim & Rapsack 2008 [162]	Eight individuals with language impairment owing to left hemisphere damage, with a range of spelling profiles	Setting not stated; daily homework	Group	Study using a single word spelling treatment intervention with an electronic spellchecker and examining the application of dual route prediction equation and multiple regression analysis, on regular, irregular and non-words, evaluating concurrence between predicted and observed errors	<u>Pre-treatment:</u> Western Aphasia Battery Arizona Battery for Reading and Spelling  ABRB repeated post-treatment	Prior to the study all individuals had demonstrated ability to improve item-specific skills in response to lexical spelling treatment  Spelling improved post-treatment and the equation and regression analysis both accurately predicted regular word spelling performance based on irregular word and non-word scores  Actual and predicted scores were congruent for six of the eight participants; two under-utilised improved lexical knowledge when spelling regular words
Beeson, Rising, Kim & Rapsack 2010 [174]	Two women with dysgraphia with better real word spelling and poorer non-word spelling, 12 healthy adult controls	Not stated; daily homework	Case series	Two stage protocol: phonological treatment to strengthen sub-lexical skills followed by training interactive use of lexical and sub-lexical information to maximise spelling performance. Attempts checked with electronic spellchecker during interactive phase. Predicted there would be generalisation to untreated words and strategic compensation for	<u>Pre-treatment:</u> WAB Boston Naming Test Weschler Memory Scale – Revised Raven’s Coloured Progressive Matrices Pyramids and Palm Trees PALPA subtests 47 & 48 Word lists of 80 stimuli for oral reading and writing to dictation (60 real, 20 non-words) matched for length  <u>Post treatment:</u> All assessments repeated	Both improved phonological processing and reading/spelling via sublexical route, and improved real word spelling and were able to detect most errors using electronic spellchecker.

				residual spelling difficulties		
Beeson, Higginson & Rising 2013 [131]	31 year old male with severe persistent Broca's aphasia	University clinic plus homework	Single case	One hour sessions twice weekly for 13 weeks (plus roughly same amount of homework) of CART with traditional handwriting (+speaking) approach and with added 'texting approach' (+speaking), using one-handed texting on a mobile phone, with 30 picturable nouns selected in collaboration with participant and his wife; 15 treated solely with trad CART, 15 solely with text	<u>Diagnostic:</u> WAB Boston Naming Test Pyramids and Palm Trees PALPA 24, 27 Arizona Battery for Reading and Spelling Raven's Coloured Progressive Matrices  <u>Follow up</u> at 19 & 22 weeks post-treatment: Stimuli sets WAB	[Hand writing requires allographic (letter shape) knowledge while texting/typing rely on spatio-motor knowledge while holding information in orthographic buffer]  Pre-treatment, participant could handwrt3 of the 30 words, and could not type any of them  Maintenance stronger in handwriting, some decline in texted items  No generalisation to untrained words; WAB aphasia quotient revealed less severity owing to improvement on spoken tasks  Interview and rating scale: participant judged spelling and overall communication to be 'better', felt his writing was 'somewhat' improved and his texting 'a lot better' - he was using this to communicate with family when they were out and also indicated he preferred to use text rather than pen and paper when face to face. 2 years later his wife judged that 40% of his successful face to face communication was achieved with his phone
Behrns, Hartelius & Wengelin	Three adults with aphasia, two male one female, mild-	Recruited from aphasia support	Case series	Training intervention using computerised	Participants given pictures to write about	Participants were invited to choose one of the writing aids – 2 male participants chose word prediction,

2009 [157]	moderate comprehension impairment	group, therapy in university clinic		<p>writing aids designed to support developmental writing impairments: a word prediction programme which can suggest words even if initial letters are incorrect, and a spellchecker which can place a misspelled word in a sentence context to reduce erroneous acceptance of incorrect spellings. 9 weeks of two training sessions per week: initial four for one hour one to one, remaining sessions for 45 minutes as part of a five-strong writing group</p>	<p>*Keystrokes and mouse activity were logged with ScriptLog software</p> <p>*Participants were asked to make an entry into a diary using their selected writing aid (no time limit)</p> <p>*On every fourth occasion the diary was completed without the writing aid, for comparison (again, no time limit)</p> <p>Variables measured: total word count, proportion of correctly spelled words, words produced per minute, proportion of edits that were successful. For the two word prediction users, measures of how often they chose a word from the list of suggestions, and whether they chose correctly, were also taken</p> <p>Baseline measures four times before intervention; during</p>	<p>female chose spellchecker; descriptive statistics indicate improvements for Male 1 and the female participant but not Male 2. Qualitative analysis: Spellchecker thought to be more demanding in terms of independent written input and controlling keyboard functions, but also to offer more learning opportunities. Some generalised writing improvement even without using aids. Hard to establish a stable baseline: indication that regular writing alone has a positive impact on performance?</p> <p>Reading difficulties noted as a factor – authors suggest auditory processing might help. Two improved participants made better use of keyboard for punctuation and had an improved rate of editing success; all produced longer sentences. Words per minute was stable for 2 and decreased for Male 2 perhaps because processing of alternative options = time-consuming.</p> <p>Revising/editing most positively affected: prediction tool especially good because it can predict from inaccurate beginnings, spellchecker good because user can see word in context of sentence.</p> <p>Improvements at sentence level – move from mainly nouns to include more verbs and functors. Suggests cognitive burden of checking</p>
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					<p>the intervention dependent variables were measured on 10 occasions; follow up measures 10 months after end of intervention</p> <p>Descriptive statistical analysis of effect size and time serial analysis conducted using statistical package 'Single Case Statistical Analysis.'</p>	<p>spelling allows development on other linguistic levels.</p>
Bruce, Edmundson & Coleman 2003 [118]	Adult male with fluent aphasia and writing impairment	Not stated	Single case	<p>Prior to software training: 12 weekly sessions focusing on single word spelling separating into component syllables: some improvements but slow and spelling deteriorated at sentence level.</p> <p>Intervention: Clinic-based training to use Dragon NaturallySpeaking™ - had software on home computer but told not to use it for first three months until he could successfully save a voice file</p> <p>17 one hour</p>	<p><u>Baseline:</u> CAT written picture description (usual three minute time constraint not applied) Spelling test: writing 144 words of varying lengths (3, 5 and 7 letters) and frequency (high, medium, low), matched for imageability, to dictation PALPA subtests 48 and 31 Reading Comprehension Battery for Aphasia (RBCA) Western Aphasia Battery (WAB) Reversible Sentence</p>	<p>Describes step by step training procedure.</p> <p>Initial voice training done in the conventional way, with words whispered by SLT if required.</p> <p>Commands were competed mostly with keyboard, apart from 'scratch that' and 'undo.'</p> <p>Correcting dictation with voice rather than keyboard was encouraged.</p> <p>Writing tasks progressed from reading sentences, then paragraphs, to sentence completion, then sentence creation with two word prompts, then story completion; finally free email</p> <p>Email initially not punctuated and poorly sequenced ideas; work done on generation of ideas and organisation using a framework of questions to help him generate single word prompts</p>



				<p>sessions spread over 8 months</p> <p>DNS used in conjunction with Word grammar check, and the built in playback (rather than independent text to speech software)</p>	<p>Comprehension Test</p> <p>Boston Naming Test</p> <p>Pen and paper writing samples</p> <p><u>During intervention:</u></p> <p>What participant said and what VRS recognised was recorded throughout, to test differences between type of task eg novel utterances versus reading aloud</p> <p>Record kept of number of times participant had to be prompted to use a command or error correction strategy, and of nature of error, and of strategies used to guide his performance</p> <p><u>Post-intervention:</u></p> <p>CAT written picture description using VRS, also audio-recorded – scored for accuracy by calculating number of words spoken including punctuation and comparing to number of words accurately perceived and produced</p> <p>Passage from Dragon initial voice training samples read aloud</p>	<p>Note: CAT picture description was not time constrained at either assessment point</p> <p>Functional: email to his children and others, shopping lists and letters; kept in touch with the research department by email rather than phone – initially to arrange meetings but became more social with comments on the news etc</p> <p>Unexpected finding: started to use writing as a main form of communication, and began keeping a diary</p>
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					Dictated writing samples for comparison with baseline pen and paper attempts After three months of home use, participant asked to write an account of how software helps him, and asked questions about how he used DNS in everyday life	
Caute & Woolf 2016 [115]	63 year old male with fluent aphasia and severe dysgraphia and dyslexia	University clinic	Single case	Emailing therapy study, 16 x 1 hour treatment sessions, using Dragon NaturallySpeaking™ and Read+Write Gold software packages	<p><u>Pre-treatment:</u> Comprehensive Aphasia Test Wisconsin Card Sorting Test Social Activities Checklist Social Network Analysis <u>Writing measures (3x pre-, 3 x post-therapy):</u> Constrained Writing Task (unpublished, devised by authors) rated by independent raters for social validity <u>Post-treatment:</u> Social Activities Checklist Social Network Analysis CAT (picture descriptions only)</p>	<p>Significant improvements in efficiency and communicative effectiveness of writing post-therapy, despite underlying deficits remaining unchanged. Gains generalised to everyday functional communication and were maintained at follow up. Increased social participation and wider social network</p> <p>Participant had difficulties with basic computing tasks owing to limited previous experience</p> <p>Spoken written picture description became more accurate, informative and well-structured</p>

Dahl, Linebarger & Berndt 2008 [158]	4 participants with non-fluent aphasia	Research institute	Case series	Using 'automatic speech recognition' (Windows Speech Recognition) plus a 'processing prosthesis' (SentenceShaper) software to decouple speech production from real time, allowing users to create fragments of text then build them into larger structures using visual icons	None given	Three of the four produced markedly more accurate structures when using the prosthesis
Deloche et al 1992 [163]	18 participants with aphasia (2 Broca's, 5 Wernicke's, 4 global, 2 conduction, 1 anomic, 1 unclassified)	Eight rehabilitation sites	Group	Picture confrontation naming delivered on a microcomputer, in three different conditions: picture + cue no feedback (no indication whether correct), Picture + cue + feedback (error beep and incorrect letter not displayed), neutral – picture only no cue. Investigating: 1 Global efficacy of computerised written cueing, 2 assessing effect of online informative feedback, 3 investigating	Pre- and post-intervention procedure: Set of 120 pictures presented twice, in blocks of 20, tested alternately for written and oral naming – written responses produced on a keyboard, participants permitted to use erase key and had to strike an end-of-word key to indicate completion	1 significant improvement over course of training and immediate improvement with cueing versus uncued i.e. picture only 2 Feedback on correct/incorrect had no significant impact on performance 3 Written naming: improvements on drilled and undrilled items; more so on drilled. Also untreated items improved, therefore oral naming may benefit from microcomputer-based written naming

				generalisation from trained to untrained (written) and treated (written) to untreated (oral) naming 3 therapy sessions a week – not clear how many weeks		
Deloche, Dordain & Kremin 1993 [175]	Two participants, one with conduction aphasia, one with surface dysgraphia	Not stated	Case series	Written confrontation naming therapy using micro-computer, 25 sessions over course of six weeks	Oral and written (with keyboard) naming – battery of 120 administered before training, immediately after, and one year later. Handwritten naming was also tested to see if effects were specific to keyboard	Before treatment, patient with conduction aphasia used orthographic cueing to find oral word forms, while patient with surface dysgraphia used phonological cues to prompt writing Both improved on drilled written items, non-drilled items and the untrained oral modality
Estes & Bloom 2011 [117]	65 year old female with conduction aphasia, contacted the researchers expressing a desire to use DNS to correspond with her family by email	Not stated; additional homework	Single case	Ten one hour training sessions over 4 weeks, using Dragon NaturallySpeaking™, followed by a 'distance learning' email programme	<u>Baseline:</u> Boston Diagnostic Aphasia Examination (including comparison of oral and written versions of the Cookie Theft picture) Boston Naming Test ASHA FACS Quality of Communication Life Scales <u>Post-intervention:</u> All measures repeated	Naïve computer user who learned to independently operate computer successfully  Dictation accuracy rose from 42% to 98%, and error recognition from 65% to 100%; software inaccuracies also reduced naturally as DNS became more familiar with her voice  Verbal production also improved, with markedly fewer fillers, plus reformulation of sentences and more complex story development  QOL: participant was still working at the same in a reduced role and

						<p>following intervention she agreed with 'I meet the communicative requirements of my job'</p> <p>Not able to use the skills developed to complete distance learning and only submitted 2 of 12 tasks. Sounds too as though story retelling is far superior to spontaneous message production</p>
Furnas & Edmonds 2014 [155]	Two PWA	Via Internet: participants at home, researchers in university clinic	Case series	<p>Computerised version of Verb Network Strengthening Treatment (VNeST) – semantic therapy designed to improve lexical retrieval by linking verbs and thematic roles - delivered via Internet, 2 hours per session, 3 times a week for 8 weeks = 24 sessions</p> <p>Line drawings to elicit simple SVO sentences</p>	<p><u>Baseline, after 8 sessions, after 16 sessions, post-treatment and follow up at 3 months:</u></p> <p>Sentence probes in both modalities</p> <p><u>Pre- and post-treatment:</u></p> <p>Spoken and written picture description task testing lexical retrieval of trained and untrained words</p> <p>Naming accuracy of untreated single words (nouns and verbs) using an object and action naming battery (O&amp;A 2000) in spoken and typed modalities</p> <p>Spoken lexical retrieval in discourse</p> <p>Cognitive functioning (WAB, CLQT) and language processing of nouns (Pyramids</p>	<p>Significant gains made and maintained for single word retrieval in spoken and typed modalities</p> <p>Generalisation to untrained single word stimuli limited for spoken but high for typed language; this was maintained at follow up</p> <p>Smaller gains for sentence production containing trained words for both modalities; none for either modality with untrained sentences – hypothesised this is because generalisation was only to nouns not verbs</p> <p>Both participants showed significant change on WAB (hand)writing subtest</p> <p>P1 improved on CLQT, and on discourse production in both modalities, with fewer typed neologisms and longer sentences</p>

					and Palm Trees) and verbs (Kissing and Dancing)	
Jackson-Waite et al 2003 [132]	Female with fluent, undifferentiated jargon aphasia	Not stated	Single case	Lightwriter (portable keyboard with synthesised speech) to strengthen writing; only text output was used as participant disliked speech synthesis. Training in 3 stages: 1 (two one-hour sessions per week for six weeks) learning to write 30 words from pairs of pictures – other item of pair used as a control (selected for usefulness in daily living rather than frequency, complexity etc); 2. (2 sessions per week for four weeks) learning 30 more words with different pictures for the same treated items, to encourage generalisation; 3. (2 sessions per week for 6 weeks) Aimed to improve functional use	<p><u>Baseline:</u> PALPA subtests 4, 5, 47, 48, 50, Pyramids and Palm Trees, Test for Reception of Grammar</p> <p><u>Stages 1 &amp; 2:</u> Statistical analysis of written picture naming performance</p> <p><u>Stage 3:</u> Questionnaire designed to elicit conversation e.g. 'Where are the nearest shops?' where each could be answered with a word from the list plus Videotaped conversation with unfamiliar conversation partners, 2 x 15 minutes</p>	<p><u>Stage 1:</u> highly significant effect on typing treated words, smaller effect on handwriting However participant did not use the items for communication and effect was picture specific – did not generalise to other pictures or real world examples of the same items</p> <p><u>Stage 2:</u> highly significant effect but again Lightwriter not used communicatively, perhaps reflecting the non-communicative nature of the therapy</p> <p><u>Stage 3:</u> significant improvement in questionnaire responses, but no change in using Lightwriter communicatively; family unwilling to prompt and participant unwilling to initiate</p>
King & Hux	Adult male with	? University	Single	8 x 2hrs weekly	<u>Pre-intervention:</u>	Prior to stroke (6 years before

1995 [136]	mild aphasia	clinic, 'quiet environment' using similar equipment to participant's home hardware	case	intervention using Write:OutLoud™, a text to speech software package (with software also installed on home computer but not used independently 1st 4 weeks: participant orally presented stories, therapist typed these verbatim including errors, and inserted more errors, then participant corrected them using software + spell check feature, therapist indicated overlooked errors 2 <sup>nd</sup> 4 weeks: 98% accuracy on above tasks, same procedure but with participant typing the story rather than therapist	WAB Two independently produced 20 minute writing samples <u>Post-intervention:</u> Two independently produced 20 minute writing samples  2 judges independently tallied in pre-, during (without therapist prompting) and post-intervention samples  20 SL pathology graduate students rated four samples and ranked them for overall writing quality based on style, story cohesion and language accuracy	intervention) participant worked as a copywriter and was still of working age (50) but was unemployed. He still wrote – articles about his experience as a stroke survivor – and edited a stroke foundation newsletter  Writing impairment very mild to begin with but significantly improved post-intervention  'Spoken output feature appears to have improved Mr C's level of independence in editing written language' P191; effect was immediate and error rate remained very low throughout intervention  Additional finding: improvement in writing between pre and post intervention sessions despite Mr C not using spoken output for these - generalisation
Lavoie, Routhier, Legare & Macoir 2016 [133]	Female with chronic aphasia	Home therapy, assessments at rehabilitation centre	Single case study	Four self-administered single word verb naming treatments, three times a week for a total of 12 sessions; pictures presented on iPad for pen and	BECLA, PPT	Significant improvement which generalised to untrained list and to verb production (presumably uncued)

				paper naming		
Lee & Cherney 2013 [134]	Adult male with aphasia	Remote therapy: clinicians at rehabilitation institute, participant at home	Single case study (part of a larger RCT to compare this type of therapy with virtual therapy for speaking)	High intensity computer based therapy (3 x 30 min sessions per day, 6 days a week for 6 weeks) to improve writing skills using a virtual therapist who guides participants through the treatment sequence – copying sentences and writing them from memory	<p><u>During treatment:</u> daily writing samples Baseline x 4, weekly during treatment, post-intervention (appears to be once, one week after training ends but this is unclear); weekly writing 'probes' of trained and untrained sentences – briefly shown on the screen and both written from memory</p> <p>All samples produced with a Smartpen on microdot paper for submission to the laboratory</p>	Pre-treatment sentence accuracy was approximately 20%; post-treatment this rose to approximately 60% for trained and untrained sentences Not clear yet whether writing with ordinary handwriting or keyboard similarly improved, nor any report of spontaneous writing rather than copying (other than to say participant communicates with his wife more easily with pen and paper to support his ideas – this participant is described as having moderate non-fluent aphasia), nor whether long-term effects
Mortley, Enderby & Petheram 2011 [137]	Male with severe writing impairment	Not stated; additional homework	Single case	Compensatory writing therapy using preserved oral spelling skills, in three stages: developing pre-requisite skills, developing compensatory strategy and promoting functional use of the strategy. The therapy used a computer for	<p><u>Pre-treatment:</u> Observation indicated no functional writing – wrote letters to dictation but not words PALPA subtests 18, 19, 22, 23, 39, 44, 53 Informal writing assessment of 51 single words to be targeted during therapy</p> <p>Post-treatment – all</p>	Significant functional benefits, with generalisation to untreated single words, sentence-level writing, narrative word processing/letter writing and dictionary use  Also improvement in both pen and paper and keyboard despite severity of impairment; very intensive and long intervention



				intensive repetitive practice with word predictive software (INTACT) developed specifically for PWA	assessments repeated	
Murray & Karcher 2000 [135]	50 year old male with chronic, moderate Wernicke's aphasia	University clinic plus home practice	Single case	35 hours (60-90 mins once a week) writing therapy for verb retrieval at both single word and sentence levels, using a cueing hierarchy (based on Hillis 1989 and Beeson 1999), 'word prompt software' (i.e. predictive text) and homework practice, with intention of augmenting functional communication as the participant sometimes used writing to support his speech Stimuli were single word and sentence (SVO) verb pictures, plus a narrative task (Cinderella) plus a procedural task (scrambled eggs)	<u>Pre- and post-treatment:</u> WAB Test of Adolescent and Adult Word Finding (TAWF) CETI  <u>Follow up:</u> Maintenance probe of writing tasks using Co:Writer 8 weeks post-intervention	Treatment tasks completed on participant's laptop using Co:Writer software (which predicts based on grammar, frequency, recency of use and semantic association)  Post-intervention writing still looks very disordered, but errors are more semantically or orthographically related than previously when they were mostly unrelated, blank or neologisms. Suggests could be successful strategy to support oral communication in Wernicke's  No quantitative generalisation, however qualitatively again there were more related than unrelated errors  Some generalisation to trained items for spoken naming, and a trend towards improvement for trained and untrained items for oral reading  No change on WAB writing, or TAWK but both participant and wife rated him higher on the CETI, including tasks related to daily writing

