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Title	Perspectives on ICT-delivered aphasia rehabilitation: exploring feasibility, usability and acceptance of this mode of rehabilitation
Authors	Kearns, Áine
Publication date	2019-10-03
Original Citation	Kearns, Á. 2019. Perspectives on ICT-delivered aphasia rehabilitation: exploring feasibility, usability and acceptance of this mode of rehabilitation. PhD Thesis, University College Cork.
Type of publication	Doctoral thesis
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Perspectives on ICT-delivered Aphasia Rehabilitation: Exploring Feasibility, Usability and Acceptance of this mode of Rehabilitation

Volume 1 of 2

Thesis presented by

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For the degree of

Doctor of Philosophy

University College Cork

School of Clinical Therapies

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October 2019

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Declaration

I declare that this thesis has not been submitted as an exercise for a degree at this or any other University. The work upon which this thesis is based was carried out in collaboration with a team of supervisors who are duly acknowledged in the text of the thesis. The Library may lend or copy this thesis upon request.

Signed:_____ Date: October 2019

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Acknowledgements

Thank you to everyone who supported me to complete this piece of work.

I extend my sincerest thanks to the people with aphasia and the speech and language therapists who took part in this research. This body of work would not have been possible without their contributions.

Thank you to my supervision team Dr. Helen Kelly and Dr. Ian Pitt for their support and advice along this journey.

I am very grateful to the Health Research Board for awarding me a Research Training Fellowship for Health Professionals. This provided me with the opportunity to fully immerse myself in this research experience. Through this process I gained a mentor, Prof Faustina Hwang and I am very appreciative of her guidance along the way.

Thank you to the Speech and Language Therapy Departments in Limerick & North Tipperary, Clare and Cork and to Headway Brain Injury and Support Services in Limerick and Cork.

I was very fortunate to have support from my colleagues in the University of Limerick when I set out on this PhD process. I am particularly grateful to Dr Rose Galvin, Dr Kieran O'Sullivan and Prof Alison Perry.

I've learned that a PhD journey can be a lonely road at times and I am so grateful to have wonderful PhD friends in Claire O'Donnell, Dominika Lisiecka and Aoife Gallagher. Thank you for being at the end of the phone whenever needed.

Finally, thank you to my family, in particular to Eilish and Sean, my fantastic parents who always support me and have faith in my abilities. And to PJ my rock! Thank you for your love, support and kindness along this windy road with "square lefts, don't cut and mind the pothole". You're the best co-pilot on any journey.

List of Acronyms

Acronym	Description
AAQoL	Aphasia Accessible Quality of Life Assessment
AOI	Area of Interest
BNT	Boston Naming Test
CAT	Comprehensive Aphasia Test
CREATE	Center for Research and Education on Aging and Technology Enhancement
CREC	Clinical Research Ethics Committee
e-ACT	Eye Tracker Auditory Comprehension Test
MCA	Middle Cerebral Artery
MMAT	Mixed Methods Appraisal Tool
MoCA	Montreal Cognitive Assessment
ORLA	Oral Reading for Language in Aphasia
PALPA	Psycholinguistic Assessments of Language Processing in Aphasia
PC	Personal Computer
PICA	Porch Index of Communicative Ability
PICOS	Participant, Intervention, Comparison, Outcome, and Study Design
PPI	Public and Patient Involvement
PwA	Person with Aphasia
RBANS	Repeatable Battery for the Assessment of Neurological Status
SAQOL-39	Stroke and Aphasia Quality of Life Scale - 39
SLT	Speech and Language Therapist
TAM	Technology Acceptance Model
TROG	Test for Reception of Grammar
TUF	Treatment of Underlying Forms
WAB	Western Aphasia Battery
WHO	World Health Organisation
UTAUT	Unified Theory of Acceptance and Use of Technology

Thesis Abstract

Background: Speech and language therapy can provide positive outcomes for people with aphasia after stroke. The intensity of therapy is a key component for successful rehabilitation outcomes but, due to resource constraints, it can be a challenge for services to provide intensive face-to-face rehabilitation. The availability of information and communication technologies (ICT) and software rehabilitation programmes offer the opportunity for intensive self-managed aphasia rehabilitation. However, it is important to establish the feasibility and acceptance of this mode of rehabilitation among those who are involved in aphasia rehabilitation; the person with aphasia (PwA) and the speech and language therapists (SLTs) who work with them.

Research Aims: This thesis provides a unique perspective on the acceptance and usage of ICT-delivered aphasia rehabilitation for post-stroke aphasia. It aims to 1) investigate the feasibility of self-administered intensive ICT-delivered aphasia rehabilitation targeting auditory sentence comprehension deficits 2) explore the experiences and perspectives of people with aphasia engaging in this form of rehabilitation and 3) explore the perspectives of SLTs on the use of ICT in aphasia rehabilitation

Methods: The research in this thesis employs a mixed methods research design including: 1) participatory health research techniques in order to develop a user-designed aphasia-accessible feedback questionnaire on ICT usability and functionality 2) a mixed methods feasibility study to examine the outcomes, acceptance and usability of ICT-delivered aphasia rehabilitation targeting auditory comprehension at sentence level and 3) a descriptive qualitative study to explore speech and language therapists' views of ICT-delivered aphasia rehabilitation.

Results: The co-design process highlighted that people with aphasia can, and should, be included in all stages of the research process and especially in the development and design of evaluation measures for use by people with aphasia. The findings of the feasibility study suggest that an ICT-delivered therapeutic programme underpinned by a general approach to auditory comprehension does not result in significant treatment effects outside of assessments that reproduce the therapy task approach. ICT-delivered aphasia rehabilitation may be acceptable to some people with aphasia and has a role within rehabilitation. However, face-to-face contact remains a valued aspect of aphasia rehabilitation for both people with aphasia and SLTs. Attention must be given to the facilitating conditions required to support the PwA and the SLTs to enable this mode of intervention.

Conclusion: This research is timely, with the rapid growth in available technologies and increasing demands for services among an ageing population. The users' perspectives, both the PwA and the SLTs working with them, must not be overlooked when considering the impact of this mode of rehabilitation. This research identifies the factors that influence acceptance and usage of ICT-delivered aphasia rehabilitation within an Irish context.

Dissemination of Findings from Thesis

Peer-Reviewed Publications:

The following articles from the thesis have been accepted for online publication:

Kearns, Á., Kelly, H., & Pitt, I. (2019). Self-reported Feedback in ICT-delivered Aphasia Rehabilitation: a Literature Review. *Disability and Rehabilitation*, (accepted manuscript). https://doi.org/10.1080/09638288.2019.1655803

- Available in Appendix 1 and reported in Chapter Four

Kearns, Á., Kelly, H., & Pitt, I. (2019). Rating experience of ICT-delivered aphasia rehabilitation: co-design of a feedback questionnaire. *Aphasiology*, 1-24. https://doi.org/10.1080/02687038.2019.1649913

- Available in Appendix 2 and reported in Chapter Five

Conference Presentations:

The following is a list of conference presentations that were completed as part of this thesis:

Kearns, A., Kelly, H., & Pitt. I. (2019). Self-administered aphasia rehabilitation targeting auditory comprehension: a feasibility study, *Oral Presentation at the Royal College of Speech and Language Therapists Conference,* Nottingham, September, 2019.

Kearns, A., Kelly, H., & Pitt. I. (2019). Self-administered aphasia rehabilitation targeting auditory comprehension: a feasibility study, *Oral Presentation at the British Aphasiology Society Research Update Meeting,* Reading, June, 2019.

Kearns, Á., Kelly, H., & Pitt. I. (2019). Self-administered aphasia rehabilitation targeting auditory comprehension: a feasibility study, *Oral Presentation at the Irish Association of Speech and Language Therapists Conference,* Dublin, April, 2019.

Kearns, Á., Kelly, H., & Hanafin, R. (2019). Speech and Language Therapists' perspectives of ICT use in Aphasia Rehabilitation, *Poster Presentation at the Irish Association of Speech and Language Therapists Conference,* Dublin, April, 2019.

Kearns, A., Kelly, H., & Pitt, I. (2018). Co-design of a Feedback Questionnaire for ICT-delivered Aphasia Rehabilitation*, Poster Presentation at the International ACM SIGACCESS Conference on Computers and Accessibility,* Galway, October 2018. https://doi.org/10.1145/3234695.3241027

Kearns, A., Pitt, I., Kelly, H., & O'Byrne, D. (2018). Development of an ICT-delivered Control Programme for use in Aphasia Crossover Intervention Study, *Poster Presentation at the International ACM SIGACCESS Conference on Computers and Accessibility,* Galway, October 2018. https://doi.org/10.1145/3234695.3241026

Kearns, A., Kelly, H., & Pitt, I. (2018). Self-administered aphasia rehabilitation targeting auditory comprehension; exploring feasibility and acceptance of ICT delivered rehabilitation, *Poster Presentation at the International Aphasia Rehabilitation Conference,* Aviero, September 2018. http://dx.doi.org/10.1080/02687038.2018.1486371

Kearns, A., Kelly, H., & Hanafin, R. (2018). Speech and Language Therapists' perspectives of ICT use in Aphasia Rehabilitation, *Poster Presentation at the International Aphasia Rehabilitation Conference*, Aviero, September 2018. http://dx.doi.org/10.1080/02687038.2018.1485841

Kearns, A., Kelly, H., & Pitt, I. (2017). Experience of Public Patient Involvement in Aphasia Research; co-design of an ICT user feedback questionnaire, *Oral Presentation at the Royal College of Speech and Language Therapists Conference*, Glasgow, September 2017.

Kearns, A., Kelly, H., & Hanafin, R. (2017). Speech and Language Therapists' perspectives of ICT use in Aphasia Rehabilitation, *Poster Presentation at the Royal College of Speech and Language Therapists Conference,* Glasgow, September 2017.

Kearns, Á., Kelly, H., & Pitt, I. (2017) Experience of Public Patient Involvement in Aphasia Research; co-design of an ICT user feedback questionnaire, *Oral Presentation at the Irish Association of Speech and Language Therapists Conference*, Dublin, May 2017.

Kearns, A., Kelly, H., & Pitt, I. (2016). Usability of ICT in Aphasia Rehabilitation; a systematic review, *Poster Presentation at the 30th World Congress of the International Association of Logopedics and Phoniatrics*, Dublin, August 2016.

Kearns, A., Kelly, H., & Pitt, I. (2016). Co-design of an ICT user experience feedback tool with people with aphasia, *Poster Presentation at the 30th World Congress of the International Association of Logopedics and Phoniatrics*, Dublin, August 2016.

Clinical Experience influencing Research

In Chapter One of this thesis, I will present the background research that prompted me to consider conducting research into the use and acceptance of Information and Communication Technologies (ICT) in aphasia rehabilitation. However, that is only one part of the motivation for completing this research. After qualifying as a speech and language therapist (SLT) in 2001, I started out in the profession working with a broad mixed caseload that included the provision of paediatric community services, school-based services within a special education setting and managing a large caseload in a public nursing home that also accommodated a small rehabilitation unit. Like many other SLTs working in the Irish health system at the time, I shared an office with other SLTs and had limited access to a computer. As a department, we had invested in therapeutic software; this was accessible on a single computer in the shared office. I spent most of my time in off-site clinics, the adults on my caseload with post-stroke communication impairments were inpatients in the rehabilitation unit of the public nursing home. So, I was somewhat disappointed and frustrated that the computer wasn't available for use with the people I was working with. Fast forward to new working conditions a few years later in a busy general hospital and I grabbed at the opportunity for further professional development. Completing an MSc. programme provided me with the chance to use computer technology with adults with aphasia. It was basic to start with and began with a collaboration with an enthusiastic gentleman, who had brought his laptop into the ward to help his communication skills. I developed a range of language tasks in PowerPoint to provide activities that he could complete when I couldn't visit him due to the heavy referrals and dysphagia caseload. This cemented my interest in ICT-delivered aphasia rehabilitation and started me down a

road of wondering who would accept this mode of intervention and would it be in conjunction with or as an alternative to face-to-face therapy. The advent of tablet technologies, the subsequent availability of low-cost devices and the proliferation of programmes prompted me to question this further. ICT appears to provide new opportunities for aphasia rehabilitation e.g. supplemental rehabilitation activities, readily available tasks or personalised therapy, remote monitoring of progress, and the potential for self-managed rehabilitation. However, my experience visiting clinics and speaking to SLTs made me realise that this mode of intervention is slow to gain momentum as a part of the speech and language therapy service provision in an Irish context. This prompted me to start this research with the broad aim to understand the stakeholders' perspectives of ICT-delivered aphasia rehabilitation, those stakeholders being people with aphasia and SLTs.

Chapter One

Chapter One – Introduction to Thesis

1.1 Introduction to Chapter

This chapter will provide the background information, to set the scene, for the research being presented in this thesis. In order to provide context to this research, the chapter will describe the issue of stroke in Ireland and internationally (1.2). It will consider the impact of post-stroke aphasia and the evidence with respect to speech and language therapy and aphasia (1.3). This chapter will also introduce the concept of use and acceptance of information and communication technology (ICT) in aphasia rehabilitation (1.4, 1.6 & 1.7). An introduction to collaborative research with people with aphasia (1.5) and eye tracking methods (1.8) used in this research will be described. The research aims will be presented (1.9), followed by an introduction to the chapters within this thesis (1.10). Finally, the philosophy and application of mixed methods employed in this research will be described (1.11).

1.2 Stroke and Aphasia

Stroke is a leading cause of death and disability worldwide and direct expenditure on stroke accounted for 2-4% of total health expenditure in Ireland in 2007 (Smith et al., 2011). Approximately 7,000 people in Ireland are hospitalised with a stroke-related event each year (McElwaine, McCormack, & Harbison, 2016). Although stroke mortality rates have decreased worldwide over the past two decades, the absolute numbers of people who have a stroke each year continue to grow and the subsequent burden of stroke is increasing (Feigin et al., 2014). The World Health Organisation identified that although the incidence of stroke is declining in many developed countries, the total number of people living with disabilities

following stroke continues to increase because of ageing populations. This trend is visible in Ireland where the rate of premature mortality associated with circulatory system diseases is noted to be decreasing due to prevention and treatment (McElwaine, et al., 2016). This reduction is welcome but it is important to note that more people are living with long term illness/disability; three-quarters of people over 75 years of age present with at least one chronic condition (DOH, 2013). An increase in the Irish population is expected to also see an increase in prevalence due to demographic change with an expected increase in the proportion of the population over 65 years of age from 11% to 15 % by 2021 (Smith et al., 2013). 70% of stroke patients in Ireland are over 65 years of age and this demographic change is expected to result in a subsequent increase in burden and healthcare costs.

Aphasia refers to an acquired loss or impairment of the language system which can impact on a person's ability to communicate effectively through spoken or written modalities. Code and Petheram (2011) highlight the challenge in measuring the size of the problem of aphasia. Many studies that report incidence and prevalence of stroke and aphasia have used different criteria and methodologies to define the presence of aphasia. There are no available figures relating to aphasia population, incidence and prevalence in Ireland. International studies have reported an incidence of aphasia after first ever ischemic stroke at 30% in Switzerland (Engelter et al., 2006), 30% in Canada (Dickey et al., 2010; Flowers, Silver, Fang, Rochon, & Martino, 2013) and 27% in England (Graham, Crichton, Koutroumanidis, Wolfe, & Rudd, 2013). Flowers et al. (2016) undertook a systematic review and meta-analysis of post-stroke aphasia frequency, recovery and outcomes. The findings indicated that aphasia occurred in almost one third of patients with mixed

(haemorrhagic and ischemic) or ischemic stroke. The risk of aphasia increases with age (Dickey, et al., 2010; Engelter, et al., 2006).

Reference to speechlessness and what we now know as aphasia can be found in the Edwin Smith Papyrus (a medical text from ancient Egypt) (Code, 2013). However, the science of aphasiology and the serious study of aphasia can be considered to have been born in the 19th century, at which time, Paul Broca's description of a patient with a speech production disorder and Carl Wernicke's explanation of sensory aphasia and language processing laid the foundations for the study of aphasiology and the development of language processing models (Code, 2013). Neoclassicism, with a focus on language localisation, dominated the study of aphasiology from the 1960s until the 1980s. Its main function was the classification of aphasia into (neo)classical types on the basis of functional profiles that emerge from language and cognitive testing and the localisation of damage in the brain on the basis of these classifications. The ability to localise damage in this manner was unreliable and the advent of brain imaging has superseded this method, however, neoclassicism continues to influence the study of aphasiology (Code, 2013). Aphasia test batteries such as the Western Aphasia Battery (Kertesz, 2007) and the Boston Diagnostic Aphasia Examination (Goodglass, Kaplan, & Barresi, 2001) assess linguistic skills including language comprehension, fluency of speech, naming ability and repetition skills. Combining these results provides a classification based on aphasia type according to neoclassicism syndromes as well as a rating of the severity of the condition. It is important to record the severity of the condition as initial aphasia severity is a predictive factor in long-term aphasia recovery (Plowman, Hentz, & Ellis, 2012).

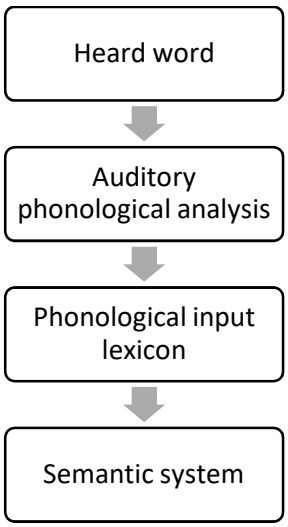
Aphasia can impact on well-being and the ability to engage in everyday social activities, which can lead to marginalisation and issues with respect to social inclusion (Mc Menamin, Tierney, & Mac Farlane, 2015; McVicker, Parr, Pound, & Duchan, 2009). Stroke survivors with aphasia are less likely to return to work when compared with those without aphasia (Graham, Pereira, & Teasell, 2011). A systematic review of important factors in health-related quality of life for people with aphasia reported that the frequency of depression is higher among people with aphasia when compared to stroke survivors without aphasia and noted that social support is an important theme for people with aphasia (Hilari, Needle, & Harrison, 2012).

1.3 Aphasia Rehabilitation

The International Classification of Functioning, Disability and Health (ICF) is a useful and widely accepted framework for aphasia rehabilitation (Worrall, Papathanasiou, & Sherratt, 2013). This framework considers the functioning or disability of the person and the contextual factors that can affect the person. People with aphasia are not a homogenous group and the ICF can provide a framework that considers not only the individual language impairment within rehabilitation planning, but the factors that are specific to the person, such as their everyday activities, interests and their environment. Worrall, et al. (2013) describe how there are many approaches to aphasia therapy. These can include, but are not limited to, intensive stimulation of the disrupted language processes (stimulation approach, e.g. intensive auditory stimulation), explicit teaching of language processing knowledge (cognitive neuropsychological, e.g. naming facilitation techniques) and training of compensational strategies for the person with aphasia or their conversation partner (functional, e.g. script training) (Worrall, et al., 2013). A person presenting with an

auditory comprehension impairment post stroke who has difficulty processing auditory information may have difficulties understanding spoken words and sentences. Therapy for auditory processing deficits can be informed by models of auditory comprehension and the most common model in the literature is based on Morton's logogen model (Morris and Franklin, 2012). See Figure 1.1.

Figure 1.1. A Model of Auditory Comprehension (Morris and Franklin, 2012, p114)



This model outlines three levels of auditory comprehension processing after hearing a spoken word; an auditory/speech level, a lexical level and a semantic level. Therapy approaches for auditory comprehension deficits can target reactivation. This aims to improve the impaired process and is carried out following an in-depth assessment to determine the level of breakdown within the model of auditory processing. An alternative therapeutic approach to reactivation is the provision of compensatory strategies for the person with aphasia (PwA) and their conversation partner to improve communication and comprehension. Morris and Franklin (2012) also highlight that a general approach can be used in auditory comprehension therapy. This approach is not informed by the levels of deficit within the language processing model, instead, therapy involves working through different types of

sentence structures with increasing comprehension difficulty (Morris and Franklin, 2012).

A Cochrane Review on Speech and Language Therapy for Aphasia following Stroke reported that individuals with aphasia demonstrate positive outcomes following rehabilitation with intensity being an important component of a successful intervention programme (Brady, Kelly, Godwin, Enderby, & Campbell, 2016). This presents a challenge to service providers striving to deliver an equitable and efficacious service to a growing number of individuals with long-term disabilities. An increase in the proportion of dysphagia (swallowing problems) referrals (Enderby and Petheram, 2002) combined with a perceived prioritisation of new referrals and dysphagia clients (Foster, O'Halloran, Rose, & Worrall, 2016) can result in resources being diverted from communication rehabilitation towards dysphagia management and those with acquired communication disorders may not receive adequate levels of treatment. The use of technology in aphasia rehabilitation has been promoted as an efficient route for the delivery of intensive speech and language therapy (Code and Petheram, 2011). Recent systematic reviews suggest that computer therapy is effective when compared to no therapy and may be as effective as clinician-delivered therapy for specific conditions (Brady, et al., 2016; Zheng, Lynch, & Taylor, 2016). However, both reviews indicate that the current quality of evidence is low due to the small number of studies available and highlight the need for further research.