						Written improvement was maintained at 8 week follow up
Pizzamiglio & Roberts 1967 [166]	20 adults with aphasia (19 CVA, one cerebral trauma), 10 male, ten female	Three hospitals (locations not given)	RCT	Participants were randomly assigned to receive therapy every day or every other day, using the 'Language Retrieval Unit', a typewriter for input, connected to an external keyboard to display this (along with information experimenters had stored). When an incorrect key was activated, the correct letter lit up. Two tasks: supply the final word in eight written sentences, and provide the written names of ten single pictured objects; one trial per experimental day on each task	Scores on each of the two tasks (therefore those who had therapy every day had more raw scores than those who had alternate day therapy) Tasks were considered to be mastered when responses were 90% accurate	Two hypotheses were tested: that there would be no difference in the rate of learning between the two groups, despite different intensity of dose, and that there would be no difference between the groups at the end of therapy or at follow up one week later.  There was a statistically significant difference between the daily and alternate day treatment group for both sentence completion and picture naming, whereby the first group needed fewer trials to achieve 90% accuracy suggesting frequency of treatment has an effect.  There was however no difference between the groups in terms of their retention of skills at follow up (though only 14/20 were retested, and it is not clear which groups they were in, only that both groups were represented)
Seron, Deloche, Moulard and Rouselle 1980 [153]	Three females and two males with aphasia and writing impairments (three post-stroke, one brain tumour, one TBI. All could copy normally but	? university clinic	Case series	Participants asked to type words to dictation; if correct letter selected it appeared on the screen, if incorrect the screen remained blank in order to avoid visual	<u>Baseline:</u> 50 words written to dictation (2-9 phonemes, 3-10 letters); no comment or correction provided <u>Training:</u> Three word batteries. B1: ten items, one syllable, high	Designed to circumvent therapist difficulty in intervening sufficiently quickly to indicate each error, and the illegibility involved when errors are repeatedly corrected on paper  Significantly reduced number of misspelled words and number of erroneously selected and ordered

	had severe (one moderate) difficulties with writing to dictation			<p>reinforcement. Procedure where the appropriate number of blank letter slots are indicated: for a totally incorrect letter a buzzer sounded and nothing appeared, while for a letter in the wrong placement but featuring somewhere in the word a buzzer sounded and the letter appeared as a dotted line under its appropriate placement; participants had to copy it to insert it</p> <p>Less prompted procedure: same procedure but with a space for the word proportional to its length but not indicating number of graphemes</p> <p>Unprompted: no indication of length and participants required to add a space at end of word</p>	<p>frequency, no consonant clusters or graphic complexities</p> <p>B2: 30 items, 1/2/3 syllables, high and low frequency, clusters and complexities such as same sound spelled differently</p> <p>B3: 50 items, 2-4 syllables including irregular spellings</p> <p>All participants began with B1 in most prompted condition; when errors were below 15% they moved to lower level of prompt; if below 5% moved to next word list bypassing less/no prompt.</p> <p><u>Post-training</u></p> <p>Same as baseline</p> <p><u>Follow up</u></p> <p>Same six weeks later</p>	<p>letters in untreated words; and effects generalised to handwriting</p> <p>Variables words containing at least one error, and total number of errors produced: significant decrease in errors post-intervention; reduced at follow up for all but one (who was probably spontaneous recovery) but still present for all but one</p> <p>Index of similarity – compares percentage of correct letters and sequencing – significant improvement post-intervention; maintained for 4 of the 5 participants</p> <p>Longer words more likely to be misspelled. Errors most commonly related to audiographic errors eg /f/ for /ph/ where the spelling is plausible – this has implications for the prompted mode as the number of letter slots does not correspond</p> <p>Acknowledges that writing to dictation is not the same as creative writing</p>
Thiel, Sage	Eight individuals	University	Case	CoWriter™ software	PALPA, BDAE, PPT	Four of eight participants showed

& Conroy 2017 [159]	with dysgraphia related to aphasia	clinic	series, with some group analysis	used to write narrative texts of increasing complexity (writing for domestic, social and business/admin needs, using predictive text, word banks and text to speech	background assessments; three novel outcome assessments of email skills, keyboard skills and email writing, and one of Cookie Theft picture description with pen and paper, CAT disability questionnaire	statistically improved spelling accuracy within emails; group level significant increase in word length
Wade, Petheram & Cain 2001 [164]	Six participants with aphasia, five controls	Hospital research unit	Group	Test of whether voice recognition software can understand aphasic speech, using voice training component of Dragon NaturallySpeaking™ preferred version 4.01	Pre-treatment: PALPA naming, word repetition, oral reading Test for Reception of Grammar	Investigated Dragon for spoken language therapy; findings are of relevant to compensatory writing: users with range of speaking impairments and regional accents able to teach software a set vocabulary, bypassing initial paragraph reading task. Now standard feature of Dragon but in earlier iterations a barrier to those who could not read

### Appendix 3.2: Quality rating tables for the systematic literature review

**Key:** ✓/✗ = first ratings, Y/N = second ratings on fifteen papers

Single case studies (SCED)

	Specify target behaviours	Design: build in a control condition	Establish a stable baseline	Continuous measures of behaviour during treatment	Raw data record	Inter-rater reliability	Assessor independent from therapist	Statistical analyses/ Description of effect sizes	Replication (multiple baselines across subjects/ therapists/ settings?)	Transfer (evidence of generalisation beyond specific target behaviour?)	Total scores (max. = 10)
Armstrong & MacDonald 2000 [139]	✓Y	✗N	✗N	✗N	✓Y	✗N	✗N	✗N	✗N	✓ independent letter/story writing	3

Beeke, Johnson, Beckley, Heilemann, Edwards, Maxim & Best 2014 [120]	✓Y	✗N	✓Y	✗N	✓Y	✓Y	✓Y	✓Y	✗N	✓Y	7
Beeson 1999 [191]	✓Y	✗N	✓Y	✓Y	✓Y	✗N	✗N	✓N	✗N	Partial Rater 2: unclear	5.5
Beeson, Higginson & Rising 2013 [131]	✓Y	✓Y	Partial x2	✓Y	✓Y	✗N	✗N	✓Y	✓ Rater 2: N effect sizes calculated from pooled data	✓Y	7.5
Bowes & Martin 2007 [127]	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓	6
Bruce, Edmundson & Coleman 2003 [118]	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	4
Caute & Woolf 2016 [115]	✓Y	✓Y	✓Y	✗N	✓Y	✓Y	✓Y	✓Y	✗N	✓Y	8
Estes & Bloom 2011 [117]	✓	✗	✗	✓	✓	✗	✗	✗	✗	✗	3
Jackson- Waite, Robson & Pring 2003 [132]	✓	✗	✗	✓	✓	✗	✗	✓	✗	✗	4
King & Hux 1995 [136]	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	8

Lavoie, Routhier, Legare & Macoir 2016 [133]	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	8
Lee & Cherney 2013 [134]	✓Y	✗N	✓Y	✓Y	✓Y	✗N	✗N	✗N	Not reported in this paper, but both raters noted that this single case study is part of an RCT	✓ Generalisation to untrained sentences	5
Lustig & Tomkins 2002 [122]	✓Y	✓Y	✓Y	✓Y	✓Y	✓Y	Partial x2	Partial x2 For social validity only, otherwise % scores	✓ Y	✓ Rater 2: direction of change in psych measure questionable	9
Mitchum, Haediges & Berndt 1993 [200]	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	8
Mortley, Enderby & Petheram 2001 [137]	✓	✓	✓	✓	✓	✗	✗	✗	✗	✓	6
Murray & Karcher 2000 [135]	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	9
Murray, Timberlake & Eberle 2007 [129]	✓	✓	✓	✓	✗	✓	✗	✗	✓	✓	7
Orjado & Beeson	✓	✓	✓	✓	✗	✓	✗	✓	✗	✓	7

2005 [192]											
Panton & Marshall 2008 [29]	✓	✓	✗	✓	✓	✓	✗	✓	✗	✓	7
Raymer, Cudworth & Haley 2003 [124]	✓Y	✓Y	✓Y	✓Y	✓Y	✗N	✗N	✓Y	✗N	✓Y	7
Robson, Pring, Marshall, Morrison & Chiat 1998 [262]	✓	✓	✓	✓	✓	✗	✗	✓	✗	✓	7
Sage & Ellis 2006 [30]	✓	✓	✓	✗	✓	✗	✗	✓	✗	✓	6
Salis & Edwards 2010 [130]	✓Y	✓Y	✓Y	✓Y	✓Y	✗N	✗N	✓Y	✗N	✓Y	7
Tsapkini & Hillis 2013 [126]	✓Y	✓Y	✗N	✓Y	✓Y	✗N	✗N	✓Y	✓Y	✓Y	7

#### Case series (SCED)

	Specify target behaviours	Design: build in a control condition	Establish a stable baseline	Continuous measures of behaviour during treatment	Raw data record	Inter-rater reliability	Assessor independent from therapist	Statistical analyses/ Description of effect sizes	Replication (multiple baselines across subjects/ therapists/ settings?)	Transfer (evidence of generalisation beyond specific target behaviour?)	Total scores (max. = 10)
Ball, Riesthal, Breeding & Mendoza 2011 [140]	✓	✗	✓	✓	✗	✓	✓	✗	✓	✗	6
Beeson,	✓Y	✓Y	✗N	✗N	✓Y	✗N	✗N	✓Y	✗N	✓Y	5

Rewega, Vail & Rapcsak 2000 [71]											
Beeson, Hirsch & Rewega 2002 [194]	✓	×	✓	✓	✓	×	×	×	×	×	4
Beeson, Rising & Volk 2003 [173]	✓	×	✓	✓	✓	×	×	✓	×	×	5
Beeson & Egnor 2006 [152]	✓	✓	✓	✓	✓	×	×	✓	✓	×	7
Beeson, Rising, Kim & Rapscak 2010 [174]	✓	✓	✓	✓	✓	×	×	✓	✓	✓	8
Behrns, Hartelius & Wengelin 2009 [157]	✓	×	×	✓	✓	✓	×	✓	×	✓	6
Clausen & Beeson 2003 [143]	✓	×	✓	✓	✓	✓	×	✓	✓	✓	8
Dahl, Linebarger & Berndt 2008 [158]	✓	×	×	×	✓	×	×	×	✓	×	3
Deloche, Dordain & Kremlin 1993 [175]	✓	✓	×	×	×	×	×	✓	×	✓	4
Furnas & Edmonds 2014 [155]	✓	✓	×	✓	×	✓	×	✓	×	✓	6
Kiran 2005 [144]	✓	✓	✓	✓	×	✓	×	✓	✓	✓	8



Krajenbrink, Nickels & Kohnen 2017 [150]	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	7
Rapp 2005 [148]	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	7
Raymer, Strobel, Prokup, Thomason & Reff 2010 [151]	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	7
Robson, Marshall, Chiat, Pring 2001 [147]	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	8
Seron, Deloche, Moulard & Rouselle 1980 [153]	✓Y	✗N	✗N	✗N	✓ Rater 2: partia l – SD not given	✗N	✗N	✓Y	✓Y	✗N	4
Thiel & Conroy 2014 [145]	✓	✓	✓	✓	✗	✓	✗	✓	✗	✗	6
Thiel, Sage & Conroy 2016 [146]	✓	✓	✓	✓	✓	✗	✗	✓	✗	✓	7
Thiel, Sage & Conroy 2016 [149]	✓	✓	✓	✓	✓	✗	✗	✓	✗	✓	7
Thiel, Sage & Conroy 2017 [159]	✓	✓	✗	✗	✓	✗	✗	✓	✗	✗	4

RCT (CASP RCT checklist)

	Did the trial address a clearly focused issue?	Was the assignment of patients to treatments randomised?	All patients properly accounted for at conclusion of trial?	Patients, health workers and study personnel 'blind' to treatment?	Groups similar at start of trial?	Aside from experimental intervention, groups treated equally?	How large was treatment effect?	How precise was estimate of treatment effect?	Can results be applied in your/local population context?	All clinically important outcomes considered?	Are the benefits worth the harms and costs?	Total score (max = 11)
Schwartz, Nemeroff & Reiss 1974 [165]	✓Y	✗N	✓Y	✗N	Partial x2 Matched for age, months post onset, education and pre-test writing assessments. But, all male!? And fewer in one group	✓Y	✗N	✗N	✗N	✗N	✗N	3.5
Pizzamiglio & Roberts 1967 [166]	✓	✓	✗	✗	✗	✗	✗	✗	✓	✗	✗	3

Group study (CASP Cohort Study Checklist)

	Did study address clearly focused issue?	Cohort recruited in acceptable way?	Exposure accurately measured to minimise bias?	Outcome accurately measured to minimise bias?	All important confounding factors a) identified, b) taken account of in design/analysis?	Follow up of subjects a) sufficiently complete? b) long enough?	What are the study results?	How precise are the results?	Do you believe the results?	Can the results be applied to the local population?	Do results fit with other available evidence?	Implications of study for practice?	Total scores (max = 12)
Beeson, Rising, Kim & Rapsack 2008	✓	✓	✓	✓	✓	No follow up	Treated words improved	Statistics provided	✓	✓	✓	Treated words improved	8

[162]													
Carlomagno, Colombo, Casadio, Emanuelli & Razzano 1991 [160]	✓Y	Not clear x2	✓Y	✓Y	Not clear x2	a)Y, b) 50 days, longer would be preferable x2	Treatment gains in writing x2	Means reported X2	✓Y	✓Y – but rater 2 noted Italian may be different	✓Y	Encouraging findings regarding impairment based treatment x2	6
Carlomagno, Pandolfi, Labruna, Colombo & Razzano 2001 [161]	✓	✓	✓	✓	✓	✓, 3 months	Trained items improved, most participant made specific benefits from one or the other program only	Means and P values	✓	As above	✓	Encouraging findings regarding impairment based treatment	8
Deloche et al 1992 [175]	✓	Procedure not described	✓	✓	✓	No follow up	Trained words improved, generalised to oral naming, feedback on accuracy did not improve spelling	Statistics but no SDs	✓	Partially, relevant to remediation not compensation	✓	Supports impairment based spelling treatment and promising finding regarding generalisation	6
Wade, Petheram & Cain 2001 [164]	✓Y	✗N Procedure not stated. Range of express	✓Y	✓Y	✗N	✗N	✓Y Standard training can be omitted, VRS can understand aphasic	✗N Results for naming task not given	✓Y	Partial x2 – limited info given	Unclear x2	Outdated but useful for background Rater 2: acceptability of software for PWA not	5.5

		ive difficult ies include d					speech					addressed	
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#### CASP Qualitative Checklist

	Clear statement of research aims?	Is qualitative methodology appropriate?	Appropriate research design?	Appropriate recruitment strategy?	Data collected in a way which addressed research issue?	Relationship between researcher & participants adequately considered?	Ethical issues taken into consideration?	Data analysis sufficiently rigorous?	Clear statement of findings?	How valuable is the research?	Total (max = 10)
Al Mahmud & Martens 2013 [167]	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	9

## **Appendix 4.1: Pre-training (T2) topic guide for in-depth semi-structured interview**

### Pre-stroke

- Reading habits before stroke?
  - everyday small scale tasks
  - longer term large scale tasks
  - level of pleasure
- Writing habits before stroke?
  - everyday small scale tasks
  - longer term large scale tasks
  - level of pleasure
- Computer use before stroke?
  - software packages used
  - proficiency
  - what tasks was computer used for?
  - Level of pleasure
- Work?
  - reading - how much, what subject matter
  - writing – how much, subject matter
- Social activities?
  - Did reading contribute to these?
  - Did writing contribute to these?
- Keeping in touch with people
  - Family? Friends? Colleagues?
  - how much
  - by what means
  - independent or supported?
- Other typical daily/weekly activities? Eg keeping a journal . . .