1.4 ICT as an Option for Aphasia Rehabilitation

The proliferation of ICT hardware such as smartphones, tablets and portable laptops has resulted in increased ownership of devices among the general population. The Central Statistics Office report on Information Society Statistics – Households

(2017) estimate that 89% of households in Ireland have access to the internet and 57% of those surveyed reported they used the internet to search health-related information (CSO, 2018). Speech and language therapy has utilised information and communication technologies (ICT) in the management of acquired communication disorders such as post-stroke aphasia since the 1980s (Burton, Burton, & Lucas, 1988; Larson and Steiner, 1985). Telerehabilitation is defined as the "*delivery of rehabilitation services via information and communication technologies*" by the American Telemedicine Association (Brennan et al., 2011). Cherney and van Vuuren (2012) describe telerehabilitation as a continuum from working synchronously with a therapist online in real-time, to working with a virtual therapist asynchronously in off-line tasks. In addition to telerehabilitation with real or virtual therapists, the use of ICT for self-management of chronic conditions has been identified as an option for management of chronic conditions including stroke (HSE, 2017).

There is emerging evidence for the effectiveness of self-administered rehabilitation targeting, in particular, expressive language skills including: word finding difficulties (Lavoie, Macoir, & Bier, 2017; Palmer et al., 2012), apraxia of speech (Varley et al., 2016) and content unit production and rate of speech (Stark and Warburton, 2018). However, as reported by Zheng, et al. (2016) the current evidence base, although increasing, remains limited and further research is required to demonstrate clinical efficacy and cost-effectiveness. Such research would also benefit from consideration of patients' views of self-managed intervention in particular to understand patients' acceptance of complex interventions (Craig et al., 2006). The views of people with aphasia were first explored in a qualitative study by Wade, Mortley, & Enderby (2003) who investigated participants' perspectives of

ICT-delivered aphasia rehabilitation targeting word finding difficulties. Subsequent research has also examined the perspectives of people with aphasia within efficacy and feasibility studies investigating self-administered aphasia rehabilitation (Choi, Park, & Paik, 2016; Marshall et al., 2013; Palmer, Enderby, & Paterson, 2013). Research exploring participants' perspectives of self-administered aphasia rehabilitation using ICT have predominantly utilised semi-structured interviews (Marshall, et al., 2013; Palmer, et al., 2013; Wade, et al., 2003) and questionnaires developed for the research study which use Likert scales and visual analogue scales (Choi, et al., 2016; Routhier, Bier, & Macoir, 2016). Wade, et al. (2003) identified that qualitative methodologies can be employed to help identify variables that can be further investigated using quantitative methods. Despite an increase in research exploring this phenomenon, an aphasia-accessible feedback questionnaire to facilitate self-reporting of the person's experience engaging in ICT-delivered aphasia rehabilitation has not yet been developed for use in planning and evaluating ICT-delivered aphasia rehabilitation. The research in this thesis plans to develop such a measure in collaboration with people with aphasia.

1.5 Collaborating with People with Aphasia in the Research Process

Public and Patient Involvement (PPI) in research incorporates meaningful engagement and active collaboration such that research is carried out by people with an understanding of the issue at the focus of the research itself (INVOLVE, 2012). Participatory research is not new in aphasia and has been used to explore participants' experiences of aphasia and a conversation partner programme (Mc Menamin, et al., 2015). Participatory design has emerged in the development of software intended for use by people with aphasia, in which people with aphasia act as design consultants and are involved at all stages of the co-design process for

computer-based therapeutic programmes (Wilson et al., 2015). Actively and meaningfully engaging people with aphasia in the process of designing a feedback questionnaire will result in a more relevant and meaningful questionnaire to provide feedback on ICT-delivered aphasia rehabilitation. This research approach seeks to recognize the value of the individual's contribution to the co-construction of knowledge, within a process that is carried out in a collaborative, practical manner which empowers the individuals involved in the study (ICPHR, 2013).

1.6 Perspectives of Speech and Language Therapists on ICT-delivered Aphasia Rehabilitation

It is undoubtedly important to understand the factors that may influence satisfaction with health care provision for people with aphasia (Tomkins, Siyambalapitiya, & Worrall, 2013). It is also important to understand other stakeholders' views of ICT-delivered aphasia rehabilitation in particular the clinicians who provide speech and language therapy. Little is known about the perspectives of speech and language therapists (SLTs) on the use of ICT in aphasia rehabilitation. Davis and Copeland (2006) surveyed a cohort of SLTs registered with the American Speech and Hearing Association (n=107) and found that 51.4% used computers in aphasia management sessions. Almost 95% of respondents used computers to supplement direct therapy, by means of home programmes, independent computer time and paraprofessional support. Technological hardware and therapeutic software have advanced since then. However, Chen and Bode (2011) more recently explored the factors that influence health professionals' decision to use novel technologies in post-stroke rehabilitation in the United States of America surveying SLTs, Occupational Therapists and Physiotherapists. The findings suggest time and costs are key factors in decision making but the authors

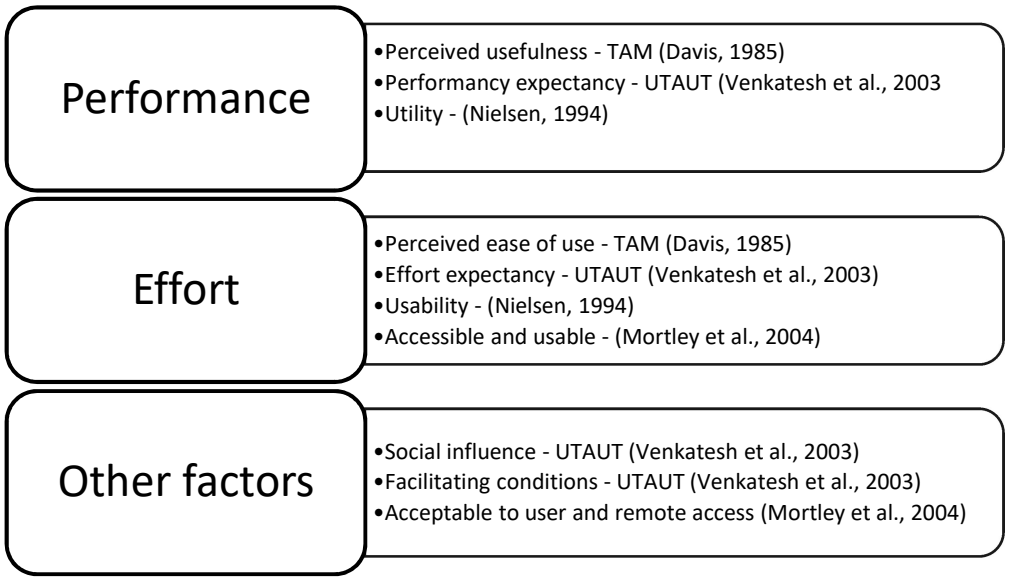
noted differences between professional groups. SLTs were less likely to consider the costs involved than their allied health colleagues. However, the authors suggest that this may reflect the nature of the difference in actual costs for equipment among professions. While patient acceptance and family support were rated as very important among all professional groups, significantly more SLTs rated functional level and family support as *very* important factors when deciding on the use of novel technologies in stroke rehabilitation (Chen and Bode, 2011).

1.7 Use and Acceptance of Technologies for Healthcare Provision

Health technology use and research exploring the use and acceptance of health technologies are gaining momentum within healthcare. Researchers have utilised technology acceptance models, derived from the field of Information Systems, in an effort to understand usage and non-usage of modern assistive technologies in health care (Holden and Karsh, 2010; Peek et al., 2014). Peek, et al. (2014) identify that two models have dominated technology acceptance research in this field: the Technology Acceptance Model (TAM) (Davis, 1985) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003). The UTAUT was developed following a review of eight models including the TAM and has been empirically validated (Venkatesh, et al., 2003) and has also been employed in health technology research exploring telerehabilitation in chronic conditions (Cranen et al., 2012). This model provides a useful framework for examining the potential for successful technology acceptance and usage. The UTAUT model describes four key predictors of ICT acceptance and use; performance expectancy, effort expectancy, social influence and facilitating condition (discussed in detail in Chapter Two). These are moderated by four constructs; gender, age, experience and voluntary control (Venkatesh, et al., 2003).

In the discussion of their findings on the evaluation of ICT-delivered therapy for word-retrieval in aphasia, Mortley, Wade, & Enderby (2004) stressed the importance of four key elements of a system for delivering remote aphasia therapy. Such a system should be "*accessible, usable and acceptable to people with aphasia"* and should provide *"remote access"* to the therapist in order to monitor progress and performance and modify therapy accordingly (Mortley, et al., 2004, p. 207). This system must also be effective in treating the targeted language impairment and should be efficient with respect to the proportion of therapist time required compared with the amount of therapy practice time achieved. This draws similarities with the concepts highlighted within the UTAUT model in terms of access, usability and acceptability of an ICT-delivered therapy system (which are associated with effort expectancy) and the associated gains of remote access (related to performance expectancy). This further supports the incorporation of a model of technology acceptance and usage within research exploring ICT-delivered aphasia rehabilitation.

Figure 1.2. Summary of Key Concepts in ICT Usage and Acceptance Research



In addition to the models of technology acceptance, it is possible to draw on other fields of research when considering the acceptance of technology or of a new

system. Nielsen (1994) offers a model of system acceptability which identifies that both social and practical acceptability issues influence overall acceptance of a system (Nielsen, 1994, p. 24). ICT-delivered aphasia rehabilitation is an example of such a system. There are many factors that influence practical acceptability including: cost, reliability, compatibility of devices and operating systems, as well as the usefulness of the system. The usefulness of the system can be further influenced by its *utility* (how it provides the required features for use) and its *usability* (how easy and pleasant it is to use). Usability has multi-dimensional properties and includes five key components: learnability (easy to learn and work through), efficiency (easy to use and good productivity), memorability (easy to remember how to use the system), errors (low error rate and when errors do occur should be easily recoverable) and satisfaction (subjectively pleasant to use) (ISO, 2018). These concepts are echoed by Mortley, et al. (2004) who proposed that a system used to deliver remote aphasia therapy should be "*accessible, usable, and acceptable to people with aphasia*" (Mortley, et al., 2004, p. 207). (See Figure 1.2 for a summary of the key concepts and related terminology for technology acceptance and use).

1.8 Eye Tracking Methodologies

The use of eye tracking as a means to explore product usability has been traced back to the 1950s (Jacob and Karn, 2003) but the nature, cost and accuracy of technologies, as well as the difficulty of data analysis, limited its use until recent times. Advances in technology mean that cheaper, faster, more accurate and easier to use eye trackers are now available, with software that can analyse information more accurately and efficiently (Duchowski, 2007). Eye-tracking technology has been used to examine visual attention in simulated activities (Strayer, Drews, & Johnston, 2003), user engagement in online health interventions (Alley et al., 2014; Wolpin et

al., 2015), reading strategies and remediation (Ablinger, Huber, & Radach, 2014; Radach and Kennedy, 2013), medical examination skills (Krupinski et al., 2006) and language processing in aphasia (Dickey and Thompson, 2009; Meyer, Mack, & Thompson, 2012). Eye tracking has also been used in studies to explore auditory language comprehension in people with aphasia compared to those without aphasia (Dickey and Thompson, 2009; Laurinavichyute, Ulicheva, Ivanova, Kuptsova, & Dragoy, 2014) and is emerging in research examining change in online sentence processing before and after rehabilitation (Mack and Thompson, 2017). Chapter 7 (7.2.1) will provide an overview of the available evidence on visual search strategies employed during online sentence processing. When compared to typical adults, participants with aphasia present with slower reaction times while processing online information in sentence comprehension tasks (Meyer, et al., 2012; Schumacher, et al., 2015) and do not employ an online agent first processing strategy (Mack, Wei, Gutierrez, & Thompson, 2016; Meyer, et al., 2012; Schumacher, et al., 2015). This contrasts with unimpaired adults who employ an agent-first processing bias. Agent-first processing bias is a tendency to initially fixate on the image in which the subject noun is the agent unless there are following morphological cues to suggest a passive sentence structure (Meyer, et al., 2012). Left-right sentence interpretation has also been described as a search strategy in sentence processing studies and participants with aphasia have been noted to present with a prolongation in the tendency to fixate on the left-most picture early in a sentence (Mack and Thompson, 2017). Additionally, Mack, et al. (2016) reported typical adults make more target fixations in the postverbal noun phrase/prepositional phase when compared to the aphasia group. Research exploring the use of eye-tracking methodologies to examine the impact of aphasia rehabilitation on language processing and user engagement

remains an emerging field within aphasia studies. This thesis will examine eye tracking data, gathered in conjunction with language outcome measures in order to determine if visual search patterns change following an ICT-delivered aphasia rehabilitation programme.

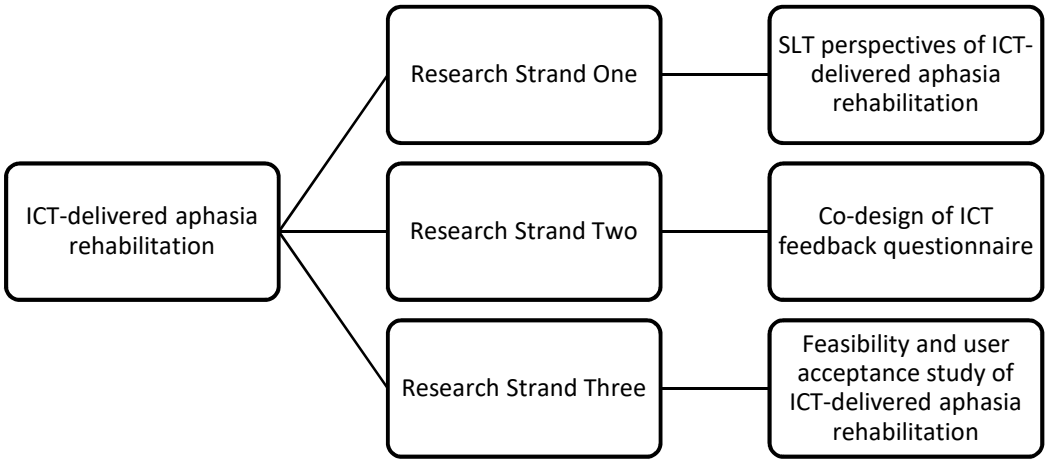
1.9 Research Aims

The research completed as part of this PhD seeks to examine ICT-delivered aphasia rehabilitation in terms of the therapeutic outcomes of this mode of rehabilitation and the perspectives of stakeholders involved in it (people with aphasia and SLTs). There are three strands to this research as presented in Figure 1.3.

These three research strands address three individual but related research aims that are presented below:

1) Explore the perspectives of SLTs on their use of ICT in aphasia rehabilitation
2) Develop a questionnaire to in collaboration with people with aphasia to facilitate self-reported feedback from people with aphasia on their experience of ICT-delivered aphasia rehabilitation
3) Investigate the feasibility of self-administered aphasia rehabilitation targeting auditory sentence comprehension deficits, exploring outcomes, usability and engagement. This study will also investigate the changes in visual search strategies following ICT delivered intervention. This eye gaze data will be recorded during online auditory comprehension tasks using a computer and eye tracker monitor.

Figure 1.3. Three Research Strands in this Thesis



The initial two years of the PhD were carried out while the PhD candidate was registered part-time and self-funded. She applied for funding in 2015 and was awarded a Health Professionals Training Fellowship from the Health Research Board in 2016. She commenced this fellowship in January 2017 and this funding directed the finalise aims of the PhD. The funding was provided to complete three research objectives; 1) development a user feedback tool using co-design techniques with people with aphasia in a participatory health research project, 2) explore perspectives on usability of computers for self-administered aphasia rehabilitation and 3) investigate the efficacy of computer technology as a mode of service delivery for self-administered aphasia rehabilitation. These are reflected in the three Research Strands of this PhD.

1.10 Description of Research Aims

Research Strand One provides an integrative literature review (Whittemore and Knafl, 2005) of SLTs' perspectives of ICT-delivered aphasia rehabilitation. This review is presented in Chapter Two and highlights the issues emerging for clinicians who are using or planning to use ICT in rehabilitation and indicates a

general paucity of good quality research on this topic area. Chapter Three describes a qualitative study exploring SLTs' perspectives of ICT-delivered aphasia rehabilitation. This study employed focus group methods and thematic analysis in order to provide an in-depth exploration of the topic.

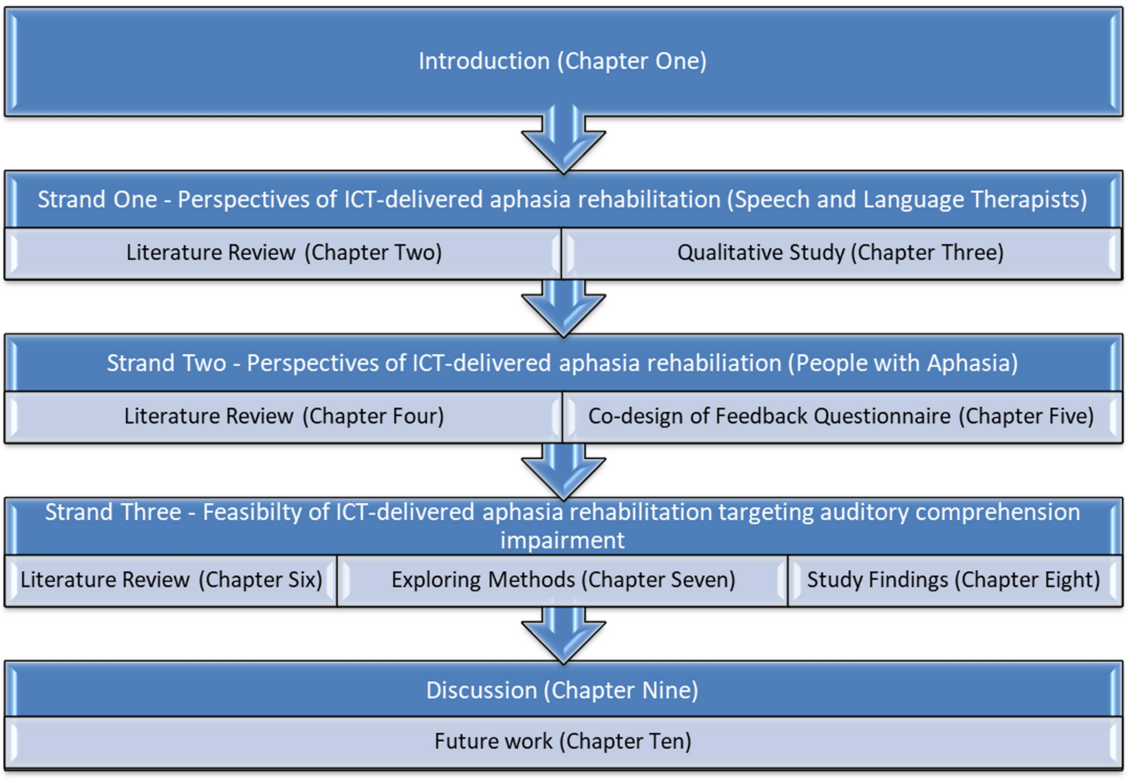
Research Strands Two seeks to investigate appropriate methods to record the experiences and perspectives of people with aphasia when engaging in ICT-delivered aphasia rehabilitation. A literature review (Grant and Booth, 2009) with restricted systematic review principles (Pluddemann, Aronson, Onakpoya, Heneghan, & Mahtani, 2018) was carried out and the review is reported in Chapter Four. The findings highlighted that there was no consensus measure being used within the research studies to facilitate the recording of self-reported feedback by participants with aphasia engaging in ICT-delivered aphasia rehabilitation. These findings prompted the PPI research described in Chapter Five. This co-design research involved the collaborative development of an ICT Feedback Questionnaire created *with* people with aphasia for use *by* people with aphasia.

Finally, Research Strand Three explores the feasibility of an ICT-delivered aphasia rehabilitation programme targeting auditory comprehension impairment at sentence level, investigating the therapeutic outcomes, programme usability and engagement with the mode of intervention. A literature review which employed restricted systematic review principles (Pluddemann, et al., 2018) was carried out to examine the current available evidence on ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments. This review is described in Chapter Six and highlights the limited attention to this topic within ICT-delivered aphasia rehabilitation research. Chapter Seven explores the methods employed within a feasibility study which aimed to investigate ICT-delivered aphasia rehabilitation

targeting auditory comprehension impairment at sentence level. This chapter describes the experimental mixed-methods, two-phase case series with crossover design. This is followed by the presentation and discussion of the findings of the feasibility study which are reported in Chapter Eight. These findings examine the therapeutic gains, usability and the engagement of participants with ICT-delivered aphasia rehabilitation targeting auditory comprehension at sentence level. This chapter will also present the findings on visual search strategies and eye gaze patterns of participants with aphasia before and after ICT-delivered aphasia rehabilitation.

Chapter Nine provides a consolidated discussion on the findings of the research in this thesis examining the outcomes from the feasibility study, the perspectives of the stakeholder groups and the current available evidence. This chapter will delineate the researcher's conclusions following the research process, outline the implications for clinical practice and policymaking and present a concluding statement of findings. Finally Chapter Ten will provide an overview of planned future work related to this research. Figure 1.4 outlines the structure of the chapters within this thesis.

Figure 1.4. Overview of Chapters in this Thesis



1.11 Mixed Methods Research

The following section will provide an overview of the history (1.11.1), rationales (1.11.2) and philosophical assumptions of mixed methods research (1.11.3) and its application (1.11.4) in the three strands of this research.

1.11.1 History of Mixed Methods Research

Over the last three decades, mixed methods research has emerged as an alternative to the traditional contrasting approaches of quantitative and qualitative research traditions (Teddlie and Tashakkori, 2009). Mixed methods research has been defined as "*research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry*" (Tashakkori and Creswell, 2007, p. 4). Mixed methods research can be utilised where a researcher

wishes to answer two questions simultaneously (Teddlie and Tashakkori, 2009). One question may be confirmatory e.g. is ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments effective? And, a second question may be exploratory e.g. what are the stakeholders' perspectives of this mode of rehabilitation? In this way, mixed methods research can answer research questions that cannot be answered by either qualitative or quantitative approaches on their own (Creswell and Clark, 2011).

1.11.2 Rationales for Mixed Methods Research

A mixed methods study examining why health service researchers undertake mixed methods research in England (O'Cathain, Murphy, & Nicholl, 2007) identified that the key reason for implementing a mixed methods approach was comprehensiveness as it provides a "*broader picture of a phenomenon*" (O'Cathain, et al., 2007). The approach is considered necessary due to the complexity of the issues being researched within health services research, as different methods allow researchers to address different aspects of the overall research question. The grounds for justifying the implementation of mixed methods research are often pragmatic and founded on the applied nature of the research with the integration of qualitative methods in order to hear the participant's voice within the research (O'Cathain, et al., 2007). This is in contrast to a transformative-emancipatory paradigm with an ideology of the emancipation of marginalised groups. However, such a worldview is also compatible with mixed methods research (Creswell and Clark, 2011). Other more cynical reasons for carrying out mixed methods research included strategic purposes for gaining funding and as a safeguard against null trial outcomes, where a qualitative component may offer more credibility to a study. Although once perceived as a fashionable trend that may have a negative effect on

quality research (O'Cathain, et al., 2007), mixed methods research can achieve a much broader understanding of participants' views than one method alone (Sampson, O'Cathain, & Goodacre, 2010). The use of mixed methods research should be determined by the research question itself. Glogowska (2011) clearly highlighted this by stating "*ultimately it is the research question that drives the choice of methodologies and methods and not vice versa"* (Glogowska, 2011, p. 256).

1.11.3 Philosophical Assumptions of Mixed Methods Research

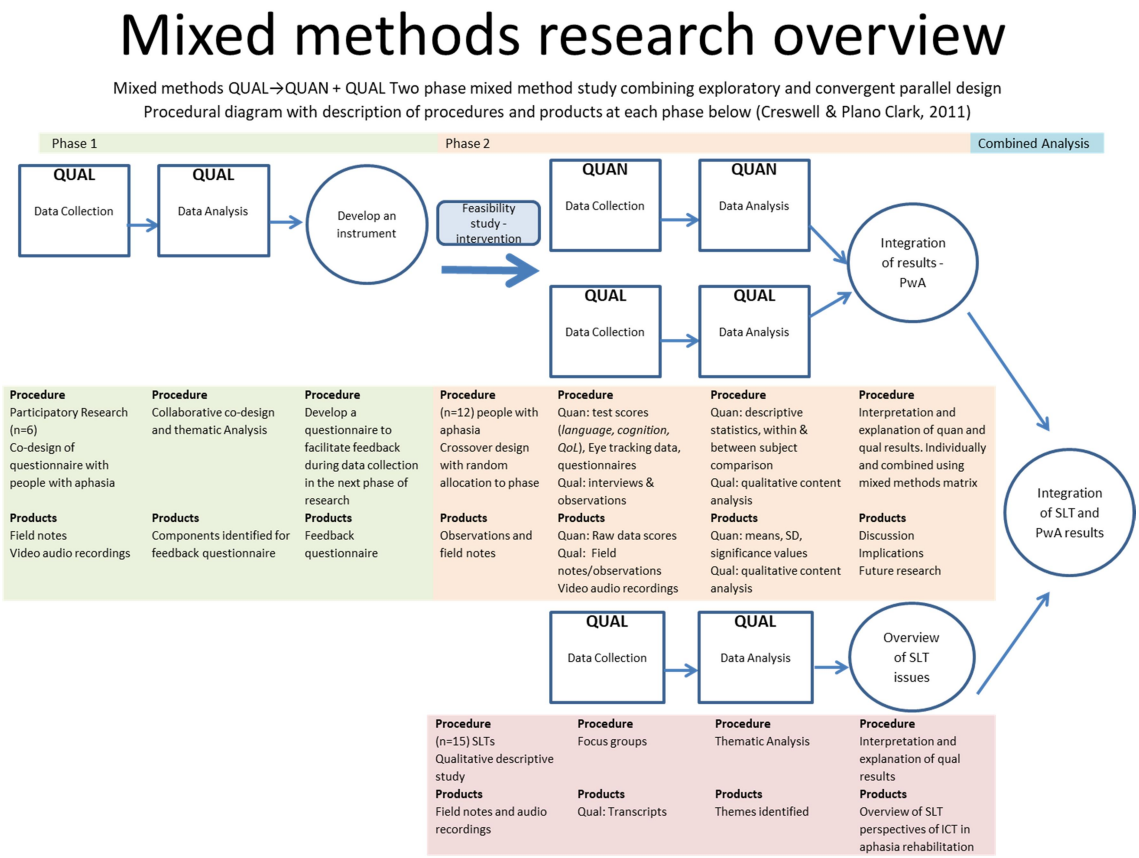
A long-running debate existed in social sciences over the incompatibility of quantitative and qualitative research in what has been called the "paradigm wars" (Oakley, 1999). Morgan (2007) proposed a renewed consideration of paradigms and argues for the consideration of a pragmatic approach as an alternative methodology in social sciences. He contends that a pragmatic approach moves away from questions about mixing methods and argues for a properly integrated methodology for social sciences. In doing so, this promotes a re-consideration of research methodology based not on the duality of qualitative and quantitative approaches but on a pragmatic alternative to research methodology. Onwuegbuzie and Leech (2005) note that pragmatic researchers can be flexible in their investigative techniques when attempting to answer a range of research questions that may arise. A positive attitude to both qualitative and quantitative research methods allows pragmatic researchers "*to use qualitative research to inform the quantitative portion of research studies, and vice versa*" (Onwuegbuzie and Leech, 2005, p. 383). In this way, the researcher can employ a bi-focal lens allowing them to focus in on micro-level issues as well as zoom out to view macro-level issues in research. A pragmatic approach relies on abductive reasoning by which the researcher moves back and

forth between induction (a qualitative approach) and deduction (a quantitative approach) when connecting theory and data (Morgan, 2007). The relationship of the researcher and the research process, as being something either objective or subjective, is considered an artificial dichotomy and a pragmatic approach supports intersubjectivity. This proposes that a pragmatic researcher works back and forth between various frames of reference. In doing so, a pragmatic researcher has no problem with both affirming that there is a single "real world" and asserting that individuals have their own different interpretations of that world (Morgan, 2007). The final key issue in research methodology addressed by Morgan (2007) reflects the inference from data; in a qualitative approach this is context-dependent while a quantitative approach supports generalisation. A pragmatic researcher must not assume that the methods, or the research approach, produce findings that are either content-bound or generalisable. Instead, transferability of research results is advocated in which researchers focus on what can be done with the knowledge produced and not on the argument of its dependence on context or generalisability. A pragmatic researcher will question what existing knowledge might be operational in a new set of circumstance and weigh up the merits of any such assertions (Morgan, 2007).

1.11.4 Applying Mixed Methods Research

Creswell and Clark (2011) suggest the use of two tools to help describe mixed methods research designs: a notation system and a procedural diagram. These tools have been used in Figure 1.5, to provide an overview of the research in this thesis which follows a pragmatic approach to research (Morgan, 2007).

Figure 1.5. Overview of Mixed Methods in this Research with Notation and Procedural diagram (Creswell and Clark, 2011)



The research presented in this thesis employs a two-phase[1], mixed method study combining exploratory and convergent parallel designs (Creswell and Clark, 2011). The initial exploratory phase (Research Strand Two) employed a participatory research approach embedded within a co-design process. This research activity facilitated the development of a meaningful and relevant outcome measure i.e. a self-reported feedback questionnaire for people with aphasia, created in collaboration with people with aphasia. Although research has been conducted investigating participants' perspectives of ICT-delivered aphasia rehabilitation there is no consensus measure available, therefore the co-design activity was a timely

[1] The use of the term *phase* in this section relates to the phase of the PhD research in its entirety and not the experimental phase of the feasibility study.

research activity. This questionnaire was carried into the second phase and acted as one of the mechanisms for self-reporting feedback during data collection in this research phase. The second phase (Research Strand Three), explored the feasibility of and perspectives to ICT-delivered aphasia rehabilitation in a convergent parallel design. An experimental two-phase case series with crossover design with both qualitative and quantitative data collection methods were used to explore the feasibility and participants' perspectives of ICT-delivered aphasia rehabilitation targeting auditory comprehension. This data was synthesised to provide a clearer understanding of the concept of acceptance and engagement with ICT-delivered aphasia rehabilitation among people with aphasia. The combined methods of data collection help to provide a more comprehensive finding in relation to the feasibility of this intervention. A parallel qualitative study (Research Strand One) which explored SLTs' perspectives of ICT-delivered aphasia rehabilitation was also carried out. The critical review of the literature in Chapter Two identifies that little research has been carried out on the perspectives of SLTs. This is in contrast to the emerging research exploring the perspectives of people with aphasia engaging with ICT in aphasia rehabilitation. A qualitative research study was considered more appropriate to provide an in-depth exploration of the SLT perspectives.

1.11.5 Techniques for Integrating Data in Mixed Methods Studies

O'Cathain, Murphy, & Nicholl (2010) identify three techniques that can be utilised in order to combine the results from a qualitative and quantitative study in order to provide more knowledge than individual analysis alone. The mixed methods feasibility study in the second phase is particularly suited to the use of a mixed methods matrix, as there are both qualitative and quantitative data on the same cases. This form of matrix allows for the collection of data from single cases to be

studied together, thus focusing attention on the cases rather than the variables (O'Cathain, et al., 2010). The final analysis of this research is the triangulation of the data from both the PwA and the SLTs. A convergence coding matrix will be used to display the findings from these two stakeholder groups on the same page. This technique is particularly useful where there is agreement, partial agreement, silence or disagreement between findings from different data sources (O'Cathain, et al., 2010). This will be represented in Chapter Nine, and will provide a discussion on the stakeholders' perspectives of ICT-delivered aphasia rehabilitation.

1.12 Chapter Summary

This chapter provided a overview of the research presented in this thesis. It provided background information that offers context to the research topic: the issue of stroke within a global and an ageing Irish population, the condition and impact of post-stroke aphasia, the potential of ICT-delivered aphasia rehabilitation and the fundamental need to consider the use and acceptance of this mode of therapy.

The research aims were presented with an overview of the chapters that will follow. Subsequent chapters will provide a comprehensive description of the research undertaken in order to address the aims of the three research strands. The use of a mixed methods design and related assumptions has been described. Finally, a short description of the method of the planned integration of data, gathered through different methods so as to offer more knowledge than single analysis alone, was defined.

Chapter Two

Chapter Two - Perspectives of Speech and Language Therapists on ICT-delivered Aphasia Rehabilitation: an Integrative Review

2.1 Introduction to Chapter

This chapter provides an overview of the background literature relevant to Research Strand One in this thesis. An integrative review was employed to explore speech and language therapists' perspectives of ICT-delivered aphasia rehabilitation. This chapter will introduce the context of the review (2.2), the aims of the review question, the methods undertaken to answer the review question (2.3), the findings of the search strategies and included studies (2.4), and the implication of these findings (2.5) as relevant to Research Strand One.

2.2 Background

Digital technologies such as smartphones, personal, laptop and tablet computers are now commonplace in everyday life. In 2018, 89% of Irish households had access to the internet. When exploring the types of devices used to access the internet, 86% of those surveyed were using mobile phones or smartphones, 43% using tablet computers and 24% using desktop computers to access the internet (CSO, 2018). The figures reflect that respondents may use multiple devices to access the internet. However, there is a difference among ages of smartphone users, with 93% of Irish people aged between 16-44 years accessing the internet using a smartphone compared with 56% of adults in the 60-74 age group. This difference is less pronounced when examining tablet computer use as almost 47% of those aged between 16-44 years used such a device to access the internet compared with 34% of those between 60-74 years of age. The use of tablet computers has increased since

the last survey completed in 2016, as has smartphone use for those age 30 and over. Searching for information on goods and services is the most common internet activity (CSO, 2018). It is worth noting that seeking health-related information was reported by 57% of those surveyed (CSO, 2018). Information and communication technology (ICT) in health care is a growing and varied field of research with many foci e.g. synchronous and asynchronous telerehabilitation, eHealth records and administration. A significant focus of research in technology and health care examines the design and implementation of technology suitable for use in this setting but Holden and Karsh (2010) suggest that not enough focus has been directed on how ready clinicians are to implement ICT in health care.

2.2.1 Technology Acceptance and Use

The Technology Acceptance Model (TAM) was developed by Davis (1985) who sought to develop a measure that would predict technology use. The model outlines that a person's intention to use an ICT system will be the best predictor of the actual use of the ICT system (Davis and Venkatesh, 1996), this is referred to as behavioural intention to use. Behavioural intention is determined by the person's attitude towards using the system and this is determined by two constructs; perceived usefulness and perceived ease of use. Perceived usefulness is defined as "*the degree to which a person believes that using a particular system would enhance his or her job*" (Davis, 1985, p. 320). Technology that allows the user to achieve the end goal and be advantageous in doing so would be deemed to have high levels of perceived usefulness. The construct of perceived ease of use is defined as "*the degree to which a person believes that using a particular system would be free of effort*" (Davis, 1985, p. 320). Therefore, a technology that is perceived to be easy to use and free from additional effort would be considered more likely to be acceptable to users.

The TAM has been used to examine technology acceptance and use within health care and a systematic review by Holden and Karsh (2010) investigating the application of this model to health care identified 16 studies which examined various aspects of health care including telemedicine technology, electronic records and internet health applications. The professionals within these studies included specialist and general practitioners, nurses, pharmacists, medical technicians, physiotherapists and occupational therapists but there was no reference to speech and language therapists (SLTs). There is evidence to suggest that perceived usefulness and behavioural intention to use are strongly associated (Holden and Karsh, 2010; Turner, Kitchenham, Brereton, Charters, & Budgen, 2010) and behavioural intention to use is strongly associated with actual use (Turner, et al., 2010). Turner, et al. (2010) reported that the relationship between perceived usefulness and actual usage is not as strong. A possible explanation could be that perceived usefulness explains some part of variation in behavioural intention to use and behavioural intention to use subsequently explains some part of the variation in actual usage. However, these variations may be different and so it is not possible to assume an association between perceived usefulness and actual usage. However, Holden and Karsh (2010) suggest that it is important to design a system that is perceived as useful to the clinician and suggest that this may influence clinicians' acceptance and subsequent use of the system. The perceived ease of use of a system is less likely to predict actual use of it (Holden and Karsh, 2010; Turner, et al., 2010).

Venkatesh, et al. (2003) built on eight models of technology acceptance including the TAM and developed a new model called the Unified Theory of Acceptance and Use of Technology (UTAUT). There are four key constructs within the UTAUT model that play a significant role in determining acceptance and use of

technology and these include: performance expectancy, effort expectancy, social influence and facilitating conditions (Venkatesh, et al., 2003). Performance expectancy is very similar to the concept of perceived usefulness and is defined as the "*degree to which an individual believes that using the system will help him or her to attain gains in job performance*" (Venkatesh, et al., 2003, p. 447). Performance expectancy is the strongest predictor of intention to use. For SLTs working within aphasia rehabilitation this is likely to represent the perceived usefulness of the therapy programme for making therapeutic gains in rehabilitation. The effort expectancy is similar to the construct of perceived ease of use in the TAM and is defined as the "*degree of ease associated with the use of the system*" (Venkatesh, et al., 2003, p. 450). This construct is likely to reflect the programme usability in terms of ease of use, learnability and memorability for SLTs who wish to introduce an ICT-based programme into aphasia rehabilitation. The original TAM did not reference the individual user's perception of others' approval or disapproval of technology usage. This concept emerged in a later iteration of the model i.e. the TAM2 (Holden and Karsh, 2010) and this concept was further developed in the UTAUT as the construct of social influences. Social influences are defined as "*the degree to which an individual perceives that important others believe he or she should use the new system*" (Venkatesh, et al., 2003, p. 451). It is possible to suggest that other clinicians, both SLTs and other health professionals, as well as the person with aphasia (PwA), family members and significant others may indeed represent social influencers within aphasia rehabilitation. Finally, a fourth construct emerged in the UTAUT which is also not present in the TAM. This construct of facilitating conditions is defined as "*the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system*"

(Venkatesh, et al., 2003, p. 453). Within ICT-delivered aphasia rehabilitation, this construct is likely to reflect the context of the aphasia rehabilitation activity including the access to resources and support systems for the SLT and the PwA. These four constructs are also considered to be moderated by four factors; gender, age, previous experience of technology and voluntariness i.e. if the decision to implement the technology is under the person's own control or not. The UTAUT has been applied to the acceptance and usage of technologies in a number of settings including education and health care (Venkatesh, Thong, & Xu, 2016) and has been used to examine factors that influence health professionals' acceptance of information systems in health (Ifinedo, 2012), new technologies in a large rehabilitation hospital (Liu et al., 2015) and tablet technology in speech and language therapy for children (Istenič Starčič, Lebeničnik, & Gačnik, 2018). Based on the constructs of the UTAUT and TAM models it is not surprising that the performance expectancy or the perceived usefulness of an ICT system is one of the most commonly cited facilitators for technology adoption in a systematic review of the adoption of mobile health (m-health) technologies, such as mobile electronic medical records and remote monitoring systems, by health professionals (Gagnon, Ngangue, Payne-Gagnon, & Desmartis, 2015). This is also noted in the findings of a survey of health professionals' use of new technology in rehabilitation which found a strong correlation between performance expectancy i.e. the belief that technology will assist therapists to improve either their own job performance or their patient outcomes, and the behavioural intention to use the technology (Liu, et al., 2015).

It is important to gain an understanding of some of the potential barriers to and facilitators of ICT use in aphasia rehabilitation from the perspectives of SLTs. It is possible to explore the acceptance and use of assistive technology and information

systems among other health professionals such as Occupational Therapists and Physiotherapists (de Joode, van Boxtel, Verhey, & van Heugten, 2012; Ifinedo, 2012; McGrath et al., 2017) and examine the experiences of SLTs who provide synchronous telehealth (Dunkley, Pattie, Wilson, & McAllister, 2010; Pitt, Hill, Theodoros, & Russell, 2018; Simic et al., 2016). The latter differs from asynchronous telerehabilitation as rehabilitation happens in real-time using ICT to connect the clinician and the PwA over the internet rather than face to face. As such it does not facilitate increased rehabilitation outside of clinical sessions as it requires the constant remote presence of a clinician but it can provide an insight into the challenges and benefits of ICT-delivered rehabilitation in real-time. This differs from asynchronous telerehabilitation and self-administered rehabilitation. Both of these can provide rehabilitation in addition to face-to-face therapy sessions or as stand-alone rehabilitation and are carried out independently by the PwA. Cost is reported as a significant barrier to the adoption of m-health (Gagnon, et al., 2015) as well as a frequently cited barrier among occupational therapists when considering assistive technology (McGrath, et al., 2017). The occupational therapists in this qualitative study expressed concerns with respect to cost as a potential barrier particularly in relation to the cost that is paid by patients, and this is especially relevant if the patient was unable to try the device first (McGrath, et al., 2017). Cost is also noted as a barrier to synchronous telehealth service delivery among SLTs working with rural residents who expressed concerns that rural residents may not be in a financial position to access ICT (Dunkley, et al., 2010). This was also maintained by the rural residents in this study but one resident suggested that costs could be managed through subsidies perhaps indicating acceptance of that mode of rehabilitation. The option for patients to trial technology before committing to

purchase was highlighted by health professionals in two studies examining the factors influencing the use of assistive living technology (de Joode, et al., 2012; McGrath, et al., 2017). The availability of support and training for the health professionals to upskill in ICT has been highlighted as both a barrier and facilitator (de Joode, et al., 2012; Dunkley, et al., 2010; Gagnon, et al., 2015; Ifinedo, 2012; Liu, et al., 2015). Time to support training was also noted as an issue as well as access and availability of appropriate resources and information (Gagnon, et al., 2015; McGrath, et al., 2017). Indeed the provision of a training manual and a cheat sheet was considered helpful among SLTs in a usability study of synchronous internet-based anomia therapy (Simic, et al., 2016).

It is important to get an understanding of the factors that may influence SLTs' acceptance and use of ICT-delivered aphasia rehabilitation in order to understand the challenges that may be faced if seeking to adopt this mode of rehabilitation within a service delivery model. There are two aims in this integrative review: 1) to identify the current, available research exploring the views of SLTs with respect to acceptance and usage of ICT-delivered aphasia rehabilitation and 2) to identify the barriers, facilitators and issues emerging with this mode of rehabilitation.