## Post-stroke

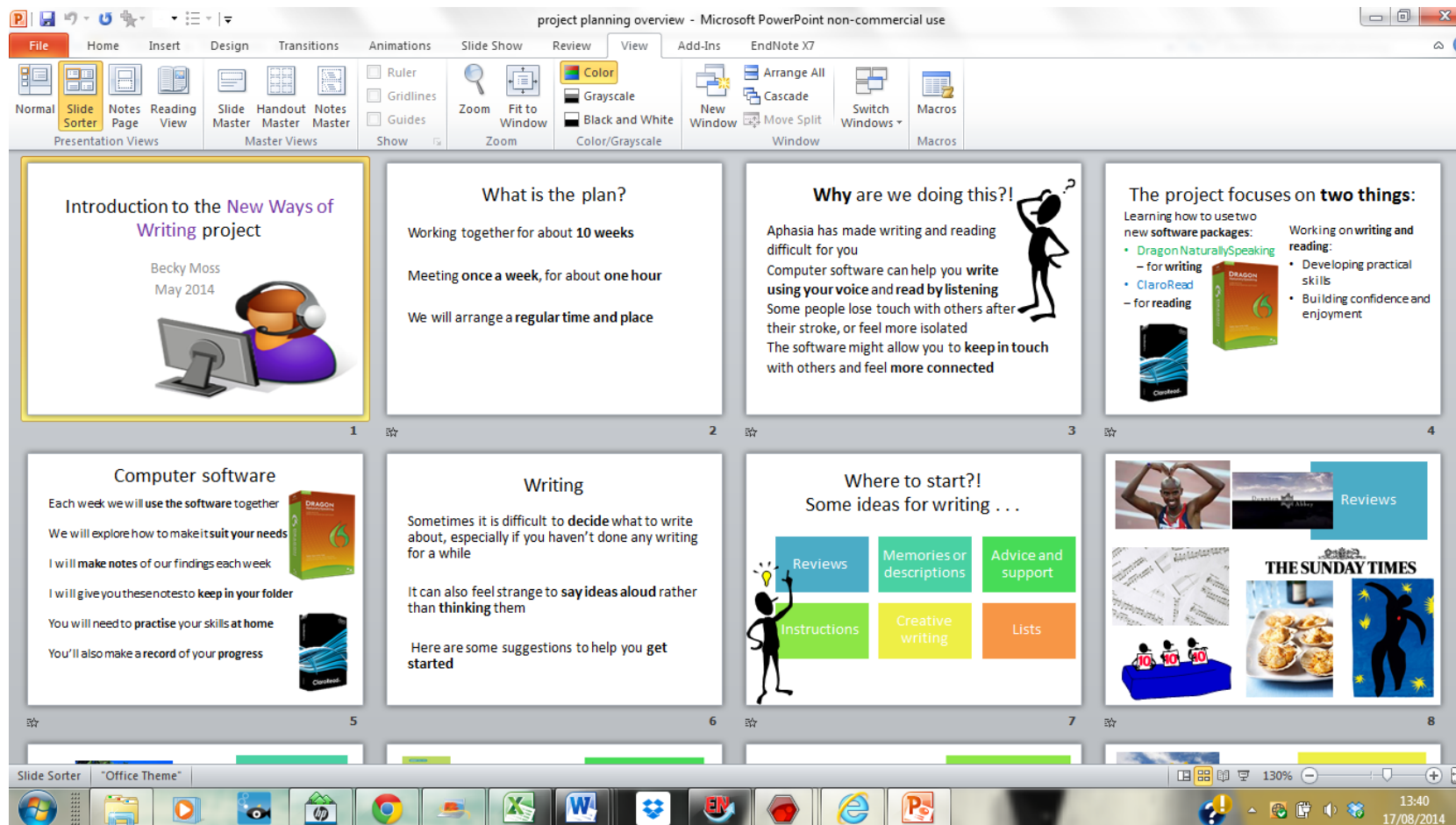
- Reading habits now?
  - everyday small scale tasks
  - longer term large scale tasks
  - level of pleasure
- Writing habits now?
  - everyday small scale tasks
  - longer term large scale tasks
  - level of pleasure
- Computer use now?
  - software packages used
  - proficiency
  - what tasks is computer used for?
  - Level of pleasure
- Work?
  - If still working, impact of stroke and aphasia?
  - Changes to work?
  - reading - how much, what subject matter
  - writing – how much, subject matter
- Social activities?
  - Does reading contribute to these?
  - Does writing contribute to these?
  - Has anything changed
    - In terms of communication
    - In terms of well-being eg confidence, self-esteem, happiness
- Keeping in touch with people
  - Family? Friends? Colleagues?
  - how much
  - by what means
  - independent or supported?
- Other typical daily/weekly activities? Eg keeping a journal . . .
- Training aims – what would you like the software to help you to do?
- Therapy: did you focus on writing/spelling/reading? What did you do?  
What was the impact?

## **Appendix 4.2: Post-training (T3 and T4) topic guide for in-depth semi-structured interview**

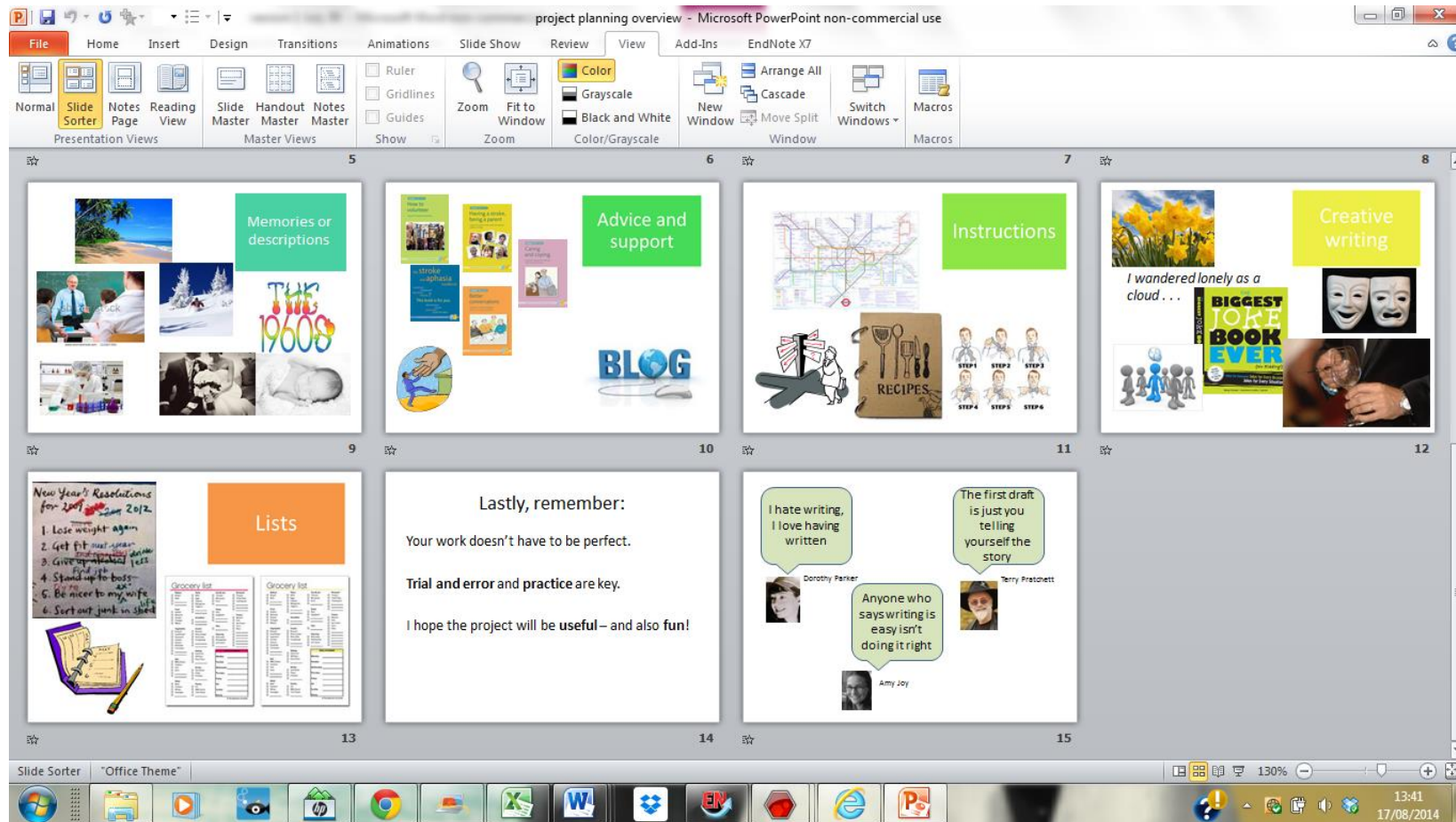
[For all issues covered by the interview, probe for satisfaction or dissatisfaction with quality and quantity of each aspect]

- Writing and reading habits now? (probe everyday small scale tasks and longer term large scale tasks)
- Computer use now? (probe software packages used, proficiency, tasks computer is used for)
- Developments at work? (probe reading/writing , confidence, participation)
- Training:
  - Expectations fulfilled? (probe how and why/why not)
  - Impact on writing/reading?
- Have your social activities changed? (probe what has stopped, what is new, why – with reference to reading/writing and with reference to well-being e.g. happiness, self-esteem, confidence)
- Keeping in touch with family, friends, colleagues? (probe how much, by what means, whether independent or supported)
- Other typical daily/weekly activities?
- Software features (probe each package)
  - What did you like?
  - What would you change? How would that improve things?
  - What was most difficult? Why? How did you overcome this?
  - What are your plans for software use now?
  - What advice would you give to software producers?
- [Three months later] Changes since we last met, when you had just finished training, impact of these changes?
  - Reading and writing
  - Computer use
  - Typical daily/weekly activities





## Appendix 4.3: Goal setting power-point presentation







**Appendix 4.4: Participant progress form for self-completion**

<p><b>When</b> did you work?</p> 	<p><b>How long</b> did you spend?</p> 	<p><b>What</b> did you do?</p>  <p>Email?</p> <p>Creative writing?</p> <p>Something else?</p>	<p><b>How</b> did you get on?</p> 

## Appendix 4.5: Sample of supporting notes for participant

### Training Session Two, Friday 6 June

I gave you a lot of new information in this session!

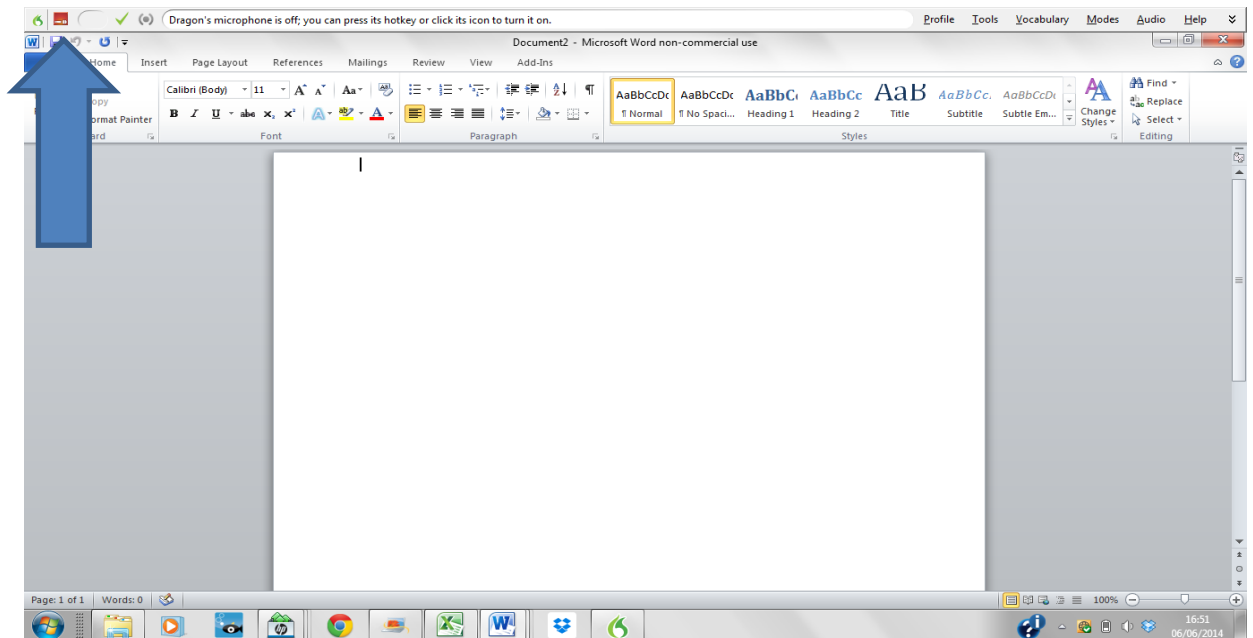
These are the main things we covered:

#### 1. Writing with Dragon

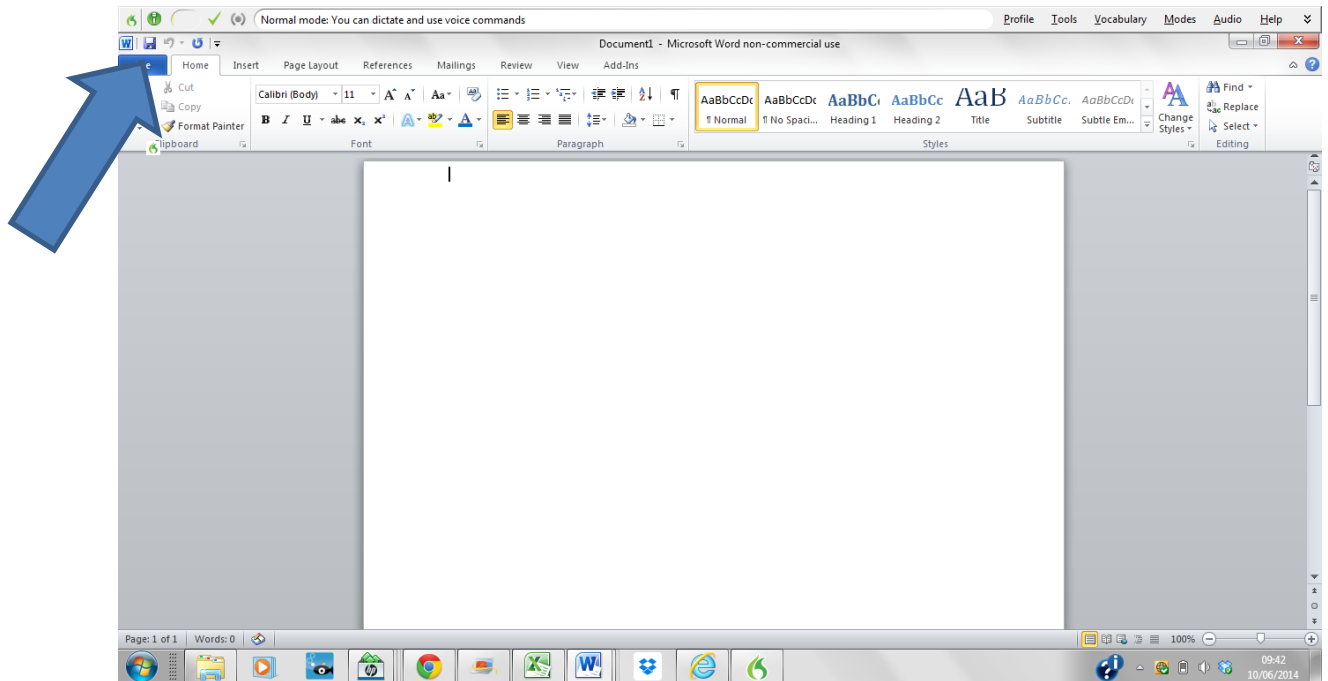
##### The microphone

To turn it on and off with the mouse: you **click** on the microphone **symbol**.

Off (red):

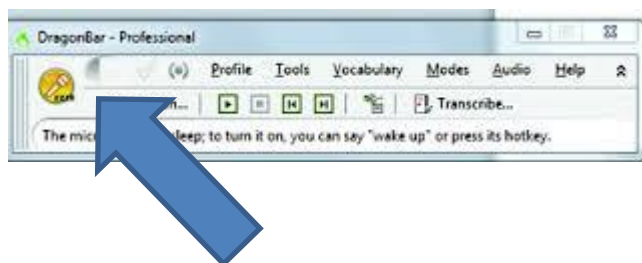


On (green):



You can also turn the **microphone on and off with voice commands.**

If you say '**stop listening**' or '**go to sleep**' the symbol is **yellow** like this:



Now Dragon **won't write** what you say. It is **paused but still listening.**

When you say '**start listening**' or '**wake up**' the microphone symbol will turn green again, and it will be ready to write what you say.

## Commands

You've used these to **move around within a document** and **add punctuation**:

- New line
- Full stop
- Delete that
- Select that (we had less success with this one but we will practice!)

There are lots more commands, we will cover them gradually.

## Dictation

You successfully wrote 90 words about your trip to the theatre.

Here is what you have written so far:

We went on Saturday to see Kevin Spacey. We went to the 6 o'clock performance and then went out to eat. We were in great seats and it was in the round. Kevin Stacey was the only person that was in it. It was in an office and it was a lawyer's office. It was a long play and so was an interval as well. Then we went to eat at a place along the road. It was a Turkish restaurant which was very good indeed. Then we came home.

You have a very clear voice and calm delivery.

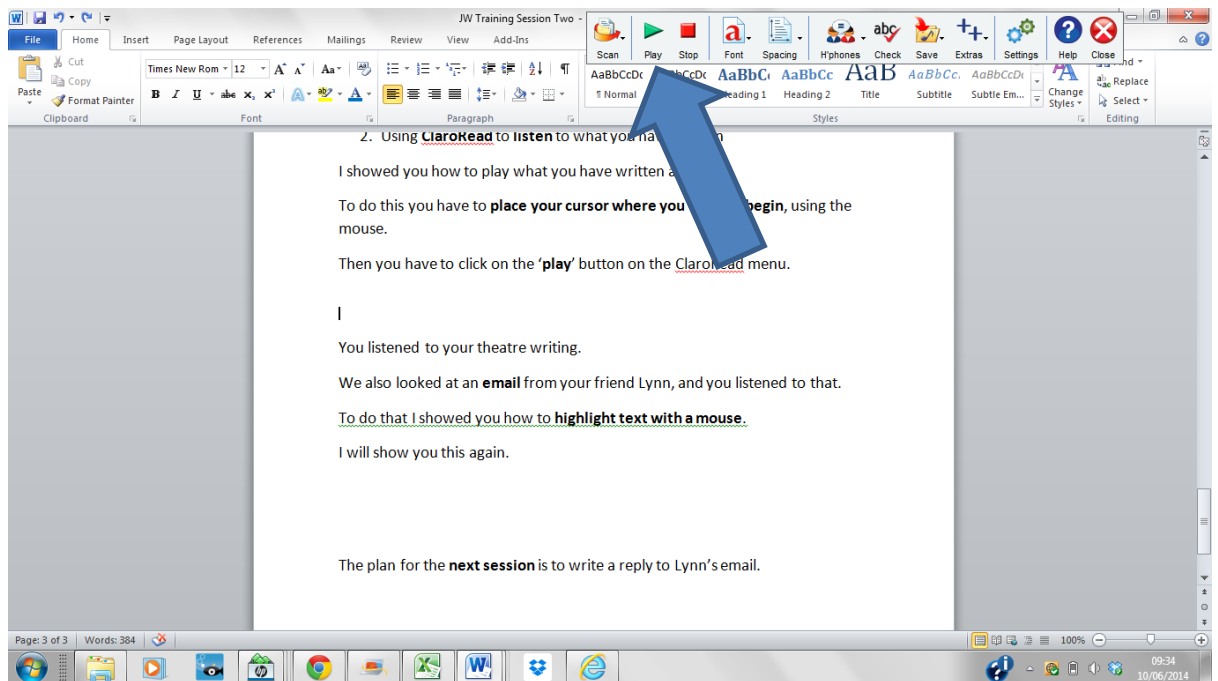
Consequently Dragon understands you really well.