2.3 Methods

An integrative review method was considered appropriate for this literature review as integrative reviews are the broadest type of research review and allow for the combination of diverse methodologies in order to more fully understand a complex phenomenon (Whittemore and Knafl, 2005). The first of five phases involved in this review process began with the identification of the problem under review with respect to the variables of interest; the concept (*perspectives of ICT-*

delivered aphasia rehabilitation), the target population (*speech and language therapists*) and the health care problem (*aphasia rehabilitation*). A literature search was carried out during the second phase. This began with searches of six online databases (CINAHL, PsycINFO, EMBASE, MEDLINE, SCOPUS and Web of Science) followed by an iterative search process in an to attempt to cover the literature in a comprehensive manner (Arksey and O'Malley, 2005). This prolonged iterative process was important as the researcher knew from recent conference proceedings that a study relevant to the problem under review had been carried out and did not appear in the initial database searching. Therefore, Google Scholar searching was completed as well as forward citation searching, searching references of selected papers and relevant internet sites including professional association bodies e.g. www.rcslt.org. The inclusion criteria for the review were as follows; 1) speech and language therapists, 2) any measure of their views, perspectives or opinions in relation to ICT acceptance and use 3) with respect to ICT-delivered aphasia rehabilitation. Studies of synchronous telerehabilitation and interventions targeting compensatory strategies only e.g. alternative and augmentative communication were excluded from the review. An important third phase of the integrative review process is the evaluation of the quality of the included studies. However, Whittemore and Knafl (2005) identified the complexities that can be involved in the evaluation of included studies with a diverse range of research designs and note there is no gold standard that exists for this process. With this in mind and considering the example provided by Whittemore and Knafl (2005), studies were evaluated on two criteria relevant to the review; methodological rigour and data relevance. Due to the exploratory nature of this review and the lack of previous reviews in this area no studies were excluded based on the appraisal of the

quality of the study or publication status. Once the data evaluation phase was completed the next phase of data analysis began.

Whittemore and Knafl (2005) note that data analysis within integrative reviews is one of the least developed features of the research process. They suggested a method which consists of data reduction, data display, data comparison, conclusion drawing, and verification. Data reduction includes techniques of "*extracting and coding data from primary sources to simplify, abstract, focus, and organize data into a manageable framework*" (Whittemore and Knafl, 2005, p. 550). Once completed the data was then displayed in a suitable format for visualisation. The use of NVivo11 and Microsoft Excel aided this process. This was followed by an iterative process of data comparison which allowed the researcher to determine patterns, themes or relationships within the data. This then facilitated the move from descriptive analysis to higher levels of abstractions and allowed the researcher to draw conclusions and verification of the final analysis.

2.4 Results

2.4.1 Study Characteristics

Following an iterative literature search, 10 studies were included in the review. See Figure 2.1 for further details. These included seven peer-reviewed publications, one conference proceeding, one thesis and one report for a funding agency. See Table 2.1 for summary details of the included studies. The methodological quality of the studies was variable and this must be taken into account when considering the findings of the studies. Only six of the studies provided sufficient information on the research design and methods so as to answer questions with respect to the studies' recruitment process, data collection methods

and data analysis (Benedon, 2018; Chen and Bode, 2011; Davis and Copeland, 2006; Gunning et al., 2017; Hill and Breslin, 2016; Swales, Hill, & Finch, 2016). Three studies used questionnaires as a means to gather data (Benedon, 2018; Chen and Bode, 2011; Davis and Copeland, 2006). Three studies also combined questionnaires with other data collection methods including; follow up focus groups (Gunning, et al., 2017), interviews (Hill and Breslin, 2016) and usability testing sessions (Reeves, Jefferies, Cunningham, & Harris, 2007). One study employed interviews for data collection (Burke, Palmer, & Harrison, 2017) and one study employed focus groups (Swales, et al., 2016). The final two studies do not provide adequate information on the methods of data collection from the clinicians. One of these studies reported that clinician's completed a brief questionnaire similar to the participants with aphasia but no additional information is provided (Sobel, Fink, & Schwartz, 2000) and the final study reports that clinicians' "*were surveyed*" with no additional information (Schröder, Schupp, Seewald, & Haase, 2007, p. 291).

Four of the included studies investigated clinicians' general acceptance and use of technology in rehabilitation (Benedon, 2018; Chen and Bode, 2011; Davis and Copeland, 2006; Swales, et al., 2016). One of these also gathered data from occupational therapists and physiotherapists working within stroke rehabilitation services and as such the findings are not restricted to aphasia rehabilitation but cover stroke rehabilitation in general, thus including aphasia rehabilitation but not referencing it solely (Chen and Bode, 2011). A second of these four studies explored SLTs' preferences for computer-based speech and language therapy with an aim to better inform developers as part of a user-centred design process (Swales, et al., 2016). Five studies investigated specific programmes developed for use in ICT-aphasia rehabilitation (Burke, et al., 2017; Hill and Breslin, 2016; Reeves, et al.,

2007; Schröder, et al., 2007; Sobel, et al., 2000) and the final study examined commercially available software as part of a study exploring clinicians' perspectives of high-intensity aphasia treatment models (Gunning, et al., 2017).

Figure 2.1. Search Strategy Results for Integrative Review (Research Strand One)

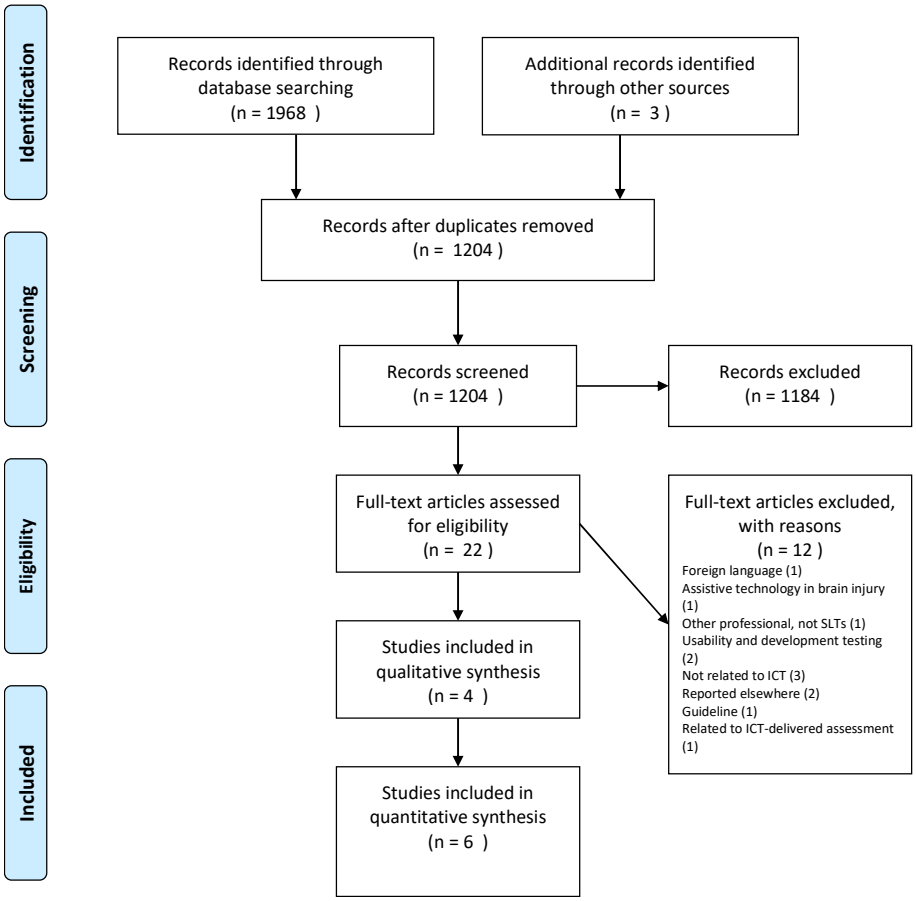


Table 2.1. Study Characteristics for Integrative Review (Research Strand One)

Author	Year	Sample Size	Professionals ~	Country	Study Aim	Data Collection Method	Publication type
Benedon	2018	228	Speech and language pathologies	United States of America	Identify opinions and attitudes towards using apps in therapy	Online Survey	Thesis
Burke et al	2017	11	Speech and language therapists	United Kingdom	Explore experiences of carrying out a self-managed computerised intervention for aphasia, to identify and understand the key factors influencing implementation	Interviews	Conference proceeding
Chen & Bode	2011	1326* SLT = 399	Speech and language pathologists Occupational therapists Physical therapists	United States of America	Identify factors or barriers in therapists' decision to acquire and use new technological devices and to examine rating differences across therapy disciplines	Survey	Peer-review publication
Davis & Copeland	2006	107	Speech and language pathologists	United States of America	Identify practice patterns related to computer use	Survey	Peer-review publication
Gunning et al.	2017	13	Speech – language pathologists	Australia	Explore perceptions of delivering high-intensity aphasia treatment through three different service models	Log of barriers, facilitators and suggestions, questionnaire and focus group	Peer-review publication
Hill & Breslin	2016	3	Speech – language pathologists	Australia	Explore the usability and acceptability of eSALT	Interviews, observational checklist and clinician satisfaction survey	Peer-review publication
Reeves et al.	2006	20	Speech and language therapists	England	User design of a prototype for use in speech and language therapy	Questionnaire and design evaluation session	Peer-review publication

Author	Year	Sample Size	Professionals ~	Country	Study Aim	Data Collection Method	Publication type
Schroder et al.	2007	Not reported	Speech therapists	Germany	Investigates therapists' indication choices of a new computer-aided training programme, to ascertain which patients were suitable for computer therapy	Limited information presented, refers to a survey but no further details	Peer-review publication
Sobel et al.	2000	Not reported	Speech – language therapists	United States of America	Track the use of MATSS and obtain satisfaction ratings	Questionnaires	Report
Swales et al.	2016	10	Speech language pathologists	Australia	Explore clinicians' preferences regarding the features of computer-based aphasia therapy programmes	Focus groups	Peer-review publication

*Total participants including physical therapists, occupational therapists and speech and language pathologists
~Titles of professions as reported within the studies

2.4.2 Study Findings

The studies report on a number of issues that impact technology acceptance and use within aphasia rehabilitation. These issues can be identified at five levels: 1) the individual patient/PwA, 2) the context or immediate environment around the PwA, 3) the SLTs and factors that influence their practice, 4) the health system in which the SLTs work and 5) the programme or device for delivering therapy. See Table 2.2 for summary information on the studies' findings.

2.4.2.1 Factors Related to the Person with Aphasia

The SLTs in the included studies identified a number of factors, with respect to the individual with aphasia, that emerge when considering introducing ICT-delivered aphasia rehabilitation. The person's motivation (Burke, et al., 2017; Hill and Breslin, 2016; Schröder, et al., 2007), personal preference (Davis and Copeland, 2006) and interest (Chen and Bode, 2011) were noted as key factors when considering introducing technology in rehabilitation. Indeed, a perceived lack of patient interest was rated as a significant barrier to the introduction of novel technology by SLTs in stroke rehabilitation (Chen and Bode, 2011). In addition, the cognitive ability of the PwA was reported to be an important factor when considering introducing ICT-delivered aphasia rehabilitation (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016) and was reported as a reason for not considering introducing this mode of rehabilitation to some individuals (Schröder, et al., 2007). SLTs are significantly more likely to rate the person's functional level as an important factor to consider when introducing technology compared to their occupational therapy and physiotherapy colleagues (Chen and Bode, 2011).

Table 2.2.Summary Information on Study Findings of SLTs' Perspectives of ICT in Rehabilitation

Factors	Benedon 2018	Burke et al. 2017	Chen & Bode 2011	Davis & Copland 2006	Gunning et al. 2017	Hill & Breslin 2016	Reeves et al. 2006	Schroder et al. 2007	Sobel et al. 2000	Swales et al. 2016
The PwA										
Motivation		x				x		x		
Personal Preference				x						
Interest			x							
Cognitive Ability		x	x			x		x		
Functional Level			x							
Visual & Auditory Skills								x		
Age & Gender	x									
IT skills		x		x	x	x				
Service Delivery										
ICT as adjunct & home activities				x		x				
Convenient for rural areas						x				
Personalised therapy						x				x
Intensive Practice		x			x					
Feedback		x			x					
The Context of the PwA										
Availability of support		x	x			x				
Family support & encouragement	x		x							
Expectations			x							
The SLT										
Sufficient caseload			x							
Confidence					x					
Preferences for programme features										x
Preference for paper activities	x									
Lack of access to ICT	x									
Lack of knowledge	x									
Age and experience	x		x							
Matching ICT to client goals	x									
Consulting colleagues for advice	x									

Factors	Benedon 2018	Burke et al. 2017	Chen & Bode 2011	Davis & Copland 2006	Gunning et al. 2017	Hill & Breslin 2016	Reeves et al. 2006	Schroder et al. 2007	Sobel et al. 2000	Swales et al. 2016
The programme or ICT device										
Suitability and flexibility	x	x				x		x	x	x
Appropriate feedback provided										x
Personalise tasks		x				x				
Usability issues		x				x	x		x	
Compatibility		x					x			x
Breakability	x									
Maintenance			x							
Broader health system										
Internet Access	x			x						
Access to ICT resources	x									
Access to licences										x
Cost	x	x	x							x
Administration access		x								
Time constraints		x				x			x	
Training for SLTs		x				x				
Training by SLTs for PwA						x				
IT support		x	x							

Other factors that are reported to influence SLTs' decisions to introduce ICT-delivered aphasia rehabilitation include the person's visual and auditory skills (Schröder, et al., 2007) as well as age and gender (Benedon, 2018), although further discussion of these factors was not provided within the studies. The ICT skills of the PwA was reported as a factor when deciding to introduce ICT-delivered aphasia rehabilitation (Burke, et al., 2017; Gunning, et al., 2017; Hill and Breslin, 2016) and was considered as relevant information during case history taking (Davis and Copeland, 2006). However, there are differing views with respect to patient ICT skills as a barrier or facilitator for ICT-delivered aphasia rehabilitation. The SLTs in one qualitative study noted it was important to avoid making assumptions about a

person's ICT potential, as one participant quote noted that it can be surprising "*how many people who you wouldn't have thought would manage it, can*" (Burke, et al., 2017). In contrast, the clinicians in a study of high-intensity therapy models agreed that computer therapy was suited to patients who already had established computer skills or to those who had the cognitive ability to learn (Gunning, et al., 2017). ICT can provide an adjunct to therapy both in face-to-face therapy sessions when used as an addition to paper-based tasks (Hill and Breslin, 2016) or as a means to provide homework between sessions (Davis and Copeland, 2006; Hill and Breslin, 2016). Indeed, one study highlighted that more and more people are using computers at home and SLTs are being asked about programmes for home use (Burke, et al., 2017). The availability of ICT-delivered aphasia rehabilitation was seen as convenient for rural patients (Hill and Breslin, 2016) and perceived benefits were noted in many studies including the beneficial outcomes of intensive practice and the provision of motivating feedback (Burke, et al., 2017; Gunning, et al., 2017) as well as personalised therapy tasks (Hill and Breslin, 2016).

2.4.2.2 The Context of the Person with Aphasia

A key facilitating factor noted in some studies was the availability of support for the PwA engaging in ICT-delivered aphasia rehabilitation (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). SLTs rated family support as very important and lack of family encouragement was seen as a barrier to introducing ICT in rehabilitation (Benedon, 2018; Chen and Bode, 2011). Burke, et al. (2017) identified that ongoing support is needed and highlighted that, although it is useful to have a carer, a support volunteer or assistant support can also facilitate ICT-delivered aphasia rehabilitation. Finally, a survey of health professionals' decision making in the adoption of new technologies in stroke rehabilitation noted that

unrealistic expectations was a significant barrier to patients' adoption and use of technology (Chen and Bode, 2011) and SLTs rated this factor higher than Occupational Therapists and Physiotherapists.

2.4.2.3 Factors Related to the Speech and Language Therapist

The studies exploring SLTs' use of programmes and apps note that SLTs are using these for therapy goals as well as compensatory aids, administrative tasks, and for measuring progress (Benedon, 2018; Davis and Copeland, 2006). Having a sufficient caseload to use a device was seen as a factor in the decision to acquire novel technologies in stroke rehabilitation (Chen and Bode, 2011). Reduced confidence among clinicians may be a factor in the initial stages of adoption, although a positive shift in confidence was noted after use (Gunning, et al., 2017). SLTs appear to be positive in terms of their willingness to use ICT now or in the future (Davis and Copeland, 2006; Hill and Breslin, 2016) and in a study of their preferences SLTs identified a number of features that they would like to have embedded in programmes and applications (Swales, et al., 2016). SLTs surveyed in one study identified a number of barriers to ICT use and reported a number of personal reasons why they were not using ICT including a preference for paper activities, the need to use one's own device and not knowing about available apps (Benedon, 2018).

SLTs' age and years of experience did not appear to have a significant influence on programme and app use in speech and language therapy (Benedon, 2018) or on the rating of factors that influence decision making for the adoption of new technology in stroke rehabilitation (Chen and Bode, 2011). Although with the latter study therapists with the most experience (> 7 years) were less likely to rate a lack of technical support and lack of patient interest as significant barriers (Chen and

Bode, 2011). When asked about the factors SLTs would consider when deciding to purchase an app, the SLTs rated clients' goals as the highest factor followed by consulting colleagues for advice (Benedon, 2018).

2.4.2.4 Factors at the Level of the Programme or Device

One of the key challenges when attempting to introduce ICT-delivered aphasia rehabilitation as reported by SLTs in the included studies relates to the programme suitability and flexibility for use with individual patients (Benedon, 2018; Burke, et al., 2017; Hill and Breslin, 2016; Schröder, et al., 2007; Sobel, et al., 2000; Swales, et al., 2016). Programmes need to provide appropriate feedback for the person's age, background and culture (Swales, et al., 2016) as well as include therapy activities with a large bank of tasks with flexible levels of difficulty including sufficiently high level language tasks (Hill and Breslin, 2016; Schröder, et al., 2007; Swales, et al., 2016) and the ability to personalise tasks for the patient (Burke, et al., 2017; Hill and Breslin, 2016). Usability issues such as software not working as expected, and not intuitive to use, were reported to be a challenging (Burke, et al., 2017). However, some studies examining specific programmes or apps for use in aphasia rehabilitation reported well-perceived ease of use of the therapy programmes by the SLTs in the study (Hill and Breslin, 2016; Sobel, et al., 2000). The compatibility of programmes for different devices and operating systems is also noted as a potential barrier to use (Burke, et al., 2017; Reeves, et al., 2007; Swales, et al., 2016). The perception that technology is easily broken emerged as a barrier to the use of apps by a participant in one study (Benedon, 2018). In addition, device maintenance was noted as a barrier to the adoption of novel health technology by health professionals, although fewer SLTs rated this as important compared to Occupational Therapists within this study (Chen and Bode, 2011).

2.4.2.5 Factors Related to the Broader Health Systems Level

In the survey by Davis and Copeland (2006) internet access at work was reported as a barrier for computer-therapy use by some of the SLT participants. Over a decade has passed and technology continues to advance but access to ICT resources remains highlighted as a barrier to the use of apps in speech and language therapy (Benedon, 2018). In this study, participants noted that there were not enough devices to share, as well as no internet access and access limitations which impacted on their ability to use ICT in practice. Access to licences also emerged as an issue, as some departments may have limited numbers due to cost which impacts on overall access (Swales, et al., 2016). Cost is a key barrier in many of the studies (Benedon, 2018; Burke, et al., 2017; Chen and Bode, 2011; Swales, et al., 2016). The cost of devices, programmes and apps, limited budgets and difficulties with reimbursements for Medicare were reported as barriers to the adoption of ICT in rehabilitation (Benedon, 2018; Chen and Bode, 2011), although SLTs were less likely to rate cost as an important barrier compared to Occupational Therapists and Physiotherapists (Chen and Bode, 2011). Loaning devices to patients and issues where devices have been "*locked down*" to prevent internet access were also highlighted as challenges for technology use (Burke, et al., 2017).

Time was identified as a potential barrier to ICT use for the SLTs, this included the time required to train, set up and oversee ICT-delivered aphasia rehabilitation (Burke, et al., 2017; Hill and Breslin, 2016; Sobel, et al., 2000). However, ICT-delivered aphasia rehabilitation was also viewed as an efficient use of SLT time and the time spent with the initial set up was identified as a key investment once up and running (Burke, et al., 2017; Hill and Breslin, 2016; Sobel, et al., 2000). Time for training was considered to be an important factor for SLTs engaging in

ICT-delivered aphasia rehabilitation (Burke, et al., 2017) and when provided was considered useful (Hill and Breslin, 2016).

The provision of ICT support was identified in two of the studies (Burke, et al., 2017; Chen and Bode, 2011). Lack of technical support and logistics such as scheduling were two of the three most significant barriers to novel ICT adoption, in conjunction with the perceived lack of patient interest (Chen and Bode, 2011). Burke, et al. (2017) identified that having a named contact in ICT helped support their research study.