## 2. Using **ClaroRead™** to **listen** to what you have written

I showed you how to play what you have written aloud.

To do this you have to **place your cursor where you want to begin**, using the mouse.

Then you have to click on the '**play**' button on the ClaroRead™ menu.



You listened to your theatre writing.

We also looked at an **email** from your friend Lucy, and you listened to that.

To do that I showed you how to **highlight text with a mouse**.

I will show you this again.

The plan for the **next session** is to write a reply to Lucy's email.

## Appendix 5.1: Ethics application form



### Senate Research Ethics Committee

#### Application for Approval of Research Involving Human Participants

Please tick the box for which Committee you are submitting your application to

<input type="checkbox"/>	Senate Research Ethics Committee
<input type="checkbox"/>	Cass Business School
<input type="checkbox"/>	School of Arts & School of Social Sciences Research Ethics Committee
<input checked="" type="checkbox"/>	School of Community and Health Sciences Research Ethics Committee
<input type="checkbox"/>	Learning Development Centre

For **Senate** applications: return one original and eight additional hardcopies of the completed form and any accompanying documents to Anna Ramberg, Secretary to Senate Research Ethics Committee, University Research Office, Northampton Square, London, EC1V 0HB. Please also email an electronic copy to [Anna.Ramberg.1@city.ac.uk](mailto:Anna.Ramberg.1@city.ac.uk) (indicating the names of those signing the hard copy).

For **School of Arts & School of Social Sciences** Research Ethics Committee submit a single copy of the application form and all supporting documentation to [Andrea Tinson](#) (Social Sciences) and [Gail Marsom](#) (Arts) by email.

For **School of Community and Health Sciences** applications: submit all forms (including the Research Registration form) electronically (in Word format in a single document) to [A.Welton@city.ac.uk](mailto:A.Welton@city.ac.uk), followed up by a single hard copy with signatures.

For **Learning Development Centre** a single copy of the application form and all the supporting documentations should be emailed to Pam Parker ([P.M.Parker@city.ac.uk](mailto:P.M.Parker@city.ac.uk)).

Refer to the separate [guidelines](#) while completing this form.

## PLEASE NOTE

- Please determine whether an application is required by going through the [checklist](#) before filling out this form.
- Ethical approval **MUST** be obtained before any research involving human participants is undertaken. Failure to do so may result in disciplinary procedures being instigated, and you will not be covered by the University's indemnity if you do not have approval in place.
- You should have completed every section of the form
- The Signature Sections must be completed by the Principal Investigator (the supervisor and the student if it is a student project)

<b>Project Title:</b>
Investigating the impact of using assistive technologies on communication and social participation for people with aphasia: a mixed methods, case series study
<b>Short Project Title (no more than 80 characters):</b>
Assistive technologies, communication and social participation in people with aphasia
<b>Name of Principal Investigator(s) (all students are required to apply jointly with their supervisor and all correspondence will be with the supervisor):</b>
Becky Moss
<b>Post Held (including staff/student number):</b>
Full-time MPhil/PhD studentship 120038870
<b>Department(s)/School(s) involved at City University London:</b>
Division of Language and Communication Science, School of Health Sciences
<b>If this is part of a degree please specify type of degree and year</b>



Full-time MPhil/PhD studentship, year 1

**Date of Submission of Application:**

7 December 2012

**1. Information for Non-Experts**

**Lay Title** (no more than 80 characters)

Assistive technologies, communication and social participation in people with aphasia

**Lay Summary / Plain Language Statement** (no more than 400 words)

Aphasia is a language and communication impairment which results from brain injury; in this project participants will have aphasia specifically as a result of stroke. People affected by aphasia experience a range of difficulties with reading, writing, speaking and understanding spoken and written language and numbers. Because language is used to conduct such a broad range of social tasks and activities, aphasia can have a profound impact on all aspects of life. The type and severity of aphasic impairments varies widely from person to person: in this project, participants will be better at speaking than they are at writing. Sometimes reading and writing difficulties can be overlooked because they are less visible, but they can lead to isolation, loss of independence and low self-esteem. Therapy which directly targets writing and reading relies on repetitive tasks over a long period and tends only to improve specifically targeted words rather than achieving a more general effect. This project will focus on enabling participants to use retained skills such as speaking to develop their reading and writing with the help of software.

This project will deliver and evaluate a training programme in which ten people with aphasia will be taught to use assistive technologies including voice recognition software and text-to-speech software, with the aim of improving their ability to communicate through written language. Training will be one-to-one, for approximately one hour a week, for 10-15 weeks, and activities will be tailored to address individual participants' goals such as correspondence through emails or letters. The project will also explore how assistive technologies can increase social participation by people with aphasia, by enabling them to have more social contact with a wider range of people, and examine whether this improves their quality of life.

Communication, social participation and well-being will be measured immediately before and after the training programme, and three months later, using a range of assessments, some of which may be developed specifically for this project. The nature of barriers to successful use of the technology experienced by the participants, and any strategies developed to overcome them, will be systematically documented. The project will build on a successful pilot study in the Division of Language and Communication Science in which an individual with aphasia was

facilitated to use assistive technologies, resulting in improvements both in written communication (particularly through email) and social participation.

## 2. Applicant Details

### This project involves:

(tick as many as apply)

<input checked="" type="checkbox"/>	Staff Research	<input checked="" type="checkbox"/>	Doctoral Student
<input type="checkbox"/>	Undergraduate	<input type="checkbox"/>	M-level Project
<input type="checkbox"/>	Externally funded	<input type="checkbox"/>	External investigators
<input type="checkbox"/>	Collaboration	<input type="checkbox"/>	Other
Provide details of collaboration and/or other			

### Address for correspondence (including email address and telephone number)

(Principal Investigator)

Becky Moss

Division of Language and Communication Science

City University

Northampton Square

London

EC1V 0HB

Telephone number to be confirmed

██████████

### Other staff members involved

<i>Title, Name &amp; Staff Number</i>	<i>Post</i>	<i>Dept &amp; School</i>	<i>Phone</i>	<i>Email</i>

Dr Katerina Hilari	Reader; Joint Research Director & Senior Tutor for Research	Division of Language and Communication Science  School of Health Sciences		
Dr Celia Woolf	Researcher	Language and Communication Science  School of Health Sciences		

#### All students involved in carrying out the investigation

<i>Name &amp; Student Number</i>	<i>Course / Year</i>	<i>Dept &amp; School</i>	<i>Email</i>

#### External co-investigators

<i>Title &amp; Name</i>	<i>Post</i>	<i>Institution</i>	<i>Phone</i>	<i>Email</i>

**Please describe the role(s) of all the investigators including all student(s)/external co-investigator(s) in the project, especially with regards to interaction with study participants.**

Becky Moss will be responsible for recruiting and training participants, and gathering and analysing data.

Katerina Hilari and Celia Woolf are joint PhD supervisors and will have minimal direct interaction with study participants, but will have access to data and will be privy to the

identities of participants. Both are qualified speech and language therapists and experienced aphasia researchers.

**If external investigators are involved, please provide details of their indemnity cover.**

### Application Details

**2.1 Is this application being submitted to another ethics committee, or has it been previously submitted to an ethics committee?** *This includes an NHS local Research Ethics Committee or a City University London School Research Ethics Committee or any other institutional committee or collaborating partners or research site. (See the guidelines for more information on research involving NHS staff/patients/ premises.)*

YES ☐ NO ☒

If yes, please provide details for the Secretary for the relevant authority/committee, as well as copies of any correspondence setting out conditions of approval.

**2.2 If any part of the investigation will be carried out under the auspices of an outside organisation, e.g. a teaching hospital, please give details and address of organisation.**

**2.3 Other approvals required – has permission to conduct research in, at or through another institution or organisation been obtained?**

YES ☐ NO ☒

If yes, please provide details and include correspondence

I will recruit participants through my contacts at an external charitable organisation, Connect – the communication disability network, and through other voluntary organisations such as the Stroke Association and Different Strokes. These organisations will be approached when necessary, depending on recruitment levels from within the City Aphasia Research Group. Their specific permission procedures will be followed and SHS REC informed if recruitment takes place through these organisations.

**2.4 Is any part of this research project being considered by another research ethics committee?**

YES ☐ NO ☒

**If yes, please give details and justification for going to separate committees, and attach correspondence and outcome**

**2.5 Duration of Project**

Start date:

Estimated end date: 30 September 2015

1 October 2012

**Funding Details**

**2.6 Please provide details of the source of financial support (if any) for the proposed investigation.**

City University PhD studentship

**2.6a Total amount of funding being sought:**

£15,500PA

**2.6b Has funding been approved?**

YES ☒

NO ☐

**If no, please provide details of when the outcome can be expected**

**2.6c Does the funding body have any requirements regarding retention, access and storage of the data?**

YES ☒ NO ☐

**If yes, please provide details**

Data will be retained for 10 years in accordance with City University's guidelines

### International Research

**2.7 Is any part of the research taking place outside of England/Wales? (if not go to section 3)**

YES ☐ NO ☒

**If yes, please provide details of where**

**2.7a Have you identified and complied with all local requirements concerning ethical approval & research governance\*?**

YES ☐ NO ☐

**2.7b Please provide details of the local requirements, including contact information.**

**2.7c Please give contact details of a local person identified to field initial complaints local so the participants can complain without having to write to or telephone the UK**

\*Please note many countries require local ethical approval or registration of research projects, further some require specific research visas. If you do not abide by the local rules of the host country you will invalidate your ethical approval from City University London, and may run the risk of legal action within the host country.

### 3. Project Details

#### 3.1 Provide the background, aim and explanation for the proposed research.

Many communicative activities demand the use of reading and writing, and impairments in these areas can lead to isolation, loss of independence and low self-esteem. A small number of single case studies have reported training people with aphasia to use Dragon NaturallySpeaking voice recognition software successfully, resulting in improved communicative ability. This mixed methods, case series study will deliver and evaluate assistive technology training, to support the written communication of ten individuals with writing and reading difficulties resulting from aphasia after stroke. Research questions will include how the technologies can reduce disabling consequences of aphasia; what the barriers are to their use and whether modifications can overcome these; whether communication is improved; whether social participation and well-being are enhanced; and what factors influence intervention outcomes. Quantitative and qualitative assessments of communication, social participation and well-being will be made at repeated baselines, immediately after delivery of the training intervention and a minimum of three months post-intervention.

The project will build on a successful single case study undertaken in the Division of Language and Communication Science by Caute and Woolf (2011) in which training an individual with fluent aphasia to use assistive technologies (voice recognition and text-to-speech software) improved both written communication and social participation. The project will train ten individuals with a range of aphasic impairments to use assistive technologies to support written communication. It will address the following research questions:

1. In what ways can assistive technologies, including voice recognition and text-to-speech software, reduce the disabling consequences of writing and reading impairments resulting from aphasia after stroke?
2. What are the barriers to successful use of these technologies by people with aphasia, and can modifications be made to enhance their efficacy?
3. How far can training in the use of assistive technologies improve individuals' ability to communicate through written language, and what support do individuals need?
4. What are participants' levels of social participation and well-being before the training, and does the training have any effect on these levels?
5. What factors (for example severity of aphasia, degree of social support) may influence intervention outcomes?

#### 3.2 Provide a summary and brief explanation of the design, methodology and plan for analysis that you propose to use.

Sample: Participants will primarily be recruited via contacts from within the City Aphasia Research Clinic in the Division of Language and Communication Science, and through voluntary organisations. Ten individuals presenting with aphasia after stroke who meet the following selection criteria will be recruited:

- ⤴ Minimum of 6 months post onset and medically stable
- ⤴ Stable baseline language and communication performance, with no significant change in the language battery of the Comprehensive Aphasia Test (CAT) at baseline T1 and a minimum of six weeks later at baseline T2; this will ensure that any improvements in performance during the study can be attributed to training and technology access rather than to spontaneous language recovery
- ⤴ No significant cognitive impairment on the CAT cognitive screen. (The Wisconsin Card Sorting Test (WCST) and/or the non-linguistic subtests of the Cognitive Linguistic Quick Test (CLQT) may also be administered to screen for cognitive impairment)
- ⤴ Ability to speak fluent English prior to stroke and retained ability to participate in assessments and training activities delivered in English
- ⤴ Presenting with acquired written word-finding and spelling difficulties (dysgraphia) as shown on CAT written picture description subtest, with better performance on spoken than written picture description. Participants may also present with deficits on other CAT subtests of reading, spoken language and auditory comprehension, but will identify their writing difficulties as a main area of concern
- ⤴ Good speech intelligibility. No evidence of neuromuscular or motor-speech impairments (dysarthria/dyspraxia) that would preclude use of voice recognition software
- ⤴ Access to a personal computer and Internet connection

**Design:** The study will employ a mixed methods, case series design, to assess the impact of a one-to-one training intervention. The intervention will be scheduled as a rolling programme to allow sufficient time and attention to each participant, and for assessments and follow-up data analysis. No more than three individuals will be training at any one stage.

**Intervention:** 10-15 one-hour training sessions will be provided per individual (training packages will be tailored according to the needs and preferences of each participant). Training will incorporate:

- Computer set up and familiarisation with equipment and software. Support will be given as necessary, for example with prompt sheets written in aphasia-friendly format;
- Consultation with each participant to identify individual goals for written communication, for example writing shopping lists, using email, internet access for information or social contact, letter writing;
- Training and support in use of assistive technologies in relation to identified goals, for example training the software to recognise a list of high frequency words and phrases, planning and composing correspondence using prompt sheets to help determine content and topic;
- Troubleshooting challenges and difficulties that arise;
- Practice exercises to complete at home to encourage generalisation.

**Outcome measures:** Assessments will be made at repeated baseline (T1 and T2, a minimum of six weeks apart), immediately after delivery of the intervention (T3) and at a minimum of three months post-intervention (T4). T1 assessments will be the CAT cognitive screen and language battery (and possibly WCST and/or CLQT as additional screening for cognitive impairment). T2 assessments will be the CAT cognitive screen and language battery (and possibly WCST and/or CLQT), the Communication Disability Profile (CDP), a validated measure of social participation (possibly the Community Integration Questionnaire or Social Network Analysis, to be confirmed), a validated measure of well-being (possibly the General Health Questionnaire, to be confirmed) and an in-depth semi-structured interview. All T2 assessments will be repeated at T3 and T4.

**Plan for data analysis:** Individual participants' quantitative data from T2, T3 and T4 will be compared to explore change in each participant's language, social participation and well-being. Qualitative data will be managed using NVivo software and will be exhaustively coded for themes and subthemes using the Framework method. Both change within individual participants and change across the group of participants will be examined.

### **3.3 Please explain your plans for dissemination, including whether participants will be provided with any information on the findings or outcomes of the project.**

All participants will be offered an accessible summary of findings at the end of the project.

Conference presentation, journal papers, thesis publication, presentation within the Division of Language and Communication Science and the School of Health Sciences, presentation to staff and clients at community and voluntary groups.



**3.4 What do you consider are the ethical issues associated with conducting this research and how do you propose to address them?**

Data protection: Unique letter and number codes denoting each participant and their assessment stage will be used in all assessment data. A list of codes and corresponding names will be filed separately and accessed only by principle investigator/supervisors. Archived written/video material will only be accessed by the immediate project team unless explicit permission has been given by the participant for the recordings to be used for teaching and/or conference presentation. Printed data used in journals will be de-identified through the use of pseudonyms and replacement of any other details which could identify participants.

Participant frustration/distress: Attempts to access assistive technologies will focus on specific language and communication difficulties, which could cause frustration and possibly even distress. Participants will be supported by the PI who has experience working with people with aphasia and facilitating communication and technology access. Participants will be invited to take breaks during training sessions if they are experiencing frustration, and will be able to terminate and reschedule sessions if they wish. Participants will be given information about how to access further therapy and/or counselling, regardless of on-going participation or withdrawal.

Informed written consent: Will be sought using carefully designed materials in order to ensure the study is transparent to people with communication disabilities. On-going assent will be sought at appropriate stages. Explicit permission to use video-recorded material for conference presentation will be obtained as necessary.

Individual outcomes: Participants may hope for functional writing and reading improvements. While therapeutic benefits may arise, the PI will make clear when recruiting participants that she is not a clinician and the study's principle focus is research into the effects of the training, in order that participants may make an informed choice.

**3.5 How is the research intended to benefit the participants, third parties and/or local community?**

The participants may experience improvements in written communication. This may lead to increased social participation and improved quality of life.

The study may help us understand how assistive technologies could work better for people with aphasia.

The study will develop aphasia friendly training materials and will make them available to other interested parties.

**3.6a Will invasive procedures (for example medical or surgical) be used?**

YES ☐

NO ☒

**3.6b If yes, what precautions will you take to minimise any potential harm?**

**3.7a Will intrusive procedures (for example psychological or social) be used?**

NO ☒

YES ☐

**3.7b If yes, what precautions will you take to minimise any potential harm?**

**3.8a In the course of the investigation might pain, discomfort (including psychological discomfort), inconvenience or danger be caused?**

YES ☒ NO ☐

**3.8b If yes, what precautions will you take to minimise any potential harm?**

Training to use the software will be time-consuming and at times may become frustrating or even distressing. PI is an experienced facilitator and will provide communication support and practical support. If participants become tired or distressed they will be invited to take a break or to stop the training session and resume it on another occasion.

**3.9 Please describe the nature, duration and frequency of the procedures?**

Initial assessments at T1, assessments and interview at T2 (six weeks later), approximately 10-15 one hour training sessions, once a week, at City Aphasia Research Clinic or the participants' usual setting, with additional practice exercises to be completed at home, assessments and interview at T3 (at the end of the training programme, assessments and interview at T4 (three months later).

#### 4. Information on participants

**4.1a How many participants will be involved?**

Ten

**4.1b What is the age group and gender of the participants?**

Over 18 years old, male and female

**4.1c Explain how you will determine your sample size and the selection criteria you will be using. Specify inclusion and exclusion criteria. If exclusion of participants is made on the basis of age, gender, ethnicity, race, disability, sexuality, religion or any other factor, please explain and justify why.**

Sample size: Ten participants is an adequate sample size for observing and measuring a range of outcomes between and within participants. We will be able to explore variation in improvements in functional writing ability and social participation, and will attempt to account for this variation. Ten is considered to be the maximum number of participants who could be assessed, trained and followed up in the time period, owing to the intensive nature of the training, the time which needs to elapse between testing, the rolling programme design, and the labour-intensive nature of the research methods the study will employ. Recruiting more than ten participants would compromise the quality of training offered to each individual.