When considering ICT-delivered aphasia rehabilitation and independent home practice, face-to-face contact was considered an important factor before beginning ICT-delivered aphasia therapy (Hill and Breslin, 2016) and SLTs felt there was a need for a larger variety of prompts and cueing within IT systems to reflect what happens in face-to-face therapy sessions (Swales, et al., 2016).

2.5 Discussion

This integrative review examined the limited available evidence on the perspectives of SLTs with respect to ICT-delivered aphasia rehabilitation. The small number of peer-review articles on this research topic highlights the limited attention afforded to this research area. It is important to understand the clinicians' perspectives of a phenomenon in order to understand the factors that may influence their acceptance and use of technology and whether they offer it as an option to a patient with aphasia, and therefore plan and provide support accordingly (Holden and Karsh, 2010).

SLTs consider a variety of factors when deciding to introduce technology into rehabilitation (Chen and Bode, 2011; Davis and Copeland, 2006; Hill and Breslin, 2016). Chen and Bode (2011) identified a number of factors that health

professionals take into account when making decisions to introduce novel technologies into stroke rehabilitation. These factors stem from three different loci: *the patient, the service provider,* and *the larger context* (Chen and Bode, 2011, p. 422). In the context of ICT-delivered aphasia rehabilitation, this reflects the PwA, the SLT and the broader health service setting. There are a number of factors that emerged in the included studies that may be considered to impact on the ability to make gains and achieve the goals set for aphasia rehabilitation. These facilitatory factors include the inherent flexibility and ability to personalise material in rehabilitation software in order to achieve personalised goals set in aphasia rehabilitation (Hill and Breslin, 2016; Swales, et al., 2016). When considering the UTAUT, these factors are likely to reflect the performance expectancy of the ICT system and therefore act as the strongest predictors of intention to use that ICT system (Venkatesh, et al., 2003). However, there are a number of factors that may pose challenges to this performance expectancy including the maintenance of devices (Chen and Bode, 2011) and compatibility of programmes for use on different devices and operating systems (Swales, et al., 2016).

Performance expectancy may be considered to act as the strongest predictor of intention to use an ICT system; however, effort expectancy is also an important factor when deciding to implement such a system. It is possible to view effort expectancy as perceived by the SLT from two standpoints: their views in relation to the ease of use for the PwA and separately in relation to their own effort expectancy. When taking into account the PwA, the SLTs in the included studies identified a number of factors that may influence the effort expectancy and ease of use of the programme/ICT system including the person's cognitive ability (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016; Schröder, et al., 2007), previous ICT

skills (Burke, et al., 2017; Davis and Copeland, 2006; Gunning, et al., 2017; Hill and Breslin, 2016) and visual and auditory skills (Benedon, 2018; Schröder, et al., 2007). SLTs also reflect on their own knowledge and confidence in relation to their ICT skills (Benedon, 2018; Gunning, et al., 2017). There are also factors that are shared between SLTs and the PwA including the ease-of-use and usability of the programme and ICT-device (Hill and Breslin, 2016).

SLTs are likely to seek recommendations and advice from fellow colleagues and this indicates that some measure of social influence is at play when considering the use and acceptance of ICT systems (Benedon, 2018). There are few other social influencers that are impacting on SLTs decision making when considering integrating ICT into rehabilitation. However, a significant social influencer identified by the SLTs as relevant to the PwA is the support provided to them from significant others e.g. families, carers, volunteers and the SLTs, which enables the PwA to engage in ICT-delivered aphasia rehabilitation (Benedon, 2018; Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). The support provided by families was seen as a key facilitator to the integration of ICT in rehabilitation (Benedon, 2018; Chen and Bode, 2011) and the support of the SLT is also a significant factor in the process (Hill and Breslin, 2016).

There are a number of factors reported in the included studies that reflect the construct of facilitating conditions e.g. training, time constraints, sufficient caseload, access to programmes and devices, funding and costs, ICT support and access (Benedon, 2018; Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). When these conditions are not realised, they frequently represent barriers to ICT-delivered aphasia rehabilitation (Benedon, 2018; Burke, et al., 2017). Cost is also noted as a barrier to ICT adoption among other professional groups in the adoption

of m-health (Gagnon, et al., 2015) when considering assistive technology (McGrath, et al., 2017) and for telehealth service delivery (Dunkley, et al., 2010). Trialling technology before committing to purchase is an important factor that influences other health professionals' decision making in relation to the adoption of, and recommendation for, new technologies (de Joode, et al., 2012; McGrath, et al., 2017). Training and the availability of support was highlighted as a factor in the studies included in this review (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016) and has been highlighted as both a barrier to, and facilitator for, the introduction of ICT in health (de Joode, et al., 2012; Dunkley, et al., 2010; Gagnon, et al., 2015; Ifinedo, 2012; Liu, et al., 2015). Time has also been identified as a two-sided factor for technology acceptance. The adoption of technology may well be time-consuming especially in the initial stages of upskilling, but it can also save time for professionals in the long run (Gagnon, et al., 2015).

2.6 Conclusion

This review of the literature on SLTs' perspectives of ICT-delivered aphasia rehabilitation identifies that little attention has been dedicated to this topic. It is important to understand what influences SLTs' views on ICT-delivered aphasia rehabilitation in order to support professionals in this field. A number of common factors have emerged in the small number of studies included in this review. It is possible to apply the Unified Theory of Acceptance and Use of Technology to re-frame the factors that emerge in the sparse literature on this topic. Important factors that frequently emerged in the literature include training, time constraints, support systems, ICT system flexibility and personal features related to the individual with aphasia e.g. cognition, visual and auditory skills and IT skills. There has been

limited consideration of the research topic in the current field of ICT-delivered aphasia rehabilitation and further research is indicated.

2.7 Chapter Summary

This chapter presented the methods and findings of an integrative review which explored SLTs' perspectives of ICT-delivered aphasia rehabilitation. SLTs are key stakeholders in aphasia rehabilitation and it is vital to consider their views and their perspectives of ICT-delivered aphasia rehabilitation in order to understand their acceptance and use of this mode of intervention. The findings note that there has been little attention to this topic within the available literature and the studies that are available are limited in quality. Further research is indicated in order to provide an in-depth investigation of SLTs' perspectives of ICT-delivered aphasia rehabilitation. Chapter Three will present a qualitative research study that examines SLT's perspectives of ICT-delivered aphasia rehabilitation and this study will provide additional information to address the research question posed in Research Strand One of this thesis.

Chapter Three

Chapter Three – A Qualitative Study of Speech and Language Therapists Perspectives of ICT-delivered Aphasia Rehabilitation

3.1 Introduction to Chapter

Speech and Language Therapists (SLTs) are key stakeholders in the delivery of aphasia rehabilitation. It is important to explore the clinicians' perspectives of Information and Communication Technologies (ICT) in aphasia rehabilitation in order to understand the factors that may influence their acceptance and use of it and therefore provide support accordingly (Holden and Karsh, 2010). An integrated review of the available literature presented in Chapter Two, identifies that there has been limited attention paid to this research topic. The findings of this review suggest that facilitating conditions are frequently cited as significant factors that impact on SLTs' decisions to introduce ICT in aphasia rehabilitation. However, there has been little peer-reviewed research on this phenomenon and further research is indicated. This chapter will report on the background (3.2), methods (3.3) and results (3.4) of a qualitative study exploring SLTs' perspectives of ICT-delivered aphasia rehabilitation and discuss the implication of the findings (3.5) for clinical practice.

3.2 Background

Chen and Bode (2011) identified a range of factors that health professionals take into account when making decisions to introduce novel technologies into stroke rehabilitation. SLTs consider a range of factors when deciding to introduce technology into rehabilitation (Chen and Bode, 2011; Davis and Copeland, 2006; Hill and Breslin, 2016). There are a number of factors that may be considered to impact on the ability to make gains and achieve the goals set for aphasia

rehabilitation. As people with aphasia are a heterogeneous population with each experiencing aphasia differently, one pertinent factor is the inherent flexibility and ability to personalise material in rehabilitation software in order to achieve personalised, on-target, goals in aphasia rehabilitation (Hill and Breslin, 2016; Swales, et al., 2016). Additionally, using ICT-delivered rehabilitation as an adjunct to face-to-face therapy is also a noted benefit of this mode of rehabilitation (Davis and Copeland, 2006; Hill and Breslin, 2016). When considering the Unified Theory of Acceptance and Use of Technology (UTAUT), these factors are likely to reflect the performance expectancy of the ICT system and therefore act as the strongest predictors of the intention to use that ICT system (Venkatesh, et al., 2003). However, there are a number of factors that may pose challenges to this performance expectancy including the maintenance of devices (Chen and Bode, 2011) and compatibility of programmes for use on different devices and operating systems (Swales, et al., 2016).

Performance expectancy may be considered to act as the strongest predictor of intention to use an ICT system; however, effort expectancy may also act as an important factor when deciding to implement such a system (Venkatesh, et al., 2003). In this context, effort expectancy can be viewed from two standpoints: the SLTs' views in relation to the ease of use for the person with aphasia (PwA) and secondly in relation to their own effort and ease of use. When considering the PwA, SLTs recognise a number of factors that may influence the effort expectancy in relation to ICT-delivered aphasia rehabilitation including the person's cognitive ability (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016; Schröder, et al., 2007), previous ICT skills (Burke, et al., 2017; Davis and Copeland, 2006; Gunning, et al., 2017; Hill and Breslin, 2016) and visual and auditory skills

(Benedon, 2018; Schröder, et al., 2007). With respect to their own effort expectancy, SLTs also reflect on their own knowledge and confidence in relation to their ICT skills (Benedon, 2018; Gunning, et al., 2017). In addition to these issues that are unique to each stakeholder group, there are also factors that are shared between SLTs and the PwA including the ease-of-use and usability of the programme and ICT-device (Hill and Breslin, 2016).

There are few external or social influencers within the available literature that are noted to impact on SLTs' decision-making when considering integrating ICT into rehabilitation. SLTs are likely to seek recommendations and advice from fellow colleagues when considering whether to use ICT systems (Benedon, 2018). In addition, SLTs have identified the support provided to the PwA from significant others e.g. families, carers, volunteers and the SLTs, as an important enabler for the PwA to engage in ICT-delivered aphasia rehabilitation (Benedon, 2018; Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). These factors may represent the social influence construct of the UTAUT. The role of social influence in the acceptance and use of technologies is controversial (Liu, et al., 2015). This construct is noted to play a significant role in technology acceptance and use where the use of technology is mandatory and is not significant in settings where the use is voluntary (Venkatesh, et al., 2003). Liu, et al. (2015) examined the factors that influence Occupational Therapists' and Physiotherapists' decisions to use technology. They found no significant effect of social influence and their decisions to implement new technologies are made independent of other professionals in the health care team.

There are a number of factors that reflect the construct of facilitating conditions e.g. training, time constraints, sufficient caseload, access to programmes

and devices, funding and costs, and ICT support (Benedon, 2018; Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). When satisfactory conditions are not realised in relation to these factors, they frequently represent barriers to ICT-delivered aphasia rehabilitation (Benedon, 2018; Burke, et al., 2017). Cost is also noted as a barrier to ICT adoption among other professional groups in the adoption of mobile health (m-health) such as electronic medical records and remote monitoring systems (Gagnon, et al., 2015). It is also reported as a factor when considering assistive technology (McGrath, et al., 2017) and telehealth service delivery (Dunkley, et al., 2010). Trialling technology before committing to purchase is an important factor that influences other health professionals' decision-making in relation to the adoption of, and recommendation for, new technologies (de Joode, et al., 2012; McGrath, et al., 2017). Training and the availability of support for SLTs are considered important by the professionals themselves (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). Training, and lack of it, has been highlighted as both a barrier to, and facilitator for, the introduction of ICT in health (de Joode, et al., 2012; Dunkley, et al., 2010; Gagnon, et al., 2015; Ifinedo, 2012; Liu, et al., 2015). Time has also been identified as a two-sided factor for technology acceptance. The adoption of technology may well be time-consuming especially in the initial stages of upskilling, but it can also save time for professionals in the long run (Gagnon, et al., 2015).

As noted in 2.4.1, the search strategy carried out as part of the integrative review on SLTs' perspectives of ICT in aphasia rehabilitation retrieved only seven peer-reviewed articles. There is a significant knowledge gap in this research area and further research is indicated. This prompted the qualitative research study that was carried out as part of Research Strand One.

3.2.1 Research Aims

This study seeks to explore SLTs' perspectives of ICT use in aphasia rehabilitation within their professional practice in an Irish context. It aims to identify the factors that influence their decision to introduce ICT into clinical practice and identify the barriers and facilitators to ICT usage and acceptance.

3.3 Methods

3.3.1 Recruitment

The study received ethical approval from the Social Research Ethics Committee (SREC) in University College Cork. Data collection commenced in December 2016 and the fourth and final focus group was completed in August 2017. A purposive sample of SLTs working within Ireland was invited to participate in the research. SLTs were recruited via email and provided with an information sheet about the research (Appendix 3). They were given the opportunity to ask questions about the research and were asked to provide written informed consent. SLTs were considered eligible if they were working with adults with acquired communication disorder for at least one session (3.5 hours) a week, there was no minimum experience required for participation in the study. Participants were advised that participation is voluntary and they could withdraw at any time up to one week after the focus group.

3.3.2 Data Collection

Four focus groups were carried out. Focus groups can provide a useful method for health research, and this mode of data collection can help provide rich data on a range of views from groups of SLTs. One key advantage of focus groups is the ability to discover not only the content of the knowledge but to explore how

decisions are made, and the naturalism of the interactions between participants can facilitate a much broader discussion than individual interviews (Green, 2013). Focus group methods have also been used in research exploring SLTs' preferences for ICT features (Swales, et al., 2016) and investigating clinicians' perspectives of high-intensity clinical programmes which included computer-delivered therapy (Gunning, et al., 2017). All focus groups took place in a boardroom of a health service facility. The groups were facilitated by the PhD researcher using a question guide (Appendix 4) to ensure fidelity to the research questions. Participants were encouraged to contribute to the discussion and were reminded there was no right or wrong answer.

In order to ensure confidentiality and respect for all within the group, participants were reminded at the start of the focus group that all comments and statements should be treated with respect and individuals' contributions should not be identified or discussed outside of the focus group. Participants were also reminded that all data gathered will be anonymised and no identifying information would be used in the write up of the research. All focus groups were audio-recorded and the recordings were transcribed by an individual not involved in the focus group. Each transcription was checked by the PhD researcher against the audio file.

3.3.3 Data Analysis

Data was analysed using inductive thematic analysis following the thematic analysis approach as outlined by Braun and Clarke (2006). Thematic analysis is a rigorous but flexible approach to qualitative data analysis that can be used across a range of research questions and epistemologies (Braun and Clarke, 2006). Two researchers (the PhD researcher and a final year SLT student under supervision) completed the first three stages of the thematic analysis and independently coded each transcript. The PhD researcher uploaded all transcripts to QSR International's

NVivo 11 software in order to store and organise the data; the final year student used paper copies and Excel to track her coding. Each transcript was read through for a sense of whole and then coded using six phases of thematic analysis as per Braun and Clarke (2006). During initial reading, any patterns or points of interest were noted and the researchers became familiar with each transcript. Initial codes were produced in an inductive manner, rather than theory-driven in nature, with the intention to capture as many themes as possible that would be refined later. Each transcript was coded separately and after each coding, the two researchers discussed the codes, their meaning and definitions, and any disagreements were resolved through discussion. Once a list of codes was generated from the four transcripts the researchers collaboratively looked at the potential themes. The PhD researcher used mind maps to visually represent the relationships between codes and between potential themes. Candidate themes and subthemes were identified. Following these initial steps of thematic analysis, the data was reviewed and refined by two researchers (the PhD researcher and PhD supervisor, Dr Helen Kelly). During this process, all the coded extracts for each theme were read through to decide whether they fit a coherent pattern. Where extracts were deemed not to fit, the two researchers discussed whether the theme itself was problematic, or if the issue lay with the extracted data. The two researchers collaboratively came to a final decision on each code and how it fitted within the subtheme and theme. When all the themes were considered to represent the coded data a second level of refinement began. This process involved the PhD researcher reviewing the themes in relation to the entire data set and required re-reading the entire data set with two purposes; to see if the themes fit the data set and to identify, and then code, any missing data that was overlooked in earlier coding stages. A thematic map was developed and the themes

were defined and further refined by identifying the "*essence*" of each theme (Braun and Clarke, 2006). In order to enhance rigour and transparency, the discussions within the research team and the outcomes of each discussion were noted at each point in the analysis process. In addition, the PhD researcher kept a reflective journal throughout the process in order to examine and reflect on her role through the research process taking into account her role within data collection and data analysis. Analytical memos were also tracked with the transcripts in NVivo 11.

3.4 Results

An overview of the participants is provided below (3.4.1). The findings of the thematic analysis (3.4.2) are presented first followed by an overview of the factors that influence the SLTs' decision to introduce ICT in aphasia rehabilitation (3.4.3). Finally, a summary of the barriers and facilitators to ICT-delivered aphasia rehabilitation (3.4.4) that were highlighted within the interviews will be reported.

3.4.1 Participants

Four focus groups were carried out between November 2016 and August 2017. Three of the focus groups took place in the mid-west region of Ireland and one in the greater Dublin area. Fifteen SLTs participated in the research. The SLTs represented a broad array of work settings in the Republic of Ireland as well as a wide range of experience working with adults with aphasia. See Table 3.1 for an overview of work setting, SLT experience, experience working with acquired communication disorders and proportion of caseload working with aphasia. All of the SLTs in this study used some form of ICT in the assessment or management of communication disorders.

Table 3.1. Participant Details - Speech and Language Therapists

Focus Group	SLT	Time spent working as SLT (years)	Time spent working with adults with acquired communication disorders (years)	Percentage of time spent working with adults with acquired communication disorders	Work setting
1	1	10-15	6-10	61-80%	rehab & community
1	2	> 20	15-20	41-60%	community
1	3	6-10	6-10	61-80%	community
1	4	10-15	10-15	< 10%	community & long-term care
2	1	6-10	6-10	< 10%	hospital
2	2	1-5	1-5	61-80%	hospital
2	3	15-20	15-20	81-100%	hospital
3	1	1-5	1-5	11-20%	community
3	2	> 20	> 20	21-40%	community
3	3	1-5	1-5	< 10%	community
4	1	6-10	1-5	41-60%	community
4	2	6-10	1-5	21-40%	community
4	3	1-5	1-5	41-60%	community
4	4	1-5	1-5	61-80%	rehab
4	5	6-10	6-10	61-80%	rehab

3.4.2 Themes

Four key themes were identified in the data; 1) Infrastructure, Resources and Support, 2) SLT Beliefs, Biases and Influencers, 3) Function and Fit, and 4) ICT and Living Successfully with Aphasia. The themes are described below with an overview of each theme and the corresponding subthemes with supporting quotes. The overview of each theme, subtheme, relevant codes and supporting quotes are presented in Appendix 5.

3.4.2.1 Infrastructure, Resources and Support

This first theme identifies many issues that are situated within the milieu of aphasia rehabilitation, including the relationships involved, the structure of services and the resources within these services. There are seven subthemes in this theme.

They include: Relationships, Service Delivery and Professional Support, Training Needs, Technological Change, Time, Cost and ICT Access and Availability.

The subtheme of Relationships encompasses the personal and professional connections within the rehabilitation environment and the everyday environments of the PwA. The issue of support for both the PwA and the SLT was discussed in each of the focus groups. The SLTs spoke about the support required to facilitate ICT-delivered intervention for aphasia rehabilitation. This support is needed to optimise successful integration of ICT into clinical practice and appears to reflect circles of support around the PwA and the SLT. With respect to support for the PwA, the person's family was seen as a key component providing this support in conjunction with support within the therapeutic relationship between the PwA and the SLT. One SLT reported: *"So you know or the other factor I find is, you really…when you have a really highly motivated family who want to work hard with them at home"* FG3P2.

The SLTs discussed how this can vary between families and they also discussed how the amount of support provided by families can change along the rehabilitation journey. Family support was frequently discussed as a facilitator for ICT integration. However, challenges and barriers were also identified. Examples were provided where the initial enthusiasm for ICT waned as rehabilitation progressed. One example of this resulted in a lack of access to a family member's ICT device that had previously been used in therapy. Another example described a situation where a family did not provide positive feedback to a PwA who used an ICT device for modified communication. Here, the PwA appropriately used emojis to indicate responses but the family did not accept this form of communication and instead pressed for articulated responses. By doing this, the SLT perceived that the use of ICT for communication was not readily supported at home, stating:

"*a…gentleman recently…he had requested or he was using his phone anyway, emojis and loads of really natural things that he would have used anyway, in a really successful manner but unless he said the word happy or whatever, the smiley face was not good enough in his families eyes. So there was so much time spent on pushing articulation of speech for a severely apraxic patient that, it was just lost and then he wasn't getting any positive feedback"* FG4P5.

The SLTs themselves also require support from within the service that they work in. They identified support from the multidisciplinary team and ICT support as important components to successful ICT integration in rehabilitation. In particular, the contribution of the Occupational Therapist when planning to introduce ICT was highlighted as important although, some noted the challenges in accessing such services. As one SLT acknowledged: *"And that depends on your working environment, I suppose we can run down the corridor and find the OT and say to them, listen, I notice on task that they are consistently missing the object or the space to the right they are not scanning all the way over"* FG4P4

The SLTs talked about the relationships between their profession and professional ICT services. This was discussed at two levels: the ICT support within the work environment and the programme developers that are creating rehabilitation software programmes. There is a perception of a chasm between the speech and language therapy and the ICT professions. One SLT suggested: *"Even that gap between us and IT or programme developers like…how do you meet in the middle…because they don't know what we want but they could do it and you know that relationship is missing"* FG3P3

While another acknowledged the role of ICT support and the perceived lack of support for ICT in rehabilitation activities: "*And you see that's another level of*

support…the IT support that we need on the job, do you know, that we could call someone and say you know look will you help me with this and we don't have that, like we have IT support for the big computers in the office if something goes wrong." FG3P2

The subtheme of Service Delivery and Professional Support extends the supportive relationships discussed in the previous subtheme and presents a vision of what the SLTs considered as one of the optimum service delivery options with respect to ICT. Here, the SLTs considered the benefits of a specialist clinical service to support ICT in SLT practice. This was envisaged in different ways. Some talked about SLT assistants to support ICT use in clinical practice. Others imagined a specialist role for an SLT, describing a clinical specialist focus on ICT in practice. This specialist SLT would work within, and provide support to, a speech and language therapy team. One SLT suggested: *"…actually a specialist IT therapist would be great if we had one of those in every department that went around, not just an IT technician but a specialist SLT IT technician!"* FG2P1

An additional subtheme identified Training Needs and highlighted the support in relation to training for both the SLT and also the PwA, who wish to engage in ICT-delivered aphasia rehabilitation. Within the discussion relevant to this subtheme, training needs were debated and largely considered unmet as the SLTs discussed what they would like to see provided and highlighted the limited training currently available to them. One SLT noted *"I'd like more training and more education opportunities"* FG4P2

In addition to their own training needs, they also discussed the training needs of the PwA. This was particularly relevant in relation to introducing ICT-delivered aphasia rehabilitation for individuals who may not have basic ICT skills and this can

act as a barrier. One SLT identified the effort that may be required to set up ICT in rehabilitation and how this impacts on her decision to introduce it: *"I'm hesitant to use it because you'd be spending so much time teaching them actually how to use an iPad, even though the apps are very intuitive, I think you have to have a mind for it. So like, if you were spending your time being like, "oh no, backward, forward, here's the home button", showing the basics, I think it would be a bit of a barrier"* FG1P3

The subtheme Technological Change highlighted that digital technology is seen as fast-changing and challenging to keep up with. These changes are bringing new benefits and the use of touch screen technologies, and accessibility features of new ICT devices was seen as an important facilitator for ICT implementation. This is seen as an opportunity with one SLT reporting: *"I think technology is so ubiquitous…like everyone has an iPhone and then they'll know to work an iPad, someone somewhere will know how to work the iPad, so I think that's a facilitator and even basic functions it's like go away and take photos of that or go and video on your own phone… that's very straightforward."* FG4P3

However, technological advances also bring new challenges for SLTs who now need to consider emerging issues with Data Management and Protection. These technological innovations create new opportunities but some feel that the Irish health service is lagging behind when compared to international health services.

Under the subtheme of Time, the SLTs repeatedly discussed the issue of time constraints and in particular the time required for their own upskilling as well as time required to set-up ICT within aphasia rehabilitation. These were highlighted in all focus groups and were identified as potential barriers to the implementation of ICT-delivered aphasia rehabilitation. One SLT identified that even though there are

resources available to assist SLTs, it is time consuming to become familiar with what apps are available: *"It's the time taken to up-skill on it, and I suppose you can use things like the aphasia software finder website, but you don't really know. You have to go download it, test it out, you know"* FG4P3

While another SLT noted that time within therapy sessions is constrained and this can impact on the decision to use ICT in sessions: *"we have 45 minutes here I'm not going to spend half of the time that this person has in front of me fighting with the iPad. Because it takes so much time and your time is gone and you are there trying to figure it out."* FG3P2

The subtheme of Cost highlighted another barrier to ICT adoption as the SLTs talked about the cost of hardware, software and licences for therapeutic programmes. This impacted on their ability to access and trial new resources with one SLT highlighting: *"And the cost of them all you're not just going to take that on yourself to download it for a check to check what it's like"* FG4P1

The cost of programmes also influenced their decision to recommend these to people with aphasia or their families who may wish to purchase software for home exercises. One SLT indicated: *"I think I'm slow enough to recommend it to somebody just because it's quite pricey"* FG1P1

The SLTs also identified that the availability of funding is restricted in some cases due to health conditions. They reported how it is easier to access Alternative and Augmentative Communication (AAC) devices for individuals with MND as this comes from a specific budget but ICT devices for a PwA is not funded as easily.

The final subtheme, ICT Access and Availability, highlighted the variability among teams with respect to access to ICT devices and apps in clinical practice and this has an impact on their ability to trial and test out new resources for future use.

One SLT noted how ICT is being used within their team: *"we have three iPads and we do have a lot of [named commercially available programmes] apps on them. Some of the girls use them regularly in their therapy"* FG4P2

This contrasts with the reports from another SLT who identified the challenge of accessing the programmes for use with patients due to the installation on specific devices within a shared office: *"we do have one or two [referencing therapeutic software programmes] unfortunately here for us they're downloaded to one particular computer, so trying to get access to the room"* FG2P3

The access to and availability of ICT devices, software and infrastructure such as WiFi, were seen primarily as barriers to the implementation of ICT-delivered aphasia rehabilitation as many of the SLTs reported having limited access. The SLTs reported that increased access would likely result in greater use of ICT in rehabilitation as this would allow them to try out the resources with people with aphasia before making recommendations. One SLT suggested: *"I think if there were more iPads available to give out on loan that had apps already…installed on them…because, I think, you kind of feel nervous about that conversation about cost…and you want someone to try something before they buy it"* FG1P3

3.4.2.2 SLT Beliefs, Biases and Influencers

This theme explores SLTs' perceptions of the factors that influence their own ICT usage in clinical practice. Under this theme, the SLTs explored their sense of competency and confidence when integrating ICT into aphasia rehabilitation and considered this against aspects of traditional face-to-face therapy activities in aphasia rehabilitation. They also examine the factors that influence the suitability of the PwA engaging in ICT-delivered aphasia rehabilitation. There are four subthemes in this

theme: Ageism, Harmonising Patients with ICT, Questioning Traditional Mind-Sets and Digital Discomfort.

The subtheme Ageism identifies a bias with respect to the age of the PwA and this was recognised by the SLTs within all focus group discussions. They identified that this conscious bias should be challenged but clinical experience has led them to consider younger adults with post-stroke aphasia as having a greater potential for successful implementation of ICT-delivered aphasia rehabilitation. One SLT reported: *"I suppose I do think well if…and it's terrible, if they are a younger client they are going to be more willing to use it and it's terrible, like, and I should automatically think about using it with older clients."* FG3P1

They recognised that older adults may be interested in using digital technologies. However, when considering the older PwA, they questioned who is pushing the agenda for introducing ICT-delivered aphasia rehabilitation, when this is being queried as an option for rehabilitation by family members or the PwA. One SLT asked: *"I wonder with that client age group [referring to older adults] whether…who is wanting the technology?"* FG4P5

The SLTs also referenced life stages and how ICT use may vary among different generations. They reflected on their own use and some reflected on their parents' use of digital technologies. There was a sense that each generation will be using more technology than the generation before and this will impact on the drivers and facilitators of ICT use in rehabilitation as time progresses. One SLT considered the future and their need to upskill to keep up with the next generation: *"And I suppose as the years go on, it's becoming more expected that we are au fait with it [ICT], it's kind of nearly at this stage you can't really say oh gosh, I actually don't know anything about it, I feel I should know something about it, that's what they are*

looking for. And as the next generation comes up…they are going to be more demanding of skills and support and knowledge in that area. So I think it's really, really essential that we get it, that we up skill on it and have the support" FG3P2

Under the subtheme Harmonising Patients with ICT, the SLTs referenced a range of factors related to the PwA that influence their decision to introduce ICT into the person's rehabilitation plan. These factors include post-stroke deficits such as visual impairment, cognitive skills, the person's pre-stroke ICT skills and their openness to ICT-delivered aphasia rehabilitation. One SLT identified how it is important to gather information on the ICT skills of the PwA as part of their initial case history: *"…establishing a patient's baseline IT skills is probably the initial thing that you do and then develop your programme or your advice around that."* FG4P5

One SLT suggested that the openness and motivation of the PwA and their family can be the catalyst for introducing ICT into rehabilitation: *"So I think it's interest and it's often they ask for it before I produce it or a family will ask for it"* FG3P2

The SLTs discussed how a discrepancy between family and SLT expectations regarding the benefits of ICT for the PwA can be challenging. Devices such as iPads may be viewed as a magical solution to the problem of post-stroke aphasia. However, this is rarely in keeping with the SLTs' evaluation of the situation. This mismatch of expectations and the challenge of balancing the needs of the PwA with the available ICT is an ongoing challenge. This was highlighted by one SLT who noted: *"I think it's that difficulty that they think that this magic slate is going to give communication back."* FG3P2

The subtheme Questioning Traditional Mind-Sets was identified as the SLTs questioned some of the traditional roles they hold in aphasia rehabilitation and the role that ICT brings to rehabilitation. The difference between traditional pen and paper activities compared to ICT-delivered rehabilitation was viewed from a variety of perspectives. Paper activities were seen as dependable resources that are easily accessible and not breakable. An alternative view was that rehabilitation software was seen as a means of ensuring consistent therapeutic cueing with one SLT suggesting the potential benefits of this for home practice: *"I guess sometimes the IT ones might cue better than you might imagine some family members, you know, unless you've done a lot of training with them about cueing and if you imagine them doing a paper-based task at home together, you might wonder how that other person supports them in a task, whereas at least on the iPad you know that they're going to do appropriate... cueing"* FG1P3

The added benefit of gamification of rehabilitation using ICT and apps was also noted with one SLT suggesting: *"But technology is interactive and there is an element of fun about it too, whereas the paper-based stuff is not so fun."* FG3P3

Some also considered there were no difference between ICT-delivered and pen and paper therapeutic activities and one SLT stated: *"I wouldn't see any difference between giving paper-based activities or IT-based activities in terms of, kind of, cueing"* FG1P2

The SLTs also questioned their role in teaching ICT skills to a PwA who does not have basic ICT skills. This role was considered unclear, although it was noted that SLTs had specific skills that would be beneficial for supporting a PwA who is learning ICT skills. This was debated in one focus group with one SLT

reporting: *"I struggle with that one [referring to training ICT skills for PwA] because I don't think that the role is defined for us"* FG4P5

This was followed up by another SLT within the group who asked: *"Yes, if we don't do it, who will?"* FG4P3

Finally, within the subtheme Digital Discomfort, the SLTs discussed their own skills and knowledge of ICT with a sense of perceived limitations. This seems to reflect a vicious circle where SLTs feel that familiarity and repeated use of ICT would enhance their skills and increase confidence but this repeated use is not happening due to their current lack of confidence, access, opportunity and caseload. One SLT considered: *"I think if I were more familiar with them and had more accessibility to them and if I were bringing them very naturally into therapy sessions I think I would see much quicker"* FG3P2

Within the same group another SLT highlighted the challenge of having a diverse caseload and with limited opportunities to use aphasia rehabilitation resources: *"we bought one app and I can't even remember what it was and then no clients came through for us to use it! And then we forgot about it and we never used it."* FG3 P1

In this way, a cycle continues where SLTs reported that they feel they are unable to keep up to date with advancing and changing digital technologies. A sense of unease and discomfort about this new mode of rehabilitation emerged in some of the discussions. Some SLTs reported feeling out of their comfort zone, especially when asked for recommendations regarding ICT devices or therapeutic software programmes to help support the PwA, and also when asked for their opinions on particularly apps by families. One SLT reported a recent incident that reflected this unease: *"I had a phone call this week from…an outpatients' son who had*

downloaded an app that I've never heard of and wanted to know my opinion on it. So I just had to say I've never heard of it, but I'll have a look at it… and, I did and then he asked what other apps I'd recommend and I kind of felt slightly panicked" FG1P1

3.4.2.3 Function and Fit

This theme was embedded in the SLTs discussion of their experience of clinical practice and the application of ICT in aphasia rehabilitation. The SLTs discussed some of their commonly used software applications for acquired communication disorders and highlighted the potential benefits of using ICT in rehabilitation. They also spoke about the challenges of finding apps that fit individual rehabilitation goals. There are two subthemes: Therapeutic Practice and Benefits and Fit for Purpose?

The subtheme Therapeutic Practice and Benefits identified the potential of ICT as a mode of providing increased intensity and flexible delivery of aphasia rehabilitation at a time and place convenient to the PwA. This was seen as a having a positive potential for ongoing service delivery while awaiting face-to-face therapy and as a means of working through rehabilitation activities at home between sessions with the SLT, with one SLT suggesting: *"And I suppose some clients going home, I suppose if there was going to be a wait for community, they would use the [named commercially available app] app as well"* FG3P1

They identified that available software may improve treatment fidelity outside of the clinic by providing standardised prompts and cues when compared to pen and paper activities delivered by family members. This was highlighted as an important factor for home-delivered aphasia rehabilitation where a PwA can independently work on their rehabilitation. One SLT emphasised the benefits of this: *"you know the way being dependant on someone else to do the homework with*

you, they can go away and do it independently and they don't feel that someone is correcting them whereas they'll get that feedback from the likes of the [named commercially available] apps and those ones" FG4P3

However, this was considered to be less common in practice and it was considered more likely that people with aphasia are assisted by family members when carrying out activities at home with one SLT suggesting: *"…it's fantastic but I think more often than not they are not doing it themselves [working independently on ICT-delivered homework activities], you are trying to get them to do it or the family."* FG3P2

The SLTs recognised the potential benefits of using ICT for home-based activities for rehabilitation and considered it ideal as an adjunct to face-to-face therapy. They discussed how face-to-face rehabilitation should not be replaced by ICT-delivered rehabilitation as they considered that the PwA needs the face-to-face contact provided in SLT sessions. One SLT highlighted the need for ongoing support: *"they [reference to the PwA] still need the face to face support"* FG2P1. This was echoed by an SLT in another group: *"I wouldn't actually completely replace with IT"* FG3P2

Within the subtheme Fit for Purpose?, the SLTs discussed that good quality, up to date, flexible software programmes that target specific rehabilitation goals can be hard to find.

The SLTs highlighted that a large range of apps are now available for aphasia rehabilitation but they questioned the quality and flexibility of many of these apps. This is particularly relevant as it can be difficult to appraise the quality with the minimal content available in free trial downloads. As one SLT stressed: "*There's no quality control, it doesn't have to reach a certain standard to have "Aphasia app"*

on it" FG1P2. This was reiterated by another SLT in the same focus group who highlighted: *"And some of those low quality ones offer a free trial, but there's no way of actually using the free trial. I downloaded a couple of them"* FG1P1

It was noted that content of some apps may not reflect culturally relevant material and the choice of accents for voice output is often limited. This was highlighted while also discussing using ICT for augmentative and alternative communication. The potential for personalising the material within the therapy sessions delivered by ICT software was seen as a positive feature of some apps. However, this is also noted as a challenge where some programmes don't facilitate such personalisation or the functions involved are not easily usable. One SLT highlighted: *"Because there is apps there but they don't have everything that you'd want and how do you move onto the next step or if there was another folder within it, where you know to edit it, you can't"* FG3P3

Two of the groups discussed how devices can be made more accessible and can be customised to each individual, providing improved and personalised ease of use for activities. One SLT explained: *"so like both the Android and the Apple devices now, I find retrofit a lot of accessibility features so not just physical stuff but also things that is really beneficial for our patients with aphasia so using the readability feature just simplifies and declutters like an Irish Independent article so somebody who is milder on the spectrum that would just declutter the whole thing, makes it much easier for them there is no junk on the page for them to have to process*" FG4P4

3.4.2.4 ICT and Living Successfully with Aphasia

This final theme explores the impact that ICT can have on a persons' recovery after a stroke. The SLTs discussed examples, from their own clinical

practice, of ICT aiding people's return to work, facilitating their resumption of their role coordinating activities within a family, and increasing independence by reducing dependence on others. All groups recognised the potential impact of ICT as being both positive and negative for a PwA. There are three subthemes in this theme: Emotional Effects of ICT, Levelling the Playing Field and Redefining Independence and Social Affiliation.

The subtheme Emotional Effects of ICT highlighted the potential of ICT to promote independence and improve psychological well-being. Introducing ICT into aphasia rehabilitation was noted to have a positive impact on individuals by providing a sense of success and achievement. One SLT reported their experience: *"...and then they've had a stroke and all of a sudden you're putting this iPad in front of them and they can kind of, with lots of help, get through like, the [named commercially available application]...or something, and there's great sense of like "I've achieved something""* FG1P2

However, the potential for negative effects of ICT were also discussed. The possibilities of failing to achieve task goals in ICT-delivered therapy activities, becoming frustrated with ICT usability and being overwhelmed by the introduction of new technology and programmes were also acknowledged. One SLT acknowledged: *"I guess there's the risk as well that, when they go home, even if you've given them clear instructions about what they're going to do, when, if they go into the wrong or, you know an ad- area that's not suitable for them and it's too challenging, they could easily have a negative experience of it, you know"* FG1P3

The SLTs also recognised that people with aphasia bring their own experience and expertise to the rehabilitation process. In the case of a PwA who brings prior ICT experience and skills to the rehabilitation process, they may actually

be in a position to teach the SLT some new skills and this was considered a positive experience. One SLT suggested: *"And often the higher functioning clients, they're educating us rather than us educating them."* FG1P2

Under the subtheme Levelling the Playing Field, the SLTs explored how ICT can provide opportunities to circumnavigate the acquired communication impairment and facilitate an alternative mode of communication. This was seen as an opportunity for people with aphasia to engage in a new mode of communication and can potentially facilitate equal access to communication for those with post-stroke aphasia in some contexts. The ubiquitous nature of digital technologies and the growth of messenger apps such as WhatsApp and Viber have resulted in a form of communication that can use both text and non-text formats to convey messages. The SLTs considered that the use of images and emojis in this manner can support communication for a PwA while not drawing attention to their communication disability and may help reduce social isolation. They questioned if the increasing use of these forms of communication which are becoming more "social acceptable" will also have the potential to facilitate increased communication participation for a PwA. One SLT considered: *"And I wonder will that [stronger focus on speech output in therapy over total communication] change over time because WhatsApp you know, it's all more frequently used."* FG4P3. This was also reflected within discussions in another group with one SLT suggesting: *"So yea, some of the communication apps, the communication aid apps, are quite nice and I think they are really nice for an iPhone or smart phone, that some people in my experience, some people who wouldn't bring around a communication book in their pocket will take out an iPhone and communicate with you through an iPhone because it's much more normal."* FG3P2

However, it was also noted that social media applications may also be inaccessible to some people with aphasia which may further impact on their ability to engage in social communication activities.

The final subtheme Redefining Independence and Social Affiliation was identified following the discussions of clinical examples of ICT providing opportunities for a PwA to regain, or renew, roles that had been taken away from them following the onset of aphasia and stroke. One example involved a young mother who could no longer engage with WhatsApp groups because of her acquired difficulties with written language. However, once introduced to speech-to-text and text-to-speech functions she was able to send and receive messages successfully. This allowed her to communicate with her husband and family to ensure her children were managing with day to day activities while she was away from the home during inpatient rehabilitation. This was recognised as an important enabler for regaining important personal roles that may appear to be lost following the onset of aphasia: *"And it kept her role pivotal in the family which is so important for mum"*FG4P2

ICT can also be empowering for a PwA. It can allow a PwA to direct their own rehabilitation goals and advocate for themselves. One group discussed how people with aphasia, in particular younger adults, are using social media and online forums to access support and information on aphasia. One SLT described how a young woman with aphasia, who wanted to raise awareness of her condition and how best to help support her communication difficulties, used her Facebook profile to circulate information to her friends: *"I had a lady who did that as well, we developed her strategies over a session or two, I typed them up and then she was, right, took a picture and posted it up to Facebook there and then, and she was like when I'm home at the weekend this is what I want everyone to know how they can support me,*

how I'm helping myself as well. So it was just really empowering for her to just take charge. Again, someone who was very cognitively able." FG4P3

3.4.3 Factors influencing Decision Making

A number of key factors were highlighted to influence the SLTs decisions to introduce ICT-delivered aphasia rehabilitation. These were primarily situated at four levels; the abilities and skills of the person post stroke, the confidence and knowledge of the SLTs, the availability of support and ICT access in the rehabilitation environment and ICT programme features. These are presented in Table 3.2 below.