Inclusion criteria:

Presenting with aphasia after stroke

Presenting with acquired written word-finding and spelling difficulties (participants may also present with reading, speaking and auditory comprehension deficits, but will identify writing difficulties as their main area of concern and will have a superior performance on spoken than written subsections of the CAT)

Minimum of six months post-onset and medically stable

Stable repeated baseline test performance on the CAT language battery

Ability to speak fluent English pre-onset and retained ability to participate in assessments and training activities delivered in English

18 years old or more

Exclusion criteria:

Presenting with aphasia but identifying speaking or auditory comprehension deficits as main area of concern

Poor speech intelligibility (eg owing to neuromuscular or motor-speech impairment) which would preclude the use of voice recognition software

Visual or auditory impairments not corrected with use of spectacles or hearing aid

Significant cognitive impairment evidenced by the CAT cognitive screen (and possibly the WCST and /or CLQT)

Extent and type of disability will influence inclusion, since improvements in certain aspects of aphasic deficits are being studied. No exclusions will be made on the basis of age, ethnicity, race, disability, sexuality or religion. A balanced sample of male and female participants will be sought, and ideally a balanced age range, though the latter factor may be skewed owing to the increased risk of stroke with age.

**4.2 How are the participants to be identified, approached and recruited, and by whom?**

The City Aphasia Research Clinic holds a list of people with aphasia who have registered their interest in participating in research, and colleagues in the department have already mentioned suitable candidates to the PI. These people will be approached by the PI by the means specified when they registered their interest (telephone, email or letter). The PI will actively seek out additional participants, in collaboration with staff and other research students in the Department of Language and Communication Sciences. External voluntary organisations may be approached if an insufficient number of participants have been recruited internally.

**4.3 Describe the procedure that will be used when seeking and obtaining consent, including when consent will be obtained. Include details of who will obtain the consent, how are you intending to arrange for a copy of the signed consent form for the participants, when will they receive it and how long the participants have between receiving information about the study and giving consent.**

Some potential participants have agreed to be approached regarding research, and the PI will contact them directly (either by telephone, email or letter as specified on their contact form), and offer them a participant information sheet (by mail or as a PDF attachment) to read and keep. Potential participants will be asked their permission for the PI to contact them again, or meet with them, after an agreed interval to discuss the study further and find out whether they have decided to participate. If they agree to take part, written consent will be taken by the PI, and a copy of the signed consent form will be given to participants. The PI will explain that baseline tests at T1 and T2 may indicate they are unsuitable to participate (either because there is a marked improvement in writing performance or because there is evidence of cognitive impairment; this issue will be handled sensitively and participants will be invited to register their interest for other studies if they wish.

**4.4 How will the participant's physical and mental suitability for participation be assessed? Are there any issues related to the ability of participants to give informed consent themselves or are you relying on gatekeepers on their behalf?**

Participants will have mental capacity to give informed consent. Information and consent materials will be carefully designed to ensure they are accessible to people with aphasia, based on City Aphasia Research Clinic protocols. PI will use supported communication to ensure the materials have been fully understood.  
Participants will be medically stable, and physically able to attend the clinic or their usual setting.  
Clinical stability will be assessed with the language battery of the CAT at repeated baseline, cognition will be assessed with the cognitive screen of the CAT (and possibly the WCST and/or CLQT).

**4.5 Are there any special pressures that might make it difficult to refuse to take part in the study? Are any of the potential participants in a dependent relationship with any of the investigators (for instance student, colleague or employee) particularly those involved in recruiting for or conducting the project?**

None

**4.6 Will the participant's doctor be notified?**

YES ☐ NO ☒

(If so, provide a sample letter to the subject's GP.)

**4.7 What procedures are in place for the appropriate referral of a study participant who discloses an emotional, psychological, health, education or other issue during the course of the research or is identified by the researcher to have such a need?**

With participant's permission, case would be discussed with supervisors, who will advise on referral to appropriate services with participant's agreement.

**4.8 What steps will be taken to safeguard the participants from over-research? (I.e. to ensure that the participants are not being used in multiple research project.)**

Within the Division of Language and Communication Science, research students and staff are implementing a strategic approach to ensure that groups and individuals are not invited to participate in multiple projects simultaneously, and that they are informed of all opportunities for participation in one visit to avoid repeated approaches. Potential participants will be directly asked about their involvement in other research outside the Division, and since this project is quite time- and labour-intensive they will be advised not to participate if they are already involved in more than one other project (the rolling programme design of the project will hopefully mean they could still participate at a later stage). Furthermore, if there is any overlap between other projects and this intervention they will not be able to participate due to the risk of confounding treatment effects. Participants will have actively volunteered to participate. All participants will be adults capable of making an informed decision about their ability to commit to the project and manage their time.

**4.9 Where will the research take place?**

City University Division of Language and Communication Science (City Aphasia Research Clinic), or the participant's usual setting if preferred, within the constraints of PI's time and resources.

**4.10 What health and safety issues, if any, are there to consider?**

Participants will be advised of fire evacuation procedure, location of toilets, food and drink facilities. The clinic is sited in a modern, accessible building suitable for people with restricted mobility and wheelchair users.

**4.11 How have you addressed the health and safety concerns of the participants, researchers and any other people impacted by this study? Have you conducted a risk assessment?**

Training will take place at sites with health and safety procedures already in place, which will be explained to participants and followed by all parties. There are no medical or safety risks

associated with the study for participants.

When training takes place at a setting other than the City Aphasia Research Clinic, the PI will have a fully charged and active mobile phone with them at all times. A colleague will be notified of the PI's location, and a messaging procedure to notify them of safe arrival and safe departure will be implemented and followed.

**4.12 Are you offering any incentives or rewards for participating?** YES ☒  
NO ☐

If yes please give details

Participants will receive training they would not otherwise have had the opportunity to access. We will provide participants with assistive software packages for the duration of their involvement in the project. If resources allow, depending on discussion with software providers, participants may be able to keep the software packages when their participation has ended.

## 5. Vulnerable groups

**5.1 Will persons from any of the following groups be participating in the study?** (if not go to section 6)

Adults without capacity to consent	<input type="checkbox"/>
Children under the age of 18	<input type="checkbox"/>
<b>Those with learning disabilities</b>	<input type="checkbox"/>
Prisoners	<input type="checkbox"/>
Vulnerable adults	<input type="checkbox"/>
Young offenders (16-21 years)	<input type="checkbox"/>
Those who would be considered to have a particular dependent relationship with the investigator (e.g. those in care homes, students, employees, colleagues)	<input type="checkbox"/>

**5.2 Will you be recruiting or have direct contact with any children under the age of 18?**

**YES** ☐

**NO** ☐

**5.2a If yes, please give details of the child protection procedures you propose to adopt should there be any evidence of or suspicion of harm (physical, emotional or sexual) to a young person. Include a referral protocol identifying what to do and who should be contacted.**

**5.2b Please give details of how you propose to ensure the well-being of the young person, particularly with respect to ensuring that they do not feel pressured to take part in the research and that they are free to withdraw from the study without any prejudice to themselves at anytime.**

**5.3 Will you be recruiting or have direct contact with vulnerable adults? YES**

☐ **NO** ☐

**5.3a If yes, please give details of the protection procedures you propose to adopt should there be any evidence of or suspicion of harm (physical, emotional or sexual) to a vulnerable adult. Include a referral protocol identifying what to do and who should be contacted.**

**5.3b Please give details of how you propose to ensure the well-being of the vulnerable adult, particularly with respect to ensuring that they do not feel pressured to take part in the research and that they are free to withdraw from**

the study without any prejudice to themselves at anytime. You should indicate how you intend to ascertain that person's views and wishes.

--

**5.3c Please give details of any City staff or students who will have contact with vulnerable adults and/or will have contact with young people (under the age of 18) and details of current (within the last 3 years) enhanced City University London CRB clearance.**

<i>Name</i>	<i>Dept &amp; School</i>	<i>Student/Staff Number</i>	<i>Date of CRB disclosure</i>	<i>Type of disclosure</i>

**5.3d Please give details of any non-City staff or students who will have contact with vulnerable adults and/or will have contact with young people (under the age of 18) and details of current (within the last 3 years) enhanced CRB clearance.**

<i>Name</i>	<i>Institution</i>	<i>Address of organisation that requested the disclosure</i>	<i>Date of CRB disclosure</i>	<i>Type of disclosure</i>

**5.4 Will you be recruiting any participants who fall under the Mental Capacity Act 2005?**

YES ☐ NO ☐

**If so you MUST get approval from an NHS NRES approved committee (see separate guidelines for more information).**



## 6. Data Collection

### 6.1a Please indicate which of the following you will be using to collect your data

*Please tick all that apply*

Questionnaire	<input type="checkbox"/>
Interviews	<input checked="" type="checkbox"/>
Participant observation	<input checked="" type="checkbox"/>
Focus groups	<input type="checkbox"/>
Audio/digital-recording interviewees or events	<input type="checkbox"/>
Video recording	<input checked="" type="checkbox"/>
Physiological measurements	<input type="checkbox"/>
Quantitative research (please provide details)	<input checked="" type="checkbox"/>
Other	<input type="checkbox"/>
<b>Please give details</b>	Quantitative tests: Comprehensive Aphasia Test, Communication Disability Profile (also possibly Wisconsin Card Sorting Test, Cognitive Linguistic Quick Test), a validated measure of social participation (possibly the Community Integration Questionnaire or Social Network Analysis), a validated measure of well-being (possibly the General Health Questionnaire)

### 6.1b What steps, if any, will be taken to safeguard the confidentiality of the participants (including companies)?

Unique letter/number code denoting participant/assessment stage in assessment data. List of codes and corresponding names will be filed separately and accessed only by principle investigator/supervisors. Archived written/video material will only be accessed by the immediate project team. Pseudonyms in published material.

### 6.1c If you are using interviews or focus groups, please provide a topic guide

Attached, pre-training topic guide and post-training topic guide; the latter is annotated to show additional issues which may be discussed at the final assessment stage when three months have elapsed post-training.

## 7. Confidentiality and Data Handling

### 7.1a Will the research involve:

<b>complete anonymity of participants</b> (i.e. researchers will not meet, or know the identity of participants, as participants are a part of a random sample and are required to return responses with no form of personal identification)?	<input type="checkbox"/>
<b>anonymised sample or data</b> (i.e. an <i>irreversible</i> process whereby identifiers are removed from data and replaced by a code, with no record retained of how the code relates to the identifiers. It is then impossible to identify the individual to whom the sample of information relates)?	<input type="checkbox"/>
<b>de-identified samples or data</b> (i.e. a <i>reversible</i> process whereby identifiers are replaced by a code, to which the researcher retains the key, in a secure location)?	<input checked="" type="checkbox"/>
<b>subjects being referred to by pseudonym in any publication arising from the research?</b>	<input checked="" type="checkbox"/>
<b>any other method of protecting the privacy of participants?</b> (e.g. use of direct quotes with specific permission only; use of real name with specific, written permission only)	<input type="checkbox"/>
<b>Please give details of 'any other method of protecting the privacy of participants' is used</b>	

### 7.1b Which of the following methods of assuring confidentiality of data will be implemented?

*Please tick all that apply*

data to be kept in a locked filing cabinet	<input checked="" type="checkbox"/>
data and identifiers to be kept in separate, locked filing cabinets	<input checked="" type="checkbox"/>
access to computer files to be available by password only	<input checked="" type="checkbox"/>
storage at City University London	<input checked="" type="checkbox"/>
stored at other site	<input type="checkbox"/>
<b>If stored at another site, please give details</b>	

### 7.1c Who will have access to the data?

Access by named researcher(s) only

YES ☒

NO ☐

Access by people other than named researcher(s)

YES ☐

NO ☒

*If people other than the named researcher(s), please explain by whom and for what purpose*

**7.2a Is the data intended for reuse or to be shared as part of longitudinal research?**

YES ☐ NO ☒

**7.2b Is the data intended for reuse or to be shared as part of a different/wider research project now, or in the future?**

YES ☐ NO ☒

**7.2c Does the funding body (e.g. ESRC) require that the data be stored and made available for reuse/sharing?**

YES ☐ NO ☒

**7.2d If you have responded yes to any of the questions above, explain how you are intending to obtain explicit consent for the reuse and/or sharing of the data.**

### **7.3 Retention and Destruction of Data**

**7.3a Does the funding body or your professional organisation/affiliation place obligations or recommendations on the retention and destruction of research data?**

YES ☒

NO

*If yes, what are your affiliations/funding and what are the requirements? (If no, please refer to University guidelines on retention.)*

Ten years

**7.3b How long are you intending to keep the data?**

Ten years, in accordance with City University guidelines. Video-recorded interviews and training sessions will be transcribed and transcripts will be de-identified. Video-recordings of participants who do not agree for their data to be shown to other parties will be deleted as soon as the PhD is completed.

**7.3c How are you intending to destroy the data after this period?**

Shredding paper, deleting computer files, erasing video data.

**8. Curriculum Vitae**

CV OF APPLICANTS (Please duplicate this page for each applicant, including external persons and students involved.)

NAME:	Becky Moss
CURRENT POST (from)	Full-time MPhil/PhD studentship from Oct 2012
Title of Post:	
Department:	Language and Communication Science
Is your post funded for the duration of this proposal?	Yes
Funding source (if not City University London)	
Please give a summary of your training/experience that is relevant to this research project	
<p><b>Jan - July 2012 (maternity cover) Research Associate, DonaTE project (Donation, Transplantation and Ethnicity), Division of Health and Social Care Research, King's College London</b></p> <p>Qualitative data analysis of in-depth interviews using NVivo9 software, developing and piloting an education intervention for intensive care unit staff, obtaining ethics permission, producing papers for academic journals, as part of a wider project exploring why the BME population is under-represented on the organ donation register and as recipients of organ transplants.</p> <p><b>Nov 2010 - Jan 2012 Research Associate, Louis Dundas Centre for Children's Palliative Care, UCL Institute of Child Health</b></p> <p><i>Evaluated Improving access to palliative care support for babies and families: an education programme to introduce principles, practices and resources in palliative care services in neonatal units across</i></p>	

*Greater London* programme. Systematic ethnographic observation of neonatal education sessions delivered in hospitals across Greater London, and writing a field journal account of the sessions; preparing and presenting progress updates to the evaluation team and the steering committee; writing the interim and full project reports to funders and for internal use; liaising with the education team and the project lead to develop a mechanism for monitoring neonatal palliative care referrals; analysing field journal, transcript and free-text survey data; writing about the project for academic journal papers.

**Oct 2006 – Dec 2010 Associate researcher and trainer, Connect – the communication disability network**

Semi-structured interviewing and qualitative data analysis, focus group chair, and report contributor for Connect's independent review of the LINC (Lewisham Intermediate Care) and LATT (Lewisham Adult Therapy Team) services, commissioned by Lewisham Primary Care Trust - review report submitted April 2010;

Co-ordinator of Pan London project (June – Dec 2010), working with North East, South East and South West London Stroke Networks to enable a group of 'champions' to cascade communication access training throughout their staff;

Project lead for *Access to Work* (Jan 2009 – Feb 2010), conducting semi-structured interviews with people with stroke and aphasia about barriers and facilitators influencing return to and retention of work, then designing and delivering a training course for employment and benefits advisers, rehabilitation and third sector staff, and colleagues/managers/employees of people with stroke;

Regular trainer/facilitator on Connect's two day training course *Making Communication Access a Reality*, for clinicians and other healthcare professionals working with people with communication disabilities after stroke, focusing on how to make interactions, documents and environments more accessible for service users;

Semi-structured interviewing and qualitative data analysis for the *Community Leaders* project, which aimed to enable people with aphasia to be active citizens and provide peer support;

Project lead for *Health Talk: making communication clearer* (October 2006 - July 2008), a trial funded by the Department of Health Section 64 Scheme, exploring whether a paper-based tool can improve communication between primary care practitioners and patients with communication disabilities. Day to day management of the trial, including securing ethics permission, recruiting primary care practices, recruiting focus groups of participants with communication difficulties, designing interview guides, qualitative in-depth interviewing of practitioners and patients, analysis of interview data, chairing focus groups, producing reports for academic and lay interested parties, presenting findings at Department of Health seminars

Revision of *The Stroke and Aphasia Handbook* for its 3<sup>rd</sup> edition (2008).

**June 2001 – March 2005 Research assistant, then associate, Department of Education and Professional Studies, King's College London**

Qualitative study of Borough of Lambeth General Practitioners in consultation with patients with limited English, exploring how communicative misunderstandings and breakdowns could be avoided or ameliorated. Main responsibilities: detailed transcription of videotaped data, discourse analysis of transcribed data, contributing to papers and presenting at conferences. I also recruited suitable patients and obtained informed consent, and video recorded primary care practitioners consulting with patients.

**April 2001 – June 2003 Research assistant, Department of Language and Communication Science, City University [based at Connect – the communication disability network]**

Funded by the ESRC's Innovative Health Technologies Programme, this project explored the barriers and facilitators experienced by people with communication impairments when accessing information, services and social interaction via the Internet. The iterative and reflexive research design allowed the research participants with aphasia to drive the project direction, and they collaborated with myself and a web designer to create their own accessible website ([www.aphasiahelp.org](http://www.aphasiahelp.org)), which presented health information, provided opportunities to make contact with peers, and enabled participants to articulate their experiences in formats of their choice. I facilitated a weekly focus group meeting of people with

aphasia, during which we explored websites, discussing design issues such as ease of navigation and more subtle factors such as the impact of content tone and style. I conducted ethnographic observation of participants in the computer suite and at home, preparing detailed and accessible minutes of the meetings, in-depth interviewed all participants at the outset and the end of the research period, transcribed and analysed interview data, made conference presentations and wrote reports and papers.

**September 1999 –April 2001 Cancer Research Campaign Psychosocial Oncology Group, UCL**

Communication skills training intervention designed to improve oncologists' skills when faced with challenging consultations. Analysis of video data using a bespoke system of discourse analysis, preparation of detailed written feedback for oncologists on a range of communicative behaviours, co-facilitation of workshops on three-day residential training courses, administering patient surveys pre- and post-consultation, and gaining consent to video-record oncology patients.