Table 3.2. Factors influencing Discussion Making

Related to	Factors that Influence Decision Making
Person with Aphasia	Age, prior ICT skills, motivation and interest, visual and cognitive skills post-stroke, family support
Speech and Language Therapists	Time to upskills, time to set-up and implement ICT in sessions, training needs, keeping skills up to date, questioning the role of SLT in teaching ICT skills
Rehabilitation Environment	Access to ICT devices and rehabilitation programmes (including licences), Access to funding for ICT, WiFi, IT support, IT support services, Data Protection Issues
Programme features	Accessibility and ease of use features, Targeted therapeutic approach – including a wide inventory of therapy tasks with a broad array of levels of difficulty in tasks, outdated ICT, quality of programmes, monitoring progress, providing motivational feedback

3.4.4 Barriers and Facilitators

A number of key barriers and facilitators were identified by the SLTs in this study. These also reflect many of the factors that SLTs consider when deciding to introduce ICT into clinical practice with a PwA. The most prominent barriers are those related to access to ICT software and hardware. The cost of licences and the availability of programmes and devices were identified as obstacles to the introduction of ICT in aphasia rehabilitation. The SLTs reported that keeping up to date with ICT advancements in clinical practice is a barrier to implementation. A

mechanism for sharing knowledge was proposed by one group member as a potential method to improve access to up-to-date information. Their own perceived skills and training needs may also act as barriers to implementation. Additionally, when considering the PwA, the presence of co-occurring cognitive and visual impairments was seen to act as a potential barrier to the successful use of ICT-delivered aphasia rehabilitation. Although the discussions within the four focus groups appear to concentrate on barriers, a number of key facilitators are also identified. The ubiquitous nature of digital technologies in everyday life was seen as a potential facilitator for the use of ICT in rehabilitation. This pervasive presence of ICT has resulted in greater access and social acceptance in general. Finally, the presence of family support, prior ICT skills, and individual motivation were noted as important facilitators for the PwA.

3.5 Discussion

This qualitative research explored SLTs' perspectives of ICT-delivered aphasia rehabilitation using focus group methods. The study sought to explore SLTs' perspectives of ICT use, to examine the factors that influence their decision to introduce ICT into clinical practice and identify the barriers and facilitators to ICT usage and acceptance. Four themes were identified: Infrastructure, Resources and Support, SLT Beliefs, Biases and Influencers, Function and Fit, and ICT and Living Successfully with Aphasia. The SLTs in this study were identifying, and advocating for, the potential that ICT can provide in aphasia rehabilitation in terms of supporting communication, regaining lost communication roles and broadening networks. However, they also highlighted numerous barriers to ICT introduction and implementation in aphasia rehabilitation. There are a large number of varied factors that influence their decision to introduce ICT into aphasia rehabilitation. These

reflect many of the factors that emerge in the limited available research on the use of ICT-delivered aphasia rehabilitation among SLTs and are consistent with findings of ICT acceptance and use among other health professional groups.

3.5.1 Perceived Benefits and Gains

The proliferation of ICT devices and available software presents an opportunity within speech and language therapy. One key perceived benefit of introducing ICT into aphasia rehabilitation is the potential to increase the intensity of rehabilitation by providing an adjunct to clinical sessions. ICT was also identified as a potential mechanism for providing a mode of rehabilitation when a person is waiting to access a service. The perceived gains that can be achieved by using an ICT system are the strongest predictors of use of that ICT system (Venkatesh, et al., 2003). These findings suggest that SLTs consider that ICT can provide increased intensity and act as an adjunct to therapy. This reflects the perceived benefits of this mode of rehabilitation as reported in other studies of SLTs' views of ICT-delivered aphasia rehabilitation (Davis and Copeland, 2006; Hill and Breslin, 2016). ICT can provide a system of cueing and prompting that was considered more consistent than what may be provided by the family. The provision of ICT generated feedback is also considered beneficial as it provides concrete results to the PwA which is considered a potential source of motivation for some in rehabilitation (Gunning, et al., 2017).

Self-managed aphasia rehabilitation in the home can provide an option for some people with aphasia (Palmer, et al., 2012). The SLTs in this study identified the potential for independent practice at home by the PwA as an important, empowering aspect of ICT-delivered aphasia rehabilitation. However, some questioned if rehabilitation is truly self-managed at home and considered the role of

the family to be important to support the individual. Family support has been rated by SLTs to be an important factor when deciding to introduce technology in stroke rehabilitation (Chen and Bode, 2011).

3.5.2 Suitability and Effort

The suitability of the available programmes with respect to targeting the specific level of breakdown in the language processing system and at an appropriate level of task complexity is highlighted as an issue when attempting to fit the programme to the needs of the individual (Hill and Breslin, 2016; Swales, et al., 2016). Similarly matching the individual's abilities and skills to the available ICT devices and software programmes were seen as a challenge.

Age was referenced in each of the focus groups as a factor that influences SLTs decisions to introduce ICT in rehabilitation. This may indeed reflect the nature of clinical practice in which the proportion of rehabilitation goals in therapy decreases with increasing age when compared to assessment, enabling or supportive goals (Palmer, Witts, & Chater, 2018). Alternatively, it may reflect the findings from Menger, Morris, & Salis (2019) who studied post-stroke internet use among a group of participants with and without aphasia and found age, but not presence of aphasia, was a significant predictor of internet use. Additionally, participants' perception of age was noted to be a barrier to acquiring or improving internet skills (Menger, et al., 2019). Within our study, the SLTs also considered the PwA's ICT skills as a key factor when deciding on ICT in rehabilitation. Prior ICT skills are considered more favourable when introducing ICT in aphasia rehabilitation (Gunning, et al., 2017; Hill and Breslin, 2016). This may be because the PwA is more readily equipped to start using ICT in rehabilitation and therefore better able to engage in the process. People with aphasia who have higher levels of prior computer

experience have been noted to spend more time working with a ICT-delivered rehabilitation programme compared to those with lower experience (Marshall et al., 2016). Those with limited experience of ICT may be more likely to question their ability to engage in ICT-delivered aphasia rehabilitation (Hill and Breslin, 2016).

The production of ICT devices with touch screen interface and integrated accessibility features has led to improved ease of use and accessibility for devices. Smartphone and tablet technology use has increased among the general Irish population in the last five years (CSO, 2018). The challenge of keeping ICT knowledge and skills up to date in an ever-changing technological environment adds additional stresses to the SLTs' already busy workloads. This can have a negative impact on SLT confidence (Gunning, et al., 2017) and perceived limited knowledge within the area (Benedon, 2018). In addition, the impact of post-stroke visual and cognitive impairments may negatively impact on the PwA's ability to engage successfully with these ICT devices and programmes (Chen and Bode, 2011; Hill and Breslin, 2016; Schröder, et al., 2007). These issues may in some way reflect the UTAUT construct of effort expectancy (Venkatesh, et al., 2003). The dichotomy of this construct is highlighted in the perception that some factors will enable ease of use of ICT-delivered aphasia rehabilitation for example accessibility features on ICT devices. However, other aspects may increase effort for both the PwA and the SLT, such as remembering how to log in and use the programme and keeping up to date with an ever-expanding repertoire of rehabilitation software and application.

3.5.3 Social Influence

ICT offers new options for modes of communication that can be exploited by people with aphasia in order to regain and renew their communication networks. The ubiquitous nature of ICT, social media and messenger platforms means that new

forms of communication e.g. picture messaging and emojis have become a normal aspect of everyday life. Using these applications is not associated with social stigma and normalises a variety of modes of communication, not just text and speech e.g. emojis, photo messaging etc. The acceptance of these alternative forms of communication can be considered positive in the content of a PwA who may have difficulty accessing traditional modes e.g. text and speech. However, this must be balanced against the context of others' acceptance, thus reflecting the construct of social influences within the UTAUT (Venkatesh, et al., 2003). The SLTs highlighted that the aspiration to return to pre-stroke communication skills may be stronger than the acceptance of modified, functional communication. This can be an issue with respect to family acceptance of modified communication in an ICT medium and may impact on the adoption of ICT in rehabilitation. Equally, unrealistic expectations that families and patients may have with respect to the potential of ICT may lead to disappointment if not realised. Family support and encouragement is an important factor in the introduction of ICT devices in rehabilitation (Chen and Bode, 2011).

3.5.4 Resources and Supports

The supporting conditions around the PwA and the SLT were highlighted as substantial issues in the focus groups with respect to usage and acceptance of ICT-delivered aphasia rehabilitation. An optimum level of support within the environments in which both parties are situated, e.g. the home and the clinic, was emphasised as a requirement for the implementation of ICT-delivered aphasia rehabilitation. The SLTs envisioned an optimum service with support from IT departments, specialised SLTs and SLT assistants that could provide them with the confidence and assistance to ensure quality ICT-delivered aphasia rehabilitation

(Chen and Bode, 2011). This support would ensure that they would receive adequate training and they could remain up to date and confident about their knowledge and skills (Chen and Bode, 2011; Hill and Breslin, 2016). Having resources available to them including internet access would ensure that sessions could run smoothly (Davis and Copeland, 2006). Similarly, having ICT devices and licenced programmes at their disposal, in order to test these out and understand their functions, and to trial these with people with aphasia before making a clinical decision to implement them, was seen as important (Benedon, 2018; Swales, et al., 2016). This would inevitably involve a change in resource allocations and a review of working practice so that time could be prioritised for these activities within a constrained work environment; something that the SLTs felt was not currently possible in most cases. Time spent on ICT activities has been highlighted in other studies (Hill and Breslin, 2016) in particular in the early set-up stages. These factors reflect the facilitating conditions construct in the UTAUT (Venkatesh, et al., 2003) and these were highlighted as significant issues among the SLTs in this study.

All of the issues highlighted above fall within a dilemma of technological change and the challenge of keeping in pace with this change. This requires a shift from traditional roles to a new understanding of the role of ICT in rehabilitation technology. The SLTs in this study identified the potential for ICT as an adjunct to face-to-face therapy but strongly valued the face-to-face contact from traditional therapeutic sessions. Face-to-face contact was considered an important factor before beginning ICT-delivered aphasia rehabilitation (Hill and Breslin, 2016). Also, Swales, et al. (2016) reported that SLTs in their study identified the need for a larger variety of prompts and cueing within therapeutic software programmes to reflect what happens in face-to-face therapy sessions.

Support for the PwA and the SLT is a shared key facilitator for the adoption of ICT-delivered aphasia rehabilitation (Chen and Bode, 2011). This support is situated in the surrounding environment for each partner in the therapeutic relationship e.g. the family home and the health care setting. The types of support differ but both forms are seen as important factors for both stakeholder groups in ICT-delivered aphasia rehabilitation.

3.5.5 Limitations

The focus groups in this study were carried out in four urban areas in the Republic of Ireland and all the participants were employed by the Health Service Executive, the national provider of health services in the Republic of Ireland. The transferability of the findings may be limited due to the number of participants and the diversity of workplace environments in which they were employed. However, the SLTs in this study represent a broad spectrum of clinical experience and practice in a variety of settings. Also, a number of the participants in Focus Groups 1 and 3 also worked in posts that were split between two services and providing services to both urban and rural communities.

The concept of data saturation as a measure of quality is noted as a contentious issue in qualitative research (O'Reilly and Parker, 2013). It has been promoted as a practice to determine sample size (Marshall, 1996) in which recruitment is ceased once new categories or themes stop emerging in the data. However, the concept of saturation was originally linked to grounded theory (Bowen, 2008; O'Reilly and Parker, 2013) and its use in other qualitative research methods is less transparent. It is not possible to state that saturation was achieved in this study as a new subtheme was identified in the final focus group (Marshall, 1996). In this study, the majority of the codes were identified in the first two focus

groups. Focus Group 3 identified five new codes. All of these were reflected in existing subthemes. The final focus group reinforced two of the new codes identified in Focus Group 3 and generated five more new codes. Three of these were situated within existing subthemes and a new subtheme was identified taking into account two of these new codes. This subtheme "Redefining Independence and Social Affiliation" was subsumed under the existing theme "ICT and Living Successfully with Aphasia". The new subtheme has similar attributes to an existing subtheme "Levelling the Playing Field" but distinct qualities in relation to the personalised effect of technology on individual experiences of empowerment and enablement; distinct to the potential of technology to facilitate participation by reducing barriers, in general. It is important to note that the four key themes were identified within the data of the first and second focus group, and no new themes emerged after this, but rather existing themes were further defined and refined.

3.6 Conclusions

The past decade has seen a significant increase in the availability and affordability of ICT devices for personal use. This has been accompanied by the increased availability of programmes and apps for aphasia rehabilitation. It is important to consider SLTs' perspectives on the use of ICT in aphasia rehabilitation as this will influence integration and options offered to patients within clinical practice. This research highlights the emerging issues for SLTs in relation to the adoption and use of ICT in rehabilitation. It provids an overview of the factors that influence their clinical decision making when using ICT in aphasia rehabilitation. These factors relate to 1) the PwA and their support network and environment, 2) the SLT attitude and skills, and 3) the service delivery environment. The strongest influencers appear to reflect two constructs of the UTAUT. Firstly, the perceived

gains of using appropriately targeted software programmes as an adjunct to face-to-face therapy, thus increasing therapy intensity, reflects the performance expectancy construct that is the strongest predictor of use. Secondly, the access to suitable hardware and software, training and support, reflects facilitating conditions that must be met to enable adoption of ICT-delivered aphasia rehabilitation. There is a positive perception of the potential benefits of using ICT in rehabilitation and in functional everyday communication. However, this is also accompanied by the perception that there are many barriers currently preventing easy implementation of this mode of rehabilitation.

3.7 Chapter Summary

This chapter provided information on the research design, methods and findings of a qualitative study undertaken as part of Research Strand One which explored the perspectives of SLTs engaging in ICT-delivered aphasia rehabilitation. SLTs are important stakeholders in the provision of ICT-delivered aphasia rehabilitation and it is important to understand their views of this mode of rehabilitation. A variety of factors that influence SLTs' decision making with respect to the use and acceptance of ICT in rehabilitation were identified. This in-depth analysis provides a deeper understanding of the issue of ICT acceptance and use in aphasia rehabilitation. These findings will be combined with the perspectives of the participants with aphasia in Research Strand Three (a feasibility study of ICT-delivered aphasia rehabilitation targeting auditory comprehension at sentence level). The combined results from both stakeholder groups in these two research strands and the implications for clinical practice will be discussed in Chapter Nine.

Chapter Four

Chapter Four - Self-reported Feedback in ICT-delivered Aphasia Rehabilitation: a Literature Review

4.1 Introduction to Chapter

This chapter provides an overview of the background literature relevant to the Research Strand Two in this thesis. A literature review employing restricted systematic review principles was carried out to explore and synthesis the findings from the current research examining self-reported feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation. This chapter will introduce the context of the review (4.2), the aims of the review question and the methods undertaken to answer them (4.3), the findings of the search strategies and included studies (4.4), and the implication of these findings (4.5) as relevant to Research Strand Two.

4.2 Background

As described in Chapter One (1.2), aphasia is a significant issue for many people post stroke with consequences that can impact on well-being and social inclusion. Intensive rehabilitation is important for successful outcomes. Information and Communication Technologies (ICT) may provide an option for intensive rehabilitation for individuals with post-stroke aphasia (Code and Petheram, 2011) but consideration must be given to the feasibility and acceptance of this mode of rehabilitation. Menger, Morris, & Salis (2016) highlight that individuals with aphasia may be vulnerable to digital exclusion, not only due to the presence of aphasia but because of concomitant factors. Aphasia may co-occur with other disabilities post stroke including hemiplegia, visual deficits and fatigue. These present challenges for individuals accessing ICT devices e.g. desktop/ laptop/ tablet

computers and smartphones, and may impact on engagement in this mode of rehabilitation. Additionally, many applications available for ICT-delivered aphasia rehabilitation have been designed *for* people with aphasia but have typically not involved people with aphasia in the design process. Some notable exceptions have involved people with aphasia in the design process of a daily planner (Moffatt, McGrenere, Purves, & Klawe, 2004), an assistive email interface (Mahmud et al., 2014) and two therapy tools (Wilson, et al., 2015). Wilson, et al. (2015) employed a team approach with a speech and language therapist, a human computer interaction researcher and people with aphasia acting as consultants, participating in the design process. A systematic scoping review investigating administration methods and patient experience of mobile tablet-based therapies following stroke concluded that treatments targeting communication, cognitive and fine-motor deficits have been positively received by patients and suggest that tablet-based therapy may be feasible for post-stroke rehabilitation (Pugliese, Ramsay, Johnson, & Dowlatshahi, 2018). Eleven of the 23 included studies involved an intervention for communication. The authors highlight that current available evidence is limited, little is known about treatment adherence and they recommend further feasibility studies should be carried out in this area.

As previously reported in this thesis there are a number of models that can be applied to frame the factors that influence the acceptance and usage of an ICT system. The model of system acceptability proposed by Nielsen (1994) was described in Chapter One (1.7) and The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, et al., 2016) has also been described in Chapter One and Chapter Two (2.2.1). The UTAUT has been used to examine factors that influence health professionals' acceptance of new technologies in stroke

rehabilitation (Liu, et al., 2015) and is emerging in research of patients' perceptions of telerehabilitation for chronic conditions (Cranen, et al., 2012), but has not been utilised in examining patients' perspectives of technology in aphasia rehabilitation research to date.

The UTAUT can be applied as a framework for understanding factors that influence the acceptance and usage of ICT in aphasia rehabilitation from the perspective of a person with aphasia (PwA). The performance expectancy construct is likely to represent the perceived usefulness and benefits gained from engaging with ICT-delivered aphasia rehabilitation. The effort expectancy construct will likely reflect the impact of the programmes' usability in terms of ease of use, learnability and memorability for the PwA. In terms of social influences, it is possible that clinicians, family members and significant others may represent social influencers within aphasia rehabilitation. Facilitating conditions are likely to reflect the context of the aphasia rehabilitation activity for the PWA including the access to resources and support systems.

Patient satisfaction has become an important part of quality health care, and patient feedback has become increasingly important in assessing quality of service delivery. However, due to the methodological challenges associated with gathering patient opinions from people with communication disorders, patients with aphasia may be excluded from patient satisfaction surveys and satisfaction studies (Tomkins, et al., 2013). Tomkins, et al. (2013) completed a qualitative, descriptive phenomenological study to explore what people with aphasia think about their health care. They used semi-structured, in-depth interviews with 50 participants with aphasia to identify factors that contribute to satisfaction and dissatisfaction and found the most frequently expressed factors included *"information exchange, ease*

and manner of communication and patient knowledge". The timing, manner and amount of information provided to the participants with aphasia were reported to be important and were associated with feelings of support and control. Many of the participants discussed the "*structure and relevance*" of therapy as well as the amount of therapy provided, the level of difficulty or challenging nature of therapy tasks, therapy activities, amount of support and service delivery as factors that influenced satisfaction and dissatisfaction. Adjusting therapy to meet the needs and expectations of the individual appears to be a significant factor influencing patient satisfaction, with personalisation and the relevance of care for individuals playing an important role in health care satisfaction among people with aphasia. The authors report that this strong emphasis on personalisation, as a major factor influencing satisfaction, is not reported among other patient populations and appears unique among patients with aphasia (Tomkins, et al., 2013).

In order to broadly evaluate ICT-delivered aphasia rehabilitation, it is necessary to consider the views of individuals engaging in this mode of rehabilitation. This feedback can assist clinicians when planning and monitoring progress in rehabilitation and may also inform the development and refinement of ICT-delivered aphasia rehabilitation. This review aimed to investigate the methods of self-reported feedback exploring usability, feasibility and acceptance of ICT-delivered aphasia rehabilitation from the perspective of the ICT-user with aphasia, and identify the content and nature of the reported feedback within studies of ICT-delivered aphasia rehabilitation.

4.3 Methods

4.3.1 Structure of the Review Question

A literature review was carried out (Grant and Booth, 2009). This employed restricted systematic review principles as outlined by Pluddemann, et al. (2018). In order to organise the scope of the review the research question was defined under the headings of concept, target population and health care problem (Whittemore and Knafl, 2005). This provided a structure to investigate studies of individuals with aphasia post stroke (*target population*) who were undertaking therapy delivered by any mode of ICT including smartphone, laptop, desktop and/or tablet computer (*health care problem*) and where participants' perceptions of the mode of therapy (*concept*) were ascertained using qualitative, quantitative or mixed research methods. These perceptions may include, for example, impressions of satisfaction, therapy acceptance and engagement with ICT-delivered aphasia rehabilitation.

4.3.2 Search Strategy

In July 2015 searches were completed on online databases comprising Scopus, PsychoInfo, CINAHL, Medline Complete, Embase and Web of Science. Four main concepts were combined in the search: aphasia, rehabilitation, technology and feedback from users of the technology. The first three concepts were previously investigated in a systematic review of the effects of computer therapy in aphasia (Zheng, et al., 2016). Search terms related to aphasia, rehabilitation, and technology were combined with terms related to self-reported feedback from ICT-users for the purpose of this current review and included the following terms: "Usability", "Utility", "Usefulness", "Acceptability", "Acceptance", "User experience", "Preference", "Perceptions", "Feasibility", "Satisfaction", "Rating", "Preference",

"Perceptions", "Barriers", "Facilitators" and "Accessibility". All published material including randomised control trials, quasi-experimental studies, observational studies, qualitative studies and partially published work e.g. conference abstracts were considered for inclusion in this review. All studies reported in the original systematic review of the effects of computer therapy (Zheng, et al., 2016) were also included for screening. This search strategy was updated in May 2019 and was subject to the same procedure outlined here.

4.3.3 Screening and Data Extraction

The inclusion criteria for the review were as follows: 1) people with post-stroke aphasia, 2) aged 18 years and over, 3) using any form of ICT device, 4) engaging in language-based rehabilitation activities, with 5) any measure of self-reported feedback. Studies solely of synchronous telerehabilitation and interventions targeting compensatory strategies e.g. alternative and augmentative communication were excluded from the review. Studies evaluating Brain-Computer Interfaces were excluded. Non-English language articles were also excluded. Studies with participants with aphasia resulting from other conditions e.g. following traumatic brain injury or due to progressive neurological conditions, were included only if it was possible to extract the findings of post-stroke aphasia participants from the other conditions/groups. Where results were presented with combined participant data only, these studies were excluded.

Titles and abstracts were screened against inclusion/exclusion criteria. Full-text review was completed for studies that met the inclusion criteria or where abstracts did not provide sufficient information to determine if eligible for inclusion. Data extraction and quality assessment using the mixed methods appraisal tool (Pace et al., 2012) were performed. Data were extracted using a template and included

participant characteristics (sample size, age, gender, aphasia type and severity), methods (aim of the study, inclusion/exclusion criteria), description of intervention and information on data collection methods and outcomes. After an initial review of the extracted data, the data was further categorised based on outcomes related to perceived positive and negative impacts of the ICT-delivered rehabilitation programme and specific usability aspects including ease of use, satisfaction and learnability. In addition, factors related to support, social attitudes, time commitment, recommendations to others and preferences for mode of intervention were also detailed. Data was synthesised descriptively by constructing tables and a narrative synthesis was carried out.

4.4 Results

4.4.1 Study Selection

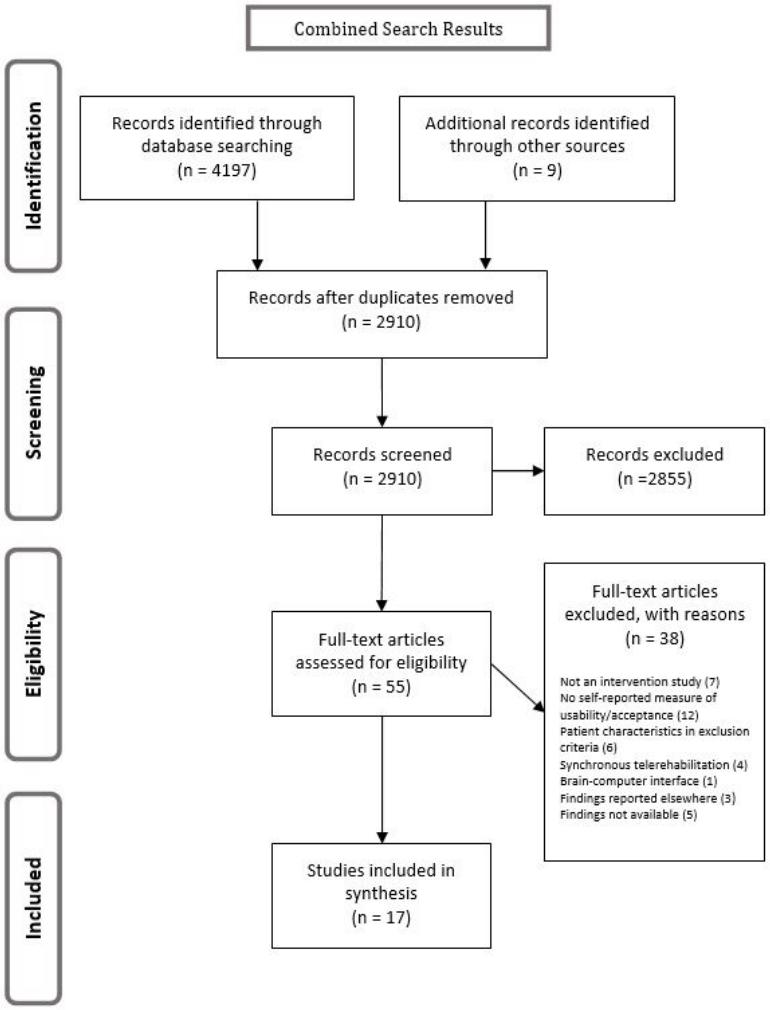
Database searching identified 4,197 records and an additional 9 records were identified within the references of screened records and one from author correspondence. Once duplicates were removed the titles and abstracts of 2,910 references were screened for eligibility. Full texts were sought for 55 articles of which 38 were excluded. Reasons for exclusion included: no language rehabilitation activity/goal within the study (7), no clear measure of self-reported feedback, usability or acceptance (12), participant characteristics e.g. traumatic brain injury and inclusion of other conditions in addition to aphasia in data analysis (6), synchronous telerehabilitation (4), self-reported findings reported elsewhere (3), Brain-Computer interface evaluation (1), non-English articles (2) and conference abstract only (3). The authors were contacted when records included abstracts only and texts published in a foreign language or when further information was required

to determine eligibility. In the case of the three conference abstracts, two studies are currently under preparation for publication and the third author could not be contacted. It was not possible to source an English version of the two foreign language publications.

4.4.2 Search Results

Seventeen studies were included in the review: 6 qualitative, 1 quantitative and 10 mixed-methods studies. See Figure 4.1 for an overview of search strategy findings.

Figure 4.1. Search Strategy Results for Literature Review (Research Strand Two)



Studies were screened using the Mixed Methods Appraisal Tool (MMAT) (Pace, et al., 2012). Although there was significant variation in the quality of research, articles were not excluded based on the quality assessment. A summary of MMAT assessments is provided in Appendix 6. A meta-analysis of the 17 studies included was not possible due to the heterogeneity in study design types, computer programmes employed and self-reported measured used. Therefore, descriptive analysis is outlined below.

4.4.3 Study Designs

Table 4.1 provides an overview of the study characteristics. One study was a nested acceptability study, carried out within a randomised control trial design, employing qualitative and quantitative data collection methods (Palmer, et al., 2013). The remaining study designs were case series (Caute et al., 2016; Cherney, Halper, Holland, & Cole, 2008; Routhier, et al., 2016), case studies (Albright and Purves, 2008; Bruce, Edmundson, & Coleman, 2003; Marshall et al., 2018), feasibility studies (Choi, et al., 2016; Mallet et al., 2016; Marshall, et al., 2013; Wenke et al., 2014), a usability study (Hill and Breslin, 2016) and qualitative research design (Amaya et al., 2018; Brandenburg, Worrall, Copland, & Rodriguez, 2017; Cherney, Halper, & Kaye, 2011; Galliers et al., 2017; Wade, et al., 2003). Eight of the studies reported therapeutic outcomes in conjunction with participant reported outcomes (Albright and Purves, 2008; Bruce, et al., 2003; Caute, et al., 2016; Cherney, et al., 2008; Choi, et al., 2016; Marshall, et al., 2018; Marshall, et al., 2013; Routhier, et al., 2016). The remaining nine studies reported the therapeutic outcomes elsewhere (Amaya, et al., 2018; Brandenburg, et al., 2017; Cherney, et al., 2011; Galliers, et al., 2017; Hill and Breslin, 2016; Mallet, et al., 2016; Palmer, et al., 2013; Wade, et al., 2003; Wenke, et al., 2014).

Table 4.1. Study and Participant Characteristics for Literature Review (Research Strand Two)

	Study Characteristics					Participant Characteristics				
Study	**Research Design**	**Method of data collection**	**Type of ICT-delivered aphasia rehabilitation**	**Aphasia Therapy Target**	**Sample size**	**Age Range (years)**	**Gender**	**Time post stroke**	**Aphasia (Severity and Type)**	**ICT experience**
Albright and Purves (2008)	Case study	Observations, interview, field notes, audio recordings	*Laptop Computer and Sentence Shaper™ programme*	Aid sentence production	1* (2)	31	female	4 years	Non-fluent agrammatic aphasia, moderate severity	Authors comment that participant owned a laptop prior to study
Amaya, et al. (2018)	Cohort	Interviews	*Laptop computer and EVA park*	Personalised communication goals	20	36-81 *(mean=57.8 years)*	11 male & 9 female	*Mean time post stroke 62.1 months SD=53.56*	Mild or moderate aphasia	Reported elsewhere
Brandenburg, et al. (2017)	Cohort	Interviews, observations, field notes and ease-of-use rating scale	*iPhone 4 and Plantronics Voyager Pro Plus Bluetooth and CommFit™ application*	Count talk time and encourage talk-time goals	12	32-71 *(mean= 56.2 years)*	7 male & 5 female	1year 1month - 5years 11months *(mean= 3years 2months)*	Western Aphasia Battery (WAB AQ) range 24.4 - 95.3 *(average 78.1)*	Eight participants were classified as experienced using mobile technology and 4 participants were described as minimally experienced
Bruce, et al. (2003)	Case study	Written account	*Personal Computer and Dragon NaturallySpeaking® programme*	Improve quality and quantity of written output	1	57	male	18 months	Fluent, mild-to-moderate aphasia	Authors comment that the participant owned a PC and was not familiar with word-processing systems before his stroke
Caute, et al. (2016)	Case series	Observations and interviews	*Kindle Keyboard 3G*	Improve reading comprehension	4	22-73	1 male & 3 female	2 - 8 years	1 x moderate aphasia 2 x mild receptive and expressive aphasia 1 x mild expressive aphasia	Not reported
Cherney, et al. (2008)	Case series	Exit interviews	*Laptop Computer and Aphasia Scripts™ programme*	Script training to aid expressive language	3	65- 78	1 male & 2 female	18 months - 4 years	1 x moderate/severe Broca's aphasia; 1 x moderate Wernicke's aphasia, 1 x moderate anomic aphasia	Authors comment that none had used a computer prior to enrolling in the study
Cherney, et al. (2011)	Cohort study	Exit interviews	*Computer and Aphasia Scripts™ programme*	Script training to aid expressive language	21*# (23)	26–78 *(mean= 57.3 years)*	14 male	10.6 - 273 months *(mean= 55.16 months)*	Western Aphasia Battery (WAB AQ) range 30.5 - 90.0 *(mean= 67.73)*	Not reported
Choi, et al. (2016)	Cohort/ feasibility study	Questionnaire and usage data	*Apple iPad and iAphasia Application*	Six therapeutic domains; auditory comprehension, reading comprehension, repetition, naming, writing and verbal fluency	8	37-67 *(mean= 50.75 years)*	4 male & 4 female	2-90 months *(mean= 30months)*	Korean Version of Western Aphasia Battery (WAB-K AQ percentile) range 21 – 88 *(mean= 49.63)*	Four never used a smartphone or tablet technology, 3 had some experience and no record for 1 participant

	Study Characteristics					Participant Characteristics				
Study	**Research Design**	**Method of data collection**	**Type of ICT-delivered aphasia rehabilitation**	**Aphasia Therapy Target**	**Sample size**	**Age Range (years)**	**Gender**	**Time post stroke**	**Aphasia (Severity and Type)**	**ICT experience**
Galliers, et al. (2017)	Cohort	Observations and interviews	*Laptop and "ready to run" installation of EVA park*	Virtual world to support language stimulation and aim to improve performance on measures of function and every day communication	20	36-81 *(mean=57.8 years)*	11 male & 9 female	*Mean time post stroke 62.1 months SD=53.56*	Mild – moderate aphasia, Communication Activities of Daily Living (CADL 2 percentile) range = 32-99 (mean=71.4)	Reported elsewhere
Hill and Breslin (2016)	Cohort/ usability study	Observation checklist, interview and field notes	*Tablet PC either Asus Vivo Tab Smart tablets with Windows 8 software or Asus EP121 tablet with a Windows 7 operating platform and eSALT(v1.1) programme*	Therapeutic activities based on individual needs	5 * (8)	67-78 *(mean= 70.8 years)*	4 male & 1 female	3 - 19 years *(mean= 8years 10months)*	Comprehensive Aphasia Test (CAT) range 41.13 - 62.5	Probed experience using a computer; 2 were very experienced, 2 had some experience and 1 had limited experience, also probed experience using a tablet; 4 had some experience and 1 participant had none, and 2 participants had previous computer-based therapy
Mallet, et al. (2016)	Cohort/ feasibility study	Questionnaire and usage data	*Apple iPad and commercially available programmes including Constant Therapy, Tactus Therapy (Language Therapy 4-in-1, Question Therapy 2-in-1, Category Therapy, Conversation Therapy) Lingraphica Small Talk Oral Motor, Speech Sounds on Cue, Jay Bacal apps*	Therapeutic activities based on individual needs	30	35-92 *(median= 62 years)*	73.5% male	Median of 5 days from hospital admission with onset of CVA	Summary not reported	Probed previous computer knowledge; 3 had none, 5 considered themselves as beginners, 17 as average and 5 as advanced. 21/30 had previous experience using an iPad
Marshall, et al. (2013)	Cohort/ feasibility study	Usage data, observations and interviews	*Laptop computer, webcam, prototype keyboard and GeST programme*	Improve gesture production	9	31-90	6 male & 3 female	24 months- 23 years	All had severe aphasia	Examined pre-stroke computer use; 4 participants used computers daily, 1 participant weekly, 1 participant occasionally and 3 had no experience of pre-stroke computer use
Marshall, et al. (2018)	Case study	Interviews	*Computer and EVA Park*	Word retrieval therapies	2	54 & 60	2 male	36 – 60 months	Moderate/Severe non-fluent & Moderate fluent	Not reported
Palmer, et al. (2013)	Qualitative/ nested study	Exit interviews and usage data	*Computer and Step by Step© programme*	Word-finding therapy	14* (24)	37-82 *(mean= 69 years)*	7 male & 7 female	1 - 29 years *(mean= 6.2 years*)	Summary not reported	Asked participants "Do you have previous experience of using a computer?" during interviews and 10 reported a negative response, 2 reported a positive response and 2 did not answer the question

	Study Characteristics					Participant Characteristics				
Study	**Research Design**	**Method of data collection**	**Type of ICT-delivered aphasia rehabilitation**	**Aphasia Therapy Target**	**Sample size**	**Age Range (years)**	**Gender**	**Time post stroke**	**Aphasia (Severity and Type)**	**ICT experience**
Routhier, et al. (2016)	Case series	Questionnaire	*Microsoft Surface Tablet and E-Prime software*	Semantic-phonological cued therapy for verb anomia	2	51-61	1 male & 1 female	1 - 6 years	1 x severe fluent aphasia, 1 x severe nonfluent aphasia	Not reported
Wade, et al. (2003)	Qualitative/ nested study	Interviews	*Laptop/personal computer and Step by Step© programme*	Word retrieval difficulties	6	53-66	5 male & 1 female	2 - 12 years	Summary not reported	One had experience of computer use prior to CVA and 4 had previous computer therapy
Wenke, et al. (2014)	Cohort comparison design/ feasibility study	Questionnaire	*Computer and commercially available programmes including REACT2, Aphasia Tutor, Language Links and Synonyms, Homonyms &Antonyms*	Targeted individual language goals	13* (54)	39-88 *(mean= 63.5 years)*	80% male & 20% female	*Mean = 9.1 years (SD 8.3)*	Summary not reported	Not reported

**study also included carers/SLTs/other people with aphasia but sample size reflects self-reported data gathered from participants with aphasia who engaged in ICT-delivered aphasia rehabilitation only (data in brackets indicates other participants in the study)*
#study does not easily distinguish between the participants with aphasia and spouses in interview analysis

The views of carers were gathered in combination with people with aphasia in five of the studies (Albright and Purves, 2008; Cherney, et al., 2011; Palmer, et al., 2013; Wade, et al., 2003; Wenke, et al., 2014). One usability study also explored the perspectives of speech and language therapists (Hill and Breslin, 2016).

4.4.4 Study Aims

The stated aims of the selected studies in relation to self-reported feedback on the target programme or ICT device were broad and included: investigation of acceptability (Caute, et al., 2016; Palmer, et al., 2013; Wade, et al., 2003) and feasibility (Mallet, et al., 2016; Marshall, et al., 2018; Marshall, et al., 2013; Wenke, et al., 2014) of the mode of therapy and/or programme, exploration of programme utility (Albright and Purves, 2008; Cherney, et al., 2008), barriers and facilitators for programme and device use (Brandenburg, et al., 2017), support and learning requirements for programme use (Bruce, et al., 2003; Caute, et al., 2016), usability (Hill and Breslin, 2016; Mallet, et al., 2016), ease of use (Marshall, et al., 2013), satisfaction with the programme (Cherney, et al., 2011; Choi, et al., 2016; Hill and Breslin, 2016; Routhier, et al., 2016; Wenke, et al., 2014), user experience (Galliers, et al., 2017) and exploration of participants' views, perceptions and experiences in relation to the target programme (Amaya, et al., 2018; Marshall, et al., 2018; Palmer, et al., 2013; Wade, et al., 2003; Wenke, et al., 2014).

4.4.5 Rehabilitation Programme Activities and ICT devices

The rehabilitation activities provided by these software programmes varied between studies and targeted: sentence production (Albright and Purves, 2008), improved written production using speech-to-text software (Bruce, et al., 2003), reading comprehension (Caute, et al., 2016), script training (Cherney, et al., 2008;

Cherney, et al., 2011), gesture therapy (Marshall, et al., 2013), lexical retrieval (Marshall, et al., 2018; Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003), increasing talk time (Brandenburg, et al., 2017), improved function and everyday communication (Galliers, et al., 2017) and individualised therapy (Amaya, et al., 2018; Choi, et al., 2016; Hill and Breslin, 2016; Mallet, et al., 2016; Wenke, et al., 2014).

Nine studies investigated the use of specialist therapeutic software applications/programmes on a laptop/desktop computer (Albright and Purves, 2008; Cherney, et al., 2008; Cherney, et al., 2011; Palmer, et al., 2013; Wade, et al., 2003; Wenke, et al., 2014) or on a tablet computer (Choi, et al., 2016; Hill and Breslin, 2016; Mallet, et al., 2016). One study explored the use of specialist behaviour research software to deliver visual stimuli for semantic-phonological cued therapy, aimed at verb anomia, delivered on a tablet computer (Routhier, et al., 2016). Bruce, et al. (2003) examined the use of non-therapeutic commercially-available software (voice recognition software) on a home computer to improve writing quality and one study investigated the use of e-readers in acquired reading comprehension rehabilitation (Caute, et al., 2016). Marshall, et al. (2013) explored the feasibility of hardware and software developed using participatory design techniques for use by people with severe aphasia, which provided a virtual gaming environment for teaching functional iconic and pantomime gesture. Three additional studies investigated a multi-user virtual world developed using participatory design techniques which ran on a laptop/computer (Amaya, et al., 2018; Galliers, et al., 2017; Marshall, et al., 2018). This virtual world allows people with aphasia to interact with therapists, support workers and other people with aphasia. It was considered appropriate to include these studies in the review as participants had

unlimited access to the virtual world outside of synchronous sessions with their support workers/clinicians. The manner of these interactions differed to traditional audio and/or video telerehabilitation e.g. participants could independently interact with elements in the virtual world such as the chat-bot, or clickable object that provides spoken cues. Two of the studies are linked to a quasi-randomised study evaluating the benefits of aphasia intervention delivered in a virtual world (Marshall et al., 2016). The third study investigated the feasibility of delivering two different treatment approaches for word retrieval in a virtual world (Marshall, et al., 2018). Finally, Brandenburg, et al. (2017) examined the use of an iPhone application developed by the research team and commercially available hardware to increase talk time.

4.4.6 Data Collection Methods

The methods of data collection for self-reported participant feedback included interviews (Albright and Purves, 2008; Amaya, et al., 2018; Brandenburg, et al., 2017; Caute, et al., 2016; Cherney, et al., 2008; Cherney, et al., 2011; Galliers, et al., 2017; Hill and Breslin, 2016; Marshall, et al., 2018; Marshall, et al., 2013; Palmer, et al., 2013; Wade, et al., 2003), written narrative (Bruce, et al., 2003) and questionnaires (using visual analogue scales) (Choi, et al., 2016; Mallet, et al., 2016; Palmer, et al., 2013; Routhier, et al., 2016; Wenke, et al., 2014). In addition to self-reported participant data, observations (Albright and Purves, 2008; Caute, et al., 2016; Galliers, et al., 2017; Hill and Breslin, 2016; Marshall, et al., 2013), field notes (Albright and Purves, 2008; Brandenburg, et al., 2017; Hill and Breslin, 2016) and usage data (Choi, et al., 2016; Galliers, et al., 2017; Mallet, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013) were gathered to provide further insight into usage and acceptance.

4.4.7 Summary of Participants

Data was gathered from 151 people with aphasia and participant details are summarised in Table 4.1. Two of the studies (Amaya, et al., 2018; Galliers, et al., 2017) report on participants from one intervention study (Marshall, et al., 2016). There was significant variability with respect to time post stroke and the onset of aphasia within the studies. Participants were recruited during the acute phase of stroke (with a median of 5 days from hospital admission with the onset of stroke to study enrolment) (Mallet, et al., 2016) and up to 29 years post-stroke (Palmer, et al., 2013). Participants were between 21 and 92 years old and represented a wide range of aphasia types and severity.

4.4.7.1 Record of Pre-Stroke ICT skills

There is variation with respect to the reporting of participants' ICT skills within the studies. Five studies did not report on participants' previous or current level of ICT skills and expertise