NAME:	Katerina Hilari
CURRENT POST (from)	2010
Title of Post:	Reader
Department:	LCS
Is your post funded for the duration of this proposal?	Yes
Funding source (if not City University London)	
Please give a summary of your training/experience that is relevant to this research project	
Katerina has extensive experience of carrying out research with people with aphasia. She is an expert on quality of life in adult acquired communication disorders and issues around its assessment. She has successfully completed three funded large scale projects with people with aphasia and is currently a grant holder in an EU funded study of aphasia therapy in Greece. She has extensive experience of supervising students and over 40 publications.	

NAME:	Celia Woolf
CURRENT POST (from)	2012
Title of Post:	Research Fellow
Department:	LCS/School of Health Sciences
Is your post funded for the duration of this proposal?	no
Funding source (if not City University London)	Tavistock Trust for Aphasia/Charles Wolfson Charitable Trust
Please give a summary of your training/experience that is relevant to this research project	
Celia is a qualified speech & language therapist and has a doctorate in the field of	

aphasia. She has previous experience as a PI on a grant relating to aphasia therapy and has led the Aphasia Research Clinic at City University. She is currently a grant holder on three research projects investigating the use of technology in aphasia therapy. She is co-author of a major text book relating to aphasia therapy (Beyond Aphasia: Therapies For Living With Communication Disability, Pound, Parr, Lindsay & Woolf, Speechmark, 2000).

**8.1 Supervisor's statement on the student's skills and ability to carry out the proposed research, as well as the merits of the research topic (up to 500 words)**

Becky is a strong PhD candidate, who has a very good academic pedigree. Her first degree and MSc qualifications are from prestigious Universities and are in subject areas that are relevant to this application. She already has extensive research experience, having worked on projects relating to health care, service provision and communication disability. Critically, she has conducted a number of projects in the field of aphasia, the topic of her proposal, including one that explored access to technology. She already has 7 publications to her name.

The project proposal is novel, and of theoretical and clinical interest. It will extend our understanding of reading and writing impairments in aphasia and generate new insights into how the disabling consequences of those impairments can be ameliorated. There will be practical outputs for SLT clinicians, such as prescribed therapy packages. We are confident of peer reviewed academic outputs, particularly given Becky's publication record to date.

Becky's proposed project has an excellent fit with the research priorities of our Division and School. At the level of the Division, it will extend our work on interventions for people with aphasia. Indeed it is a development of pilot work that was conducted in our Aphasia Research Clinic. The proposal also fits with our focus on therapeutic uses of technology, with several grants currently exploring this area. At the level of the School there is synergy with our drive to influence health care practice and to improve health outcomes.

Finally, the feasibility of the study is excellent. Becky brings a good portfolio of research skills that will be relevant to this proposal. She has strong links with voluntary sector organisations for people with aphasia, such as Connect, so is well placed to recruit her participants, and she will also be able to draw on previous participants of the Aphasia Research Clinic.

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<b>Supervisor's Signature</b>	
<b>Print Name</b>	KATERINA HILARI

**9. [Participant Information Sheet](#) and 10. [Consent Form](#)**

Please use the templates provided below for the Participant Information Sheet and Consent Form. They should be used for all research projects and by both staff and students. Note that there are occasions when you will need to include additional information, or make slight changes to the standard text – more information can be found under the [application guidelines](#).

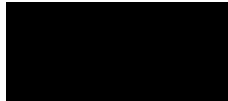
**11. Additional Information**

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## 12. Declarations by Investigator(s)

- I certify that to the best of my knowledge the information given above, together with any accompanying information, is complete and correct.
- I have read the University's guidelines on human research ethics, and accept the responsibility for the conduct of the procedures set out in the attached application.
- I have attempted to identify all risks related to the research that may arise in conducting the project.
- I understand that **no** research work involving human participants or data can commence until **full** ethical approval has been given

	Print Name	Signature
<b>Principal Investigator(s)</b> (student and supervisor if student project)	KATERINA HILARI	
<b>Associate Dean for Research (or equivalent) or authorised signatory</b>		
<b>Date</b>	Thursday 6 <sup>th</sup> December 2012	

## School of Health Sciences Research Ethics Committee

### RESEARCH REGISTRATION FORM *(Replaces form EC3 for SHS approvals)*

**This form must be completed for all research projects regardless of whether the proposal is going to an NHS, School or other approved research ethics committee. All sections must be completed as indicated; failure to do so will lead to the form being returned to you, and the project remaining unregistered.**

Please complete this form and **email** it to Alison Welton

().

**PhD, Master's and other students** must ensure that the form is emailed by their supervisor at City University, and contains the following statement "**I have read & approved [Name of student]'s submission: [name of project]**".

**Application date:**

0	7	/	1	2	/	2	0	1	2
---	---	---	---	---	---	---	---	---	---

**Short project title:**

**Assistive technologies, communication and social participation in people with aphasia**

*(80 characters)*

**Name of Principal Investigator(s)<sup>1</sup>:**

**Becky Moss**

**Department or Unit:**

**Language and Communication Sciences**

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<sup>1</sup>

Should be a member of academic staff at City University London

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**Name of Student:** **Becky Moss**

*(if applicable)*

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**Name of Supervisor:** **Dr Katerina Hilari and Dr Celia Woolf**

*(For Students Only)*

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**Course:** **MPhil/PhD**

*(For Students Only)*

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**Student number:** **120038870**

*(For Students Only)*

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**External organisation(s) involved:** **None**  
*(if any)*

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**Funding bodies:** **City University PhD studentship (full time)**  
*(if any)*

---

**Planned completion date:**

3	0	/	0	9	/	2	0	1	5

**A Research Proposal**

**Full title of research proposal:**

Investigating the impact of using assistive technologies on communication and social participation for people with aphasia: a mixed methods, case series study

Please provide a **brief structured lay summary** of your proposed research, including: aims, rationale, methodology, and any ethical issues. (<500 words) **[PLEASE DO NOT ATTACH YOUR FULL PROJECT PROPOSAL.]**

#### *Aims*

The project builds on Caute and Woolf's (2011) study which trained an individual with aphasia to use assistive technologies (AT) and improved his written communication and social participation. Ten participants with aphasia will train to use AT (voice recognition software, text-to-speech software). Research questions:

1. How can AT reduce the disabling consequences of writing/reading impairments resulting from aphasia?
2. What are the barriers to successful use of AT by this group; can modifications enhance ATs' efficacy?
3. How does AT training improve individuals' ability to communicate through written language; what support is needed?
4. What are participants' levels of social participation and well-being before the training, and does the training have any effect on these levels?
5. What factors may influence intervention outcomes?

#### *Rationale*

This project will extend and consolidate the intervention, exploring the software's potential in a wider set of conditions and increase generalizability of findings. Qualitative data will complement quantitative data and systematically capture changes in social participation and well-being. Potential impacts include improving access to AT for people with aphasia, and developing aphasia-friendly training materials.

#### *Methodology*

Sample: ten individuals with aphasia, meeting pre-determined selection criteria.

Design: mixed methods, case series design, scheduled as a rolling programme to allow sufficient time/attention for each participant, assessment and follow-up data analysis. Maximum three individuals training at any stage.

Intervention: 10-15 one hour sessions per participant: familiarisation with equipment/software, identifying goals for written communication, training/support, trouble-shooting difficulties, home-based exercises.

Outcome measures: Quantitative and qualitative assessments of written communication, social participation and well-being before and immediately after intervention delivery, and a minimum of three months later.

#### *Ethical issues*

Data protection: Unique letter/number codes denoting participant/assessment stage in all assessment data. List of codes and corresponding names will be filed separately and accessed only by principle investigator/supervisors. Archived written/video material will only be accessed by the immediate project team. Printed data used in

journals will be de-identified through the use of pseudonyms and replacement of any other details which could identify participants.

Participant frustration/distress: Attempts to access AT will focus on specific language and communication difficulties, which could cause frustration and possibly even distress. Participants will be supported by the PI who has experience working with people with aphasia and facilitating communication and technology access. Participants will be invited to take breaks during training sessions if they are experiencing frustration, and will be able to terminate and reschedule sessions if they wish. Standard City Aphasia Research Clinic pathways to accessing further therapy and/or counselling will be available regardless of on-going participation or withdrawal.

Informed written consent: Will be sought using carefully designed materials suitable for people with communication disabilities. On-going assent will be sought. Explicit permission to use video-recorded material for conference presentation will be sought.

Individual outcomes: Participants may hope for functional writing and spelling improvements. While therapeutic benefits may arise, the PI will make clear when recruiting participants that she is not a clinician and the study's principle focus is research, in order that participants may make an informed choice.

## B Research Ethics Approval

After you have received confirmation of initial registration, you will need to prepare a full application and submit it to **one** approved research ethics committee.

In general, projects involving the participation of patients recruited through the NHS or NHS staff will need to go through the **NRES** (<http://www.nres.npsa.nhs.uk/>), as will projects involving non-anonymised patient records and patient tissues. The applications can be made through the IRAS portal (<https://www.myresearchproject.org.uk/>). You will also need to register such projects with NHS Trust R&D offices and obtain an honorary NHS contract or research passport.

**However**, some NHS research ethics committees do not require approval for health services research. If you can submit an email or letter from the appropriate R&D office(s) or NRES committee confirming that NRES approval is not required, you may **instead** submit your proposal to a SHS Ethics Committee or Senate Research Ethics Committee.

Please indicate to which one of the following committees you intend to submit a **full research ethics application**

(Please *check as appropriate*)

- NRES (NHS research ethics committee) YES ☐  
NO ☒
- Senate Research Ethics Committee<sup>2</sup> YES ☐  
NO ☒
- SHS Research Ethics Committee<sup>3</sup> YES ☒  
NO ☐
- Another research ethics committee (*please give details below*)  
YES ☐ NO ☒

- This project does not require ethical approval (*please give details below*) ☐

---

2

*A full application on form EC1 will have to be made to Senate REC for research ethical approval*

3

*A full application on form EC1 (SHS version) will have to be made to SHS REC for research ethical approval*

i) It is a service evaluation or audit

☐

ii) It does not involve human subjects or participants

☐

*(Please check as appropriate and give details of justification below)*

### **C Research involving staff or Students at City University London**

Projects which involve the recruitment of School staff or students require approval by the appropriate associate dean for research, undergraduate or postgraduate students. This ensures that the same group of staff/students are not repeatedly contacted to become involved in research projects. Principal investigators should not contact students or staff directly.

If you wish to recruit staff or students into a research project please contact the administrator to the SHS REC Alison Welton

(XXXXXXXXXX) in the first instance to discuss obtaining approval.

Does this project involve the recruitment of staff or students at City University:

1) This project will recruit staff

YES ☐ NO ☒

2) This project will recruit postgraduate students

YES ☐ NO ☒

3) This project will recruit undergraduate students

YES ☐ NO ☒

*(Please check as appropriate)*

### **D Additional information required for University reporting and indemnity**

**This project is** (please tick)

Undergraduate

☐

Taught Postgraduate (MSc)

☐

Doctoral Student

☒

Staff

☐

**This project involves** (please tick)

Children

☐

Vulnerable adults

☐

Research outside of England or Wales

☐

*Please specify:*

**Funding, this project is** (please tick)

Externally funded

☐

Internally funded

☒

Unfunded

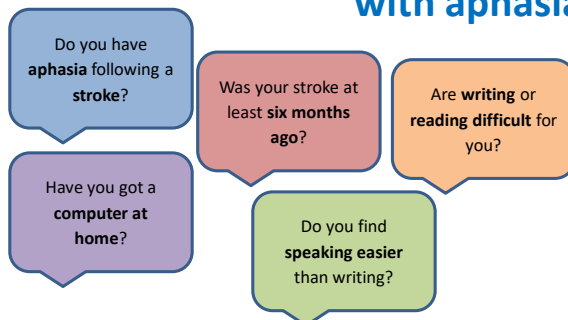
☐



## Appendix 5.2: Project flyer



### Can computer software help people with aphasia to write?



If you answered **yes** to all of these questions, this **research project might suit you**

#### What is the research project about?

- We want to find out if **computer software** can **help** people with aphasia to **write** and **read**, and **stay in touch** with people.
- We would **teach you** to use the technology and **help you** get used to it.
- The project is Becky Moss' **PhD project**.

#### What would it involve?

- Training would last **one hour, once a week**. It would take **10-12 weeks**.
- Training sessions would be **video recorded**. You could choose to train at **City University London** or **your home**.
- You would be given **practice work** to do **at home**.
- We would do some language and memory **assessments**, and **interviews**, before and after the training.

#### Want to know more?

Contact Becky:



### Appendix 5.3: Project information sheet

## Can computer software support writing and promote social participation for people with aphasia?

### Would you like to join a research study?

**Read** this sheet carefully **before you decide**. It will tell you:

- The **aims** of the research
- What you would **have to do**.

You can **discuss the study** with other people.

**Take your time**. Ask **questions** if it is not clear or if you want to know more.

### What is the study about?

We want to find out if **computer software** can **help** people with aphasia to **write and read**.

We will **teach you** to use the software.

We will collect information using **assessments, interviews** and **observation**.

The study is a **PhD project**.

### What will it involve?

If you take part you will work with Becky for about six months in total.

#### Before the training:

We will do some **language** and **memory tests** to check the project is **suitable** for you.

If it is suitable, we will do some **in depth language assessments** and an **interview**.

The interview will be **audio-recorded**.

**Six weeks later** you will do some more assessments. Then the training begins.

#### During the training:

You can choose to train at City University or your home.

Training will last **one hour**. It will be **once a week**. Training will take **10-12 weeks**.

Training sessions will be **video recorded**.

You will be given **practice work** to do **at home**.

**After the training:**

You will do some more **assessments** and another **interview**.

**Three months later** we will do the **final** assessments and interview.

There is a diagram showing **what will happen** on the **last page** of this information sheet.

**Why you?**

We are asking you because:

- You have had a stroke and have **aphasia**
- **Writing** and/or **reading** is **difficult** for you
- You find **speaking easier** than writing
- Your stroke was **six months ago** or more
- You have a **computer at home**
- You are **not receiving speech** and language therapy at the moment.

**Do you have to take part?**

No, it is **your choice**.

If you decide to take part you will need to sign a **consent form**.

You can say 'yes' now then **change your mind**. You don't have to say why.

This will **not affect** any other treatment or service you have.

**Is there any risk or inconvenience?**

There are **no medical risks** or dangers.

The project is about six months long. You will need to give up some of your time.

Training can be tiring or frustrating. If you get tired we can **rest** or **stop** and carry on next time.

Becky will **help** you solve difficulties.

### Will the project help me?

We hope the training will **improve** your **writing** and/or **reading**.

We **cannot guarantee** that everyone will improve.

This is a **research** study, not speech and language **therapy**.

It may help us understand how computer software can work better for people with aphasia.

### What happens at the end of the research?

We will give you a copy of **your assessment results** if you would like one.

Later we will tell you the findings of the whole study.

The project will be **published** as Becky's **PhD thesis**.

It will be presented at **conferences**, and published in **academic journals**.

It will also be presented to **community/voluntary groups** for **people with aphasia after stroke**.

### Is it confidential?

**Yes**. Only Becky and the research team will see the data.

Becky will **ask your permission** before showing video recordings to anyone else.

Your **identity** will **not be revealed** in any published material.

Paper data will be kept in a locked filing cabinet at City University.

Computer files will be password protected.

### What if there is a problem?

**Talk to Becky** or to her **supervisors**. They will do their best to **solve problems**.

If they cannot help, to **complain** about the study you should phone the **Secretary to Senate Research Ethics Committee** on 020 7040 3040.

Tell them the name of the project is:

**Can computer software support writing and promote social participation  
for people with aphasia?**

Or you can write to the Secretary:

Anna Ramberg

[Anna.Ramberg.1@city.ac.uk](mailto:Anna.Ramberg.1@city.ac.uk)

Secretary to Senate Research Ethics Committee

Research Office, E214

City University London

Northampton Square

London

EC1V 0HB

#### Who has reviewed the study?

This study has **been approved** by City University London School of Health Sciences Research Ethics Committee.

#### Contact details

Becky Moss

[REDACTED]

Dr Katerina Hilari

[REDACTED]

**Thank you for reading this information sheet.**



#### Appendix 5.4: Consent form

### Can computer software support writing and promote social participation for people with aphasia?

Please  
initial  
box

1.	<p>I <b>agree to take part</b> in this research project.</p> <p>The project has been <b>explained to me</b>.</p> <p>I have <b>read Participant information sheet version 3: 12-3-2014</b>, which I can keep.</p> <p>I have been given the chance to <b>ask questions</b> and have them <b>answered</b>.</p> <p>I understand the study will involve:</p> <ul style="list-style-type: none"><li>• <b>Screening tests</b> to check the study is suitable for me</li> <li>• <b>Interviews</b> at the <b>beginning</b> and <b>end</b> of the training, and <b>three months later</b></li> <li>• Allowing the interview to be <b>videotaped</b></li> <li>• <b>Assessments</b> at the <b>beginning</b> and <b>end</b> of the training, and <b>three months later</b></li> <li>• <b>Training to use computer software</b></li> <li>• Allowing training sessions to be videotaped</li></ul>	
----	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--

	<ul style="list-style-type: none"> <li>• Doing <b>practice exercises</b> on the computer <b>at home</b></li> </ul>	
--	--------------------------------------------------------------------------------------------------------------------	--

2.	<p>I agree the following information about me may be kept:</p> <ul style="list-style-type: none"> <li>• Screening tests</li> <li>• Assessments and interviews</li> <li>• Training video data</li> </ul> <p>I understand that <b>any information</b> I provide is <b>confidential</b>.</p> <p>Please <b>choose one and tick</b>:</p> <ol style="list-style-type: none"> <li>1. Destroy my information when I finish the study</li> <li>2. Keep my information <b>for 10 years</b> then destroy it</li> <li>3. Use my information for teaching purposes for as long as it is needed</li> </ol> <p>There will be <b>no information that could identify me</b> in project reports.</p>	
3.	<p>I understand that my participation is <b>voluntary</b>.</p> <p>I can <b>change my mind</b> at any stage of the project.</p> <p>I do not need to give a reason.</p>	



	Any <b>future treatment</b> or service I receive <b>will not be affected</b> .	
4.	<p><b>I agree</b> to City University London <b>recording and processing</b> information about me.</p> <p>I understand that this information will be used only for the purpose(s) set out in this statement.</p> <p>My consent is conditional on the University complying with its duties and obligations under the Data Protection Act 1998.</p>	
5.	<b>I agree to take part in the above study.</b>	

\_\_\_\_\_  
\_\_\_\_\_

Your name

\_\_\_\_\_  
\_\_\_\_\_

Signature

Date

Becky Moss

\_\_\_\_\_  
\_\_\_\_\_

Researcher name

\_\_\_\_\_  
\_\_\_\_\_

Signature

Date

\_\_\_\_\_

\_\_\_\_\_

**Appendix 7.1: Assessment scores for  
Participant 1: Peter**

Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	4.0
		T2	4.0
		T3	3.6
		T4	4.0
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture descr Reading Writing Written picture descr	25 - 75	T1 only	65
			68
			56
			63
			48
			51
			42
Single word writing: PALPA 40	0 - 40	T1	0
		T2	0
		T3	1 (2.5%)
		T4	0
Single word reading: PALPA 50	0 - 60	T1	49 (81.7%)
		T2	47 (78.3%)
		T3	45 (75%)
		T4	46 (76.7%)

Research question 1

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	42
			T2	42
			T3	42
			T4	42
	T-score CAT written picture description keyboard	25 - 75	T1	42
			T2	42
			T3	75
			T4	75
	Constrained writing pen & paper total token	N/A	T1	0
			T2	0
			T3	0
			T4	0
	Constrained writing pen & paper lexical	0 - 100	T1	0
			T2	0
			T3	0

	variety		T4	0
	Constrained writing keyboard total token	N/A	T1	0
			T2	0
			T3	162
			T4	85
	Constrained writing keyboard lexical variety	0 - 100	T1	0
			T2	0
			T3	51.2
			T4	69.4
	Constrained writing pen & paper SVJ total score	0 - 40	T1	0
			T2	0
			T3	0
			T4	0
	Constrained writing keyboard SVJ total score	0 - 40	T1	0
			T2	0
			T3	30.4
			T4	24.4
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	3
			T2	3
			T3	3
			T4	3
	GORT-4 keyboard standard comprehension score	1 - 20	T1	2
			T2	3
			T3	4
			T4	6

Research question 2

Test	Scale range score	Time point	Score
Social participation: SNA	6 - 65	T2	13
		T3	17
		T4	21
Mood: GHQ12	0 - 12	T1	0
		T2	1
		T3	0
		T4	0
Quality of life:SAQOL-39g	1 - 5	T1	3.9
		T2	4.2
		T3	4.4
		T4	4.1

**Appendix 7.2: Assessment scores for  
Participant 2: Rohan**

Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	2.8
		T2	2.6
		T3	2.6
		T4	3.0
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture descr Reading Writing Written picture descr	25 - 75	T1 only	54
			59
			55
			59
			62
			64
			60
Single word writing: PALPA 40	0 - 40	T1	31 (77.5%)
		T2	35 (87.5%)
		T3	29 (72.5%)
		T4	33 (82.5%)
Single word reading: PALPA 50	0 - 60	T1	52 (86.7%)
		T2	55 (91.7%)
		T3	52 (86.7%)
		T4	54 (90%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	60
			T2	67
			T3	65
			T4	68
	T-score CAT written picture description keyboard	25 - 75	T1	57
			T2	59
			T3	42
			T4	42
	Constrained writing pen & paper total token	N/A	T1	18
			T2	26
			T3	28
			T4	23

	Constrained writing pen & paper lexical variety	0 - 100	T1	100
			T2	100
			T3	78.6
			T4	82.6
	Constrained writing keyboard total token	N/A	T1	14
			T2	15
			T3	29
			T4	138
	Constrained writing keyboard lexical variety	0 - 100	T1	92.9
			T2	100
			T3	82.8
			T4	68.1
	Constrained writing pen & paper SVJ total score	0 - 40	T1	17.3
			T2	24.6
			T3	29.4
			T4	30.3
	Constrained writing keyboard SVJ total score	0 - 40	T1	16.0
			T2	25.2
			T3	8.0
			T4	8.6
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	5
			T2	3
			T3	3
			T4	3
	GORT-4 keyboard standard comprehension score	1 - 20	T1	2
			T2	4
			T3	5
			T4	4

**Research question 2**

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	7
		T3	6
		T4	13
Mood: GHQ12	0 - 12	T1	2
		T2	0
		T3	0
		T4	0
Quality of life:SAQOL-39g	1 - 5	T1	3.7
		T2	3.3
		T3	3.4
		T4	3.3

**Appendix 7.3 Assessment scores for Participant 3: Sarah**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	3.6
		T2	3.8
		T3	4.0
		T4	4.0
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 - 75	T1 only	65
			68
			62
			61
			60
			65
			61
Single word writing: PALPA 40	0 - 40	T1	31 (77.5%)
		T2	33 (82.5%)
		T3	36 (90%)
		T4	31 (77.5%)
Single word reading: PALPA 50	0 - 60	T1	56 (93.3%)
		T2	58 (96.7%)
		T3	56 (93.3%)
		T4	57 (95%)

Research question 1

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	61
			T2	68
			T3	66
			T4	68
	T-score CAT written picture description keyboard	25 - 75	T1	61
			T2	56
			T3	75
			T4	71
	Constrained writing pen & paper total token	N/A	T1	26
			T2	36
			T3	26
			T4	26
	Constrained writing pen &	0 - 100	T1	84.6
			T2	77.8

	paper lexical variety		T3	80.8
			T4	96.2
	Constrained writing keyboard total token	N/A	T1	16
			T2	15
			T3	115
			T4	52
	Constrained writing keyboard lexical variety	0 - 100	T1	93.8
			T2	93.3
			T3	51.3
			T4	57.7
	Constrained writing pen & paper SVJ total score	0 - 40	T1	32
			T2	29.4
			T3	25.2
			T4	33.2
	Constrained writing keyboard SVJ total score	0 - 40	T1	13.2
			T2	19.4
			T3	23.2
			T4	29.5
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	3
			T2	2
			T3	3
			T4	5
	GORT-4 keyboard standard comprehension score	1 - 20	T1	3
			T2	4
			T3	4
			T4	8

Research question 2

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	40
		T3	40
		T4	40
Mood: GHQ12	0 - 12	T1	0
		T2	0
		T3	0
		T4	0
Quality of life: SAQOL-39g	1 - 5	T1	4.0
		T2	3.9
		T3	4.2
		T4	4.1

**Appendix 7.4: Assessment scores for  
Participant 4: Karen**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	4.0
		T2	3.8
		T3	4.0
		T4	4.0
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 - 75	T1 only	67
			68
			58
			75
			66
			61
			42
			42
Single word writing: PALPA 40	0 - 40	T1	0
		T2	5 (12.5%)
		T3	5 (12.5%)
		T4	12 (30%)
Single word reading: PALPA 50	0 - 60	T1	57 (95%)
		T2	58 (98.3%)
		T3	53 (88.3%)
		T4	57 (95%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	42
			T2	42
			T3	42
			T4	42
	T-score CAT written picture description keyboard	25 - 75	T1	75
			T2	75
			T3	75
			T4	75
	Constrained writing pen & paper total token	N/A	T1	0
			T2	0
			T3	0
			T4	0
	Constrained writing pen &	0 - 100	T1	0
			T2	0

Reading	paper lexical variety		T3	0
			T4	0
	Constrained writing keyboard total token	N/A	T1	139
			T2	174
			T3	231
			T4	219
	Constrained writing keyboard lexical variety	0-100	T1	65.5
			T2	59.8
			T3	66.2
			T4	66.7
	Constrained writing pen & paper SVJ total score	0 - 40	T1	0
			T2	0
			T3	0
			T4	0
	Constrained writing keyboard SVJ total score	0 - 40	T1	36.0
			T2	35.2
			T3	33.0
			T4	33.4
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	9
			T2	9
			T3	8
			T4	9
	GORT-4 keyboard standard comprehension score	1 - 20	T1	3
			T2	8
			T3	7
			T4	9

**Research question 2**

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	8
		T3	8
		T4	9
Mood: GHQ12	0 - 12	T1	11
		T2	12
		T3	12
		T4	12
Quality of life: SAQOL-39g	1 - 5	T1	2.7
		T2	2.4
		T3	2.0
		T4	3.1

**Appendix 7.5: Assessment scores for  
Participant 5: Albert**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	3.8
		T2	4.0
		T3	4.0
		T4	4.0
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 - 75	T1 only	65
			68
			62
			73
			71
			62
			72
Single word writing: PALPA 40	0 - 40	T1	40 (100%)
		T2	38 (95%)
		T3	38 (95%)
		T4	39 (97.5%)
Single word reading: PALPA 50	0 - 60	T1	60 (100%)
		T2	59 (98.3%)
		T3	60 (100%)
		T4	60 (100%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	72
			T2	75
			T3	75
			T4	75
	T-score CAT written picture description keyboard	25 - 75	T1	67
			T2	72
			T3	75
			T4	75
	Constrained writing pen & paper total token	N/A	T1	75
			T2	82
			T3	94
			T4	93
	Constrained writing pen &	0 - 100	T1	77.3
			T2	82.9

	paper lexical variety	N/A	T3	71.3
			T4	71
			T1	35
			T2	38
	Constrained writing keyboard total token	0 - 100	T3	95
			T4	428
			T1	82.7
			T2	84.2
	Constrained writing keyboard lexical variety	0 - 40	T3	73.7
			T4	49.5
			T1	33.8
			T2	30.4
	Constrained writing pen & paper SVJ total score	0 - 40	T3	37.4
			T4	30.2
			T1	30.8
			T2	30.6
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T3	29.6
			T4	23.8
			T1	7
			T2	8
	GORT-4 keyboard standard comprehension score	1 - 20	T3	8
			T4	9
			T1	5
			T2	8

**Research question 2**

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	24
		T3	24
		T4	25
Mood: GHQ12	0 - 12	T1	9
		T2	12
		T3	4
		T4	1
Quality of life: SAQOL-39g	1 - 5	T1	2.2
		T2	2.7
		T3	2.3
		T4	2.5

**Appendix 7.6: Assessment scores for  
Participant 6: Dean**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	4.0
		T2	4.0
		T3	4.0
		T4	3.6
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 - 75	T1 only	67
			68
			64
			69
			56
			57
			59
Single word writing: PALPA 40	0 - 40	T1	0
		T2	18 (45%)
		T3	18 (45%)
		T4	15 (37.5%)
Single word reading: PALPA 50	0 - 60	T1	41 (68.3%)
		T2	41 (68.3%)
		T3	50 (83.3%)
		T4	49 (81.7%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	59
			T2	62
			T3	64
			T4	62
	T-score CAT written pic desc keyboard	25 - 75	T1	68
			T2	68
			T3	66
			T4	75
	Constrained writing pen & paper total token	N/A	T1	27
			T2	29
			T3	40
			T4	42
	Constrained writing pen &	0 - 100	T1	88.9
			T2	100

	paper lexical variety		T3	75
			T4	76.2
	Constrained writing keyboard total token	N/A	T1	37
			T2	27
			T3	88
			T4	72
	Constrained writing keyboard lexical variety	0 - 100	T1	83.8
			T2	85.2
			T3	65.9
			T4	65.3
	Constrained writing pen & paper SVJ total score	0 - 40	T1	31.0
			T2	28.4
			T3	29.4
			T4	27.6
Reading	Constrained writing keyboard SVJ total score	0 - 40	T1	29.6
			T2	37.4
			T3	25.6
			T4	27.0
	GORT-4 pen & paper standard comprehension score	1 - 20	T1	4
			T2	4
			T3	5
			T4	3
	GORT-4 keyboard standard comprehension score	1 - 20	T1	3
			T2	5
			T3	8
			T4	5

**Research question 2**

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	18
		T3	23
		T4	23
Mood: GHQ12	0 - 12	T1	5
		T2	1
		T3	1
		T4	1
Quality of life: SAQOL-39g	1 - 5	T1	4.1
		T2	4.4
		T3	4.3
		T4	4.7

**Appendix 7.7: Assessment scores for Participant 7: William**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	3.8
		T2	3.6
		T3	3.8
		T4	Declined
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 - 75	T1 only	
			62
			65
			48
			66
			56
			58
			57
Single word writing: PALPA 40	0 - 40	T1	26 (65%)
		T2	30 (75%)
		T3	31 (77.5%)
		T4	Declined
Single word reading: PALPA 50	0 - 60	T1	57 (95%)
		T2	60 (100%)
		T3	58 (96.7%)
		T4	Declined

Research question 1

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	57
			T2	61
			T3	66
			T4	Declined
	T-score CAT written picture description keyboard	25 - 75	T1	57
			T2	61
			T3	42
			T4	Declined
	Constrained writing pen & paper total	N/A	T1	14
			T2	0
			T3	21

	token		T4	Declined
	Constrained writing pen & paper lexical variety	0 - 100	T1	100
			T2	0
			T3	95.2
			T4	Declined
	Constrained writing keyboard total token	N/A	T1	26
			T2	36
			T3	145
			T4	Declined
	Constrained writing keyboard lexical variety	0 - 100	T1	84.6
			T2	80.6
			T3	62.1
			T4	Declined
	Constrained writing pen & paper SVJ total score	0 - 40	T1	28.4
			T2	0.0
			T3	29.0
			T4	Declined
	Constrained writing keyboard SVJ total score	0 - 40	T1	25.8
			T2	24.2
			T3	22.8
			T4	Declined
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	2
			T2	3
			T3	4
			T4	Declined
	GORT-4 keyboard standard comprehension score	1 - 20	T1	3
			T2	3
			T3	6
			T4	Declined

Research question 2

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	65
		T3	65
		T4	Declined
Mood: GHQ12	0 - 12	T1	3
		T2	2
		T3	3
		T4	Declined
Quality of life: SAQOL-39g	1 - 5	T1	3.8
		T2	3.8
		T3	3.4
		T4	Declined



**Appendix 7.8: Assessment scores for  
Participant 8: Janet**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	3.6
		T2	3.2
		T3	3.4
		T4	4.0
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 - 75	T1 only	52
			59
			52
			57
			56
			57
			59
Single word writing: PALPA 40	0 - 40	T1	25 (62.5%)
		T2	31 (77.5%)
		T3	27 (67.5%)
		T4	33 (82.5%)
Single word reading: PALPA 50	0 - 60	T1	56 (93.3%)
		T2	56 (93.3%)
		T3	55 (91.7%)
		T4	57 (95%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	59
			T2	62
			T3	57
			T4	61
	T-score CAT written picture description keyboard	25 - 75	T1	56
			T2	60
			T3	66
			T4	64
	Constrained writing pen & paper total token	N/A	T1	36
			T2	20
			T3	3
			T4	31
	Constrained writing pen & paper lexical	0 - 100	T1	83.3
			T2	100
			T3	100

	variety		T4	77.4
	Constrained writing keyboard total token	N/A	T1	16
			T2	19
			T3	49
			T4	47
	Constrained writing keyboard lexical variety	0 - 100	T1	81.3
			T2	78.9
			T3	77.6
			T4	76.6
	Constrained writing pen & paper SVJ total score	0 - 40	T1	20.3
			T2	23.6
			T3	4.0
			T4	15.6
	Constrained writing keyboard SVJ total score	0 - 40	T1	29.6
			T2	24.6
			T3	29
			T4	29
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	3
			T2	3
			T3	5
			T4	3
	GORT-4 keyboard standard comprehension score	1 - 20	T1	2
			T2	4
			T3	4
			T4	7

**Research question 2**

Test	Scale score range	Time point	Score
Social participation: SNA	6 - 65	T2	23
		T3	25
		T4	29
Mood: GHQ12	0 - 12	T1	5
		T2	1
		T3	2
		T4	1
Quality of life: SAQOL-39g	1 - 5	T1	4.4
		T2	4.3
		T3	4.2
		T4	4.6

**Appendix 7.9: Assessment scores for  
Participant 9: Doreen**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	3.0
		T2	2.6
		T3	3.0
		T4	3.2
Language: CAT domain T-scores Spoken comp Written comp Repetition Spoken picture description Reading Writing Written picture description	25 – 75	T1 only	62
			51
			56
			59
			46
			50
			55
Single word writing: PALPA 40	0 - 40	T1	10 (25%)
		T2	14 (35%)
		T3	8 (20%)
		T4	13 (32.5%)
Single word reading: PALPA 50	0 - 60	T1	41 (68.3%)
		T2	49 (81.7%)
		T3	50 (83.3%)
		T4	49 (81.7%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	55
			T2	42
			T3	42
			T4	52
	T-score CAT written picture description keyboard	25 - 75	T1	54
			T2	25
			T3	67
			T4	60
	Constrained writing pen & paper total token	N/A	T1	15
			T2	0
			T3	8
			T4	0
	Constrained writing pen & paper lexical	0 - 100	T1	100
			T2	0
			T3	100

Reading	variety		T4	0
	Constrained writing keyboard total token	N/A	T1	14
			T2	10
			T3	4
			T4	1
	Constrained writing keyboard lexical variety	0 - 100	T1	64.3
			T2	90
			T3	100
			T4	100
	Constrained writing pen & paper SVJ total score	0 - 40	T1	7.4
			T2	0.0
			T3	5.2
			T4	0.0
	Constrained writing keyboard SVJ total score	0 - 40	T1	5.0
			T2	4.8
			T3	13.6
			T4	3.0
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	1
			T2	1
			T3	1
			T4	1
	GORT-4 keyboard standard comprehension score	1 - 20	T1	1
			T2	1
			T3	2
			T4	2

**Research question 2**

Test	Scale score range	Time point	Score
Social participation: SNA	6 – 65	T2	23
		T3	23
		T4	23
Mood: GHQ12	0 – 12	T1	1
		T2	0
		T3	3
		T4	0
Quality of life: SAQOL-39g	1 - 5	T1	3.4
		T2	4.0
		T3	3.7
		T4	3.7

**Appendix 7.10: Assessment scores for Participant 10: Simon**  
Screening and monitoring

Test	Scale score range	Time point	Score
Cognition: CLQT composite severity score	0 - 4	T1	3.8
		T2	3.6
		T3	3.8
		T4	3.8
Language: CAT domain T-scores	25 - 75	T1 only	
Spoken comp			67
Written comp			65
Repetition			60
Spoken picture description			
Reading			75
Writing			66
Written picture description			61
			62
Single word writing: PALPA 40	0 - 40	T1	26 (65%)
		T2	31 (77.5%)
		T3	32 (80%)
		T4	30 (75%)
Single word reading: PALPA 50	0 - 60	T1	59 (98.3%)
		T2	58 (6.7%)
		T3	59 (98.3%)
		T4	57 (95%)

**Research question 1**

	Test	Scale score range	Time point	Score
Writing	T-score CAT written picture description pen & paper	25 - 75	T1	62
			T2	67
			T3	72
			T4	72
	T-score CAT written picture description keyboard	25 - 75	T1	62
			T2	70
			T3	75
			T4	75
	Constrained writing pen & paper total token	N/A	T1	49
			T2	50
			T3	51
			T4	57

	Constrained writing pen & paper lexical variety	0 - 100	T1	83.7
			T2	82
			T3	74.5
			T4	77.2
	Constrained writing keyboard total token	N/A	T1	51
			T2	58
			T3	248
			T4	327
	Constrained writing keyboard lexical variety	0 - 100	T1	74.5
			T2	75.9
			T3	49.6
			T4	51.1
	Constrained writing pen & paper SVJ total score	0 - 40	T1	25.4
			T2	27.6
			T3	25.2
			T4	27.4
	Constrained writing keyboard SVJ total score	0 - 40	T1	29.8
			T2	28.8
			T3	16.8
			T4	18.2
Reading	GORT-4 pen & paper standard comprehension score	1 - 20	T1	6
			T2	5
			T3	5
			T4	6
	GORT-4 keyboard standard comprehension score	1 - 20	T1	5
			T2	7
			T3	7
			T4	9

**Research question 2**

Test	Scale score range	Time point	Score
Social participation SNA	6 - 65	T2	48
		T3	51
		T4	54
Mood: GHQ12	0 - 12	T1	0
		T2	0
		T3	1
		T4	1
Quality of life: SAQOL-39g	1 - 5	T1	3.8
		T2	3.9
		T3	4.3
		T4	3.9

## Appendix 8.1 Thematic Index

1. Pre-stroke life and literacy
  - 1.1 Writing
  - 1.2 Reading
  - 1.3 Computing experience, technology tasks
  - 1.4 Leisure activities
  - 1.5 Employment
  - 1.6 Other
2. Post-stroke life and literacy
  - 2.1. Impact on writing/reading
  - 2.2 Impact on employment
  - 2.3 Writing/reading adaptations and strategies already made/attempted (including software)
  - 2.4 Current computer use/tasks
  - 2.5 Therapy received
  - 2.6 Other
3. Training
  - 3.1 Aims, goal statements
  - 3.2 Degree to which goals were reached
  - 3.3 Concrete outputs
  - 3.4 Individual differences
  - 3.5 Further suggestions for training
  - 3.6 Future plans
  - 3.7 Other
4. Social participation, mood and quality of life
  - 4.1 Social
  - 4.2 Psychological
  - 4.3 Physical
  - 4.4 Cognitive
  - 4.5 Impact of software
  - 4.6 Other
5. Dragon NaturallySpeaking™
  - 5.1 Tasks software used for
  - 5.2 Interactive tutorial and Help
  - 5.3 Voice training
  - 5.4 Dictation
  - 5.5 Commands
  - 5.6 Combining voice and keyboard
  - 5.7 Conventional writing
  - 5.8 Independent use
  - 5.9 Other
6. ClaroRead™
  - 6.1 Tasks software used for
  - 6.2 Prosody
  - 6.3 Navigation
  - 6.4 Independent use
  - 6.5 Other
7. Other hardware and software issues
  - 7.1 Email
  - 7.2 Microsoft Office
  - 7.3 Laptop
  - 7.4 Mouse/touchscreen
  - 7.5 Headset/microphone
  - 7.6 Other

## Appendix 8.2: Sample chart to illustrate the Framework process

Chart 2: Stroke and post-onset

	2.1 Impact on writing and reading	2.2 Impact on employment	2.3 Writing/reading adaptations already made, strategies attempted (including software)	2.4 Current computer use/tasks	2.5 Therapy received	2.6 Other
<b>Peter</b>	<p>T2 275-285 Alice in Wonderland, can still dip into old, familiar books</p> <p>T2 287-305 Can manage short things now if 'not intellectual', in last few years</p> <p>T2 308-310 Donated some books to charity</p> <p>T2 316 Short story spelling = nice and simple</p>	T2 164-197 Retirement coinciding with stroke	<p>T2 335-355 Independent spelling and handwriting practice</p> <p>T2 357-368 Not wanting to focus solely on keyboard writing</p> <p>Obs session 1: already has Claro installed and says has used before – noted need to check his settings and see what he uses it for and how comfortable he is with it</p>	<p>T2 357-368 Not wanting to focus solely on keyboard writing</p> <p>T2 369-382 Can only use computer for reading at present</p> <p>T2 384 Would like to be able to create written material</p> <p>T2 393-406 Would like to listen to text aloud; has ClaroRead installed</p>	<p>T2 325-326 Students with issues (like mine after stroke)</p> <p>T2 335-355 Independent spelling and handwriting practice</p> <p>T2 339-342 Therapy was focused on speaking</p> <p>T3 75-86 Wanted to take part in other research but pacemaker excluded him</p>	
<b>Rohan</b>						
<b>Sarah</b>						
<b>Karen</b>						
<b>Albert</b>						
<b>Dean</b>						
<b>William</b>						
<b>Janet</b>						
<b>Doreen</b>	T2 163- 'I want to go	T2 396-400 Hard not	T2 188-200 Girlfriend	T4 119 iPad these	T2 329-369 Hospital 5	

	<p>back to it' Leisure: biographies, everything! Library, one book a week for pleasure</p> <p>T2 186 Reading rate these days? Shakes head</p> <p>T2 188-200 Girlfriend bought me: can't read aloud, but in my mind!</p> <p>T2 201 Look at the newspaper at the Centre – I'm going to read in the future</p> <p>T4 63-79 Love of writing, 10 on a scale of 0-10, part of identity because of writing statements at work</p> <p>Obs 131 'Other thing I want to be doing with my life is reading. I can't'</p>	<p>being out there in the daily things; I will work again – part-time, work-life balance different now</p> <p>T2 416 Feels pressure of work was partly to blame for stroke</p> <p>T3 85-88 Distressed, never knew I'd have to sign off work, retire at the age I am now</p> <p>T3 89 Life before accident compared to now</p> <p>Obs 142 eventually I'm going to work again</p> <p>Obs 143 Miss it, emotional to me, but future now</p>	<p>bought me: can't read aloud, but in my mind!</p> <p>T2 201 Look at the newspaper at the Centre – I'm going to read in the future</p> <p>T2 209 Tried talking books? No, want to but not getting that at the moment [followed by me explaining Claro]</p> <p>T2 229-237 Bit of writing, 'but that's with myself – sentences, but not successfully'</p> <p>T2 238 I point out she sometimes writes down words to prompt when struggling to find a word</p> <p>T2 426 Intending to go to college to do English – not clear whether Language or Literature</p>	<p>days? Mostly games, for memory, word searches</p> <p>T4 iPad as a diary and organiser</p> <p>T4 158 Planning to buy a laptop, prefers Microsoft to Apple</p>	<p>weeks, therapy one year, but all speaking, no writing or reading</p>	
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			<p>T4 119-137 iPad these days? Mostly games, for memory, word searches</p> <p>T4 141 But I want to spell again</p> <p>T4 iPad as a diary and organiser</p>			
<b>Simon</b>						

### Appendix 8.3: Dragon NaturallySpeaking™ commands prompt sheet

You say:	And then Dragon:
Wake up	Microphone ready to type what you say
Go to sleep	Microphone stops listening
New line	Like pressing the return key
New paragraph	Like pressing the return key twice – misses out one line
Full stop	.
Comma	,
Question mark	?
Exclamation mark	!
Open quotes	“speech”
Close quotes	”speech”
Open paren	(text)
Close paren	(text)
Delete that	Gets rid of the last thing you said, in chunks. Say this more than once if you want to get rid of lots of text. Move your <b>mouse to the end</b> of what you want to delete if it is not the last thing you said
Cap [before the word]	Gives a capital letter to a word in the middle of a sentence
Backspace	Moves cursor back a single space



#### Appendix 8.4: Completed writing samples

Peter wrote the following email to his son, whose response also appears below, independently, in between his fourth and fifth training sessions:

Hello [name], this is your dad writing to you. And this is the way that I've been taught by the University. It is a little while from the father's day and your birthday. I am writing to you by a microphone attached to the computer. The words that I am writing are fingers from my mouth.

I have realised that writing words the way that you can do it is not very good now. So I am going to have the University to use a microphone with the machine. I say the words and the microphone translates them as words that are useful for the computer.

It's not very easy for someone to say words in their mouth that are able to be translated to sentences in the computer. But I think that I shall be a bit better in time.

I have not asked anybody to look at these sentences before, except the PH D student I am working with, and [wife]. So it will be a bit like the sentences that I speak at the moment. But eventually I hope I will be able to write words that I used to have in the past with sentences and structures that are normally written.

I will stop now, because I am going on wittering. And I think that this word is probably okay but I must admit it's very good.

Your happy father.

Hi Dad!

Lovely to hear from you. That was such a nice surprise to hear from you I got a bit emotional! So glad the software is working for you and I'm really so so proud of you for what you're doing. I'll do my best to respond to all the emails you send me. I'm actually at the airport right now in Barcelona. Just arrived for a job here over the next few days, leaving on Saturday. Take care Dad. Love you!!

Peter also wrote to a friend and former colleague independently, in between his fifth and sixth training sessions. In his email he described Dragon NaturallySpeaking™ in colourful terms: 'It gets into your brain like an insect, that doesn't scramble your brain but gets it started.' He rapidly received a warm response: 'This is the most wonderful email I have ever received and rivals my two babies talking for the first time. I am so delighted this is working for you and I accept your invitation to having

lunch together' (Peter, son and former colleague, observation notes training session 6).

Sadly, much of the written work produced by Rohan using Dragon NaturallySpeaking™ was very inaccurate. This is illustrated by his attempt at the CAT written picture description (T3, below), which rendered much of his spoken output nonsensical:

'Manny sleeping and ill get this down to the Dumfries from the dark underserved is falling down and undergo as one employee being with this diary dinners at Oregon see clear money many supreme very period and this 3 feet on the table available is what his glasses empty failures from his thinking is drinking then went to break them to sleep tonight's the authority here over the'

In her third training session, Sarah wrote an account of a recent evening out:

We went on Saturday to see Kevin Spacey. We went to the 6 o'clock performance and then went out to eat. We were in great seats and it was in the round. Kevin Stacey was the only person that was in it. It was in an office and it was a lawyer's office. It was a long play and so was an interval as well. Then we went to eat at a place along the road. It was a Turkish restaurant which was very good indeed. Then we came home.

As reported, Karen did not wish to create any novel or spontaneous compositions during her training sessions, preferring to use ClaroRead™ to listen to access coursework documents provided by her tutors and then making notes with the keyboard. However, she did test Dragon NaturallySpeaking™ by reading aloud from one of the manuals provided by her tutors, and her dictation was reproduced entirely accurately.

Albert wrote the following anecdote about a disastrous workplace experience, during his fifth training session:

When [bank 1] merged with [bank 2] they decided to have a new advertising campaign and therefore decided to change their advertising agency. As the marketing director I was charged with selecting and then briefing appropriate candidates. I chose three candidates [firm 1], [firm 2] and the current Scottish agency, [firm 3].

I gave them all the same brief and allow them six weeks to prepare the campaign which was going to be presented at one hourly sessions to the new board of [his employer]. My staff and I naturally answered a series of questions that came up from all of them during the preparation period. I particularly told them that this must be a very formal session because it was to the board of [the employer].

Presentation day came and we tossed for a running order which seemed a fair way to start the ball rolling. I left them all in the preparation room and returned to take my place with the board giving a small presentation and formal introduction to the players.

[Firm 3] had drawn first and they made a dull, formal presentation; no response at all came from the board.

[Firm 1] came into the room all wearing tartan jackets; I was truly amazed and quietly furious, but said nothing. They began their presentation by saying that we should recognise the tartan of their jackets being that of the [name] clan, the founders of [bank 1]. At that moment I heard an exclamation from the chairman, Sir [name

surname], perhaps the leader of the highly distinctive “Scottish Mafia”.

He immediately explained that [clan] had founded [bank 3] not the [bank 1]. He immediately called for them to be dismissed from the room and for me to go with him at once to his office; you can just imagine the atmosphere!

I thought my career had come to an end but I went dutifully at the Masters calling to receive what was going to be in my view an absolute bollocking!! Sir [name] was most displeased but I told him that I had given strict instructions for them to behave naturally and certainly not to dress up. To be fair he was most understanding and that his initial reaction was a result of his quick-tempered response to the [clan] quote. However I was given strict instructions to see them off the premises!

[Firm 2], which was an exciting new agency at the time, made a splendid presentation (much to my relief!!!) And all the board applauded. It so happened that this campaign was awarded the highest award that any television ad was given that year.

The moral of this story is you can have a terrible start as long as something comes good by the end.

Dean wrote a letter to the Department for Work and Pensions, describing his concern that his benefits were to be cut, during his third training session:

[address]

4 December 2014

Dear Sir or Mdm,

[case number]

I am writing you to say I am very disappointed with the letter I received about my disability allowance. I am very concerned about the letter I am concerned that you haven't made their right decision about my disability allowance. I think you may need to look at it again and give me another decision. I think that you need to reassess me and look at my situation before you make this decision. I am finding it very hard to cope with my situation and I need help to live my life as normal as possible, so I'll be very grateful if you could look at my situation and give me what I asked for all what am entitled to.

On the letter you said you have spoken to my GP on the 5/9/2014. But I have spoken to my GP and he has told me he hasn't received any think from the Department for work and pensions.

The letter I have received from you was dated 30<sup>th</sup>, September 2014 . However, I didn't received the letter until 13 November 2014. I have spoken to someone in your office about it and they had told me that my appeal can be extended.

Yours sincerely,

[name surname]

Independently at home, between training sessions four and five, William wrote a witty account of a failed DIY experiment (besides some notes

acknowledging how well he felt the software was functioning on this occasion):

That is a interesting software which has called Dragon.

It's a speech recognize software is fun. Sometimes.

It's a test and to see the software is working.

It's brilliant today, is amazing. I *don't* know why but the software suddenly working well.

## Plumber tale

I decided to do a bit of plumbing in the kitchen. I bought a tap and loads of washers and a bit of plumbing tape and I bring my old tool box from my shed. I was thinking it was really easy job just for the four new one and that's all.

The first thing was turn water off and there is a small tap under the sink. I found it and turn it off position. Nothing.

I lie. When I was watching the tap, a small leak sprung in a separate pipe. Suddenly a flood water was rushing out from the cupboard on the floor.

I panic.

I hold the tap for a vein idea of stop **to** water. But it didn't work. I was searching the main inlet water. I did I found it in the driveway. While the water STILL rushing OUT on THE KITCHEN floor. Eventually I decide to clean up the mess. Two hours hard work. And I haven't touched plumbing again. Ever.

During training session nine, Janet wrote a letter of complaint to the owners of a café in which she was treated rudely owing to her aphasia:

[name and address]

I would like to complain about the woman who was dismissive with my speech, now unfortunately I've got to stroke and aphasia, to me it's not brilliant but I tried my best, but I was going out and the woman she is said' you are talking double Dutch'

So I was so angry and of course I said Actually I've Got a stroke and aphasia , but the woman said 'ha', I was so angry I went away, but I'm going to bring it to your attention, so that next time she needs to learn remember some people they can't communicate

easily, but should be kind and help them.

I'm a regular customer, but if not I will go and get my coffee elsewhere.

Regards

[name surname]

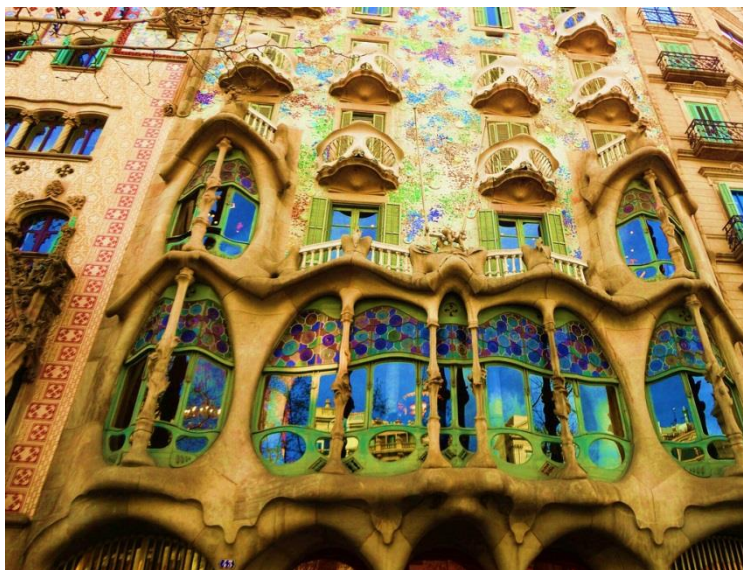
As noted, Doreen found it difficult to translate her ideas into words, and found a blank screen very off-putting. After many challenging training sessions, our solution in session 10 was for me to provide her with photographs and prompts, which functioned to support her dictated descriptions of memories related to them:

## Describing pictures

Building



Paris is a place that of wanted to go for a long time and year



Barcelona is the place that being to 3 times and it said place that I keep going back to the cause of the architecture and

Outdoors





the Grand Canyon is a place of and beauty with am and do experience I have found was overwhelming and all okay and the scale of the was immense and I would go there again because last time I was fine and now I am a stroke victim

Simon opted to produce one long, continuous piece of text, working on it both in his training sessions and independently. By the end of his training it had reached almost 2,000 words in length; an excerpt is given here:

This presentation is for [charity], the Monda on the y morning group.

As everybody knows because, i bought some cakes in, I have just reached by 60 birthday, my wife [name] is also 60 later on this year. I have four children and three grandchildren. My son is [name] and he is married to [name], they have two boys, [name] is five years old aged, [name] is two years old. They live within five minutes of where I live at the moment. My eldest daughter [name], and her daughter [name] live with us at the present time. Our middle daughter [name], she is 23 years old but has special needs, she suffers from selective mutism, this involves not talking to people unless she knows the person involved. But when she's at home and knows everybody she doesn't stop talking and you have to tell her to stop talking because it drives you mad. She is also on the Autistic scale . She goes to work three days a week , she does do other activities activities but she probably could never hold down a full-time job because she needs there with washing and cooking and she can't use the telephone so if there is a problem she

couldn't ring anybody for help. This leaves us with a bit of a problem insomuch, when we die we will have to arrange someone to look after [name]. Our youngest daughter [name] has just finished university and is currently working for camp [name] as a recruitment manager.

As this is a group of mainly male members you can understand that I have so much difficulty living with three daughters when they watch all the rubbish on TV and I am trying to watch the sport on the TV.

This presentation is about what I was doing before the stroke. I was trained as a quantity surveyor and worked for [company]. I went to [name] College which I attended for five years I was just about to take my final year exams when I started the company. I started the company in the April of that year and my exams were due in June and July. Originally I anticipated doing my final exams but the company was going well and it was difficult to motivate myself. I was fully intending to take me exams until the day before. When I look back on it I think it was sad not to take the exams but fortunately the company took off and I was able to continue to work in the company until I had the stroke 30 years on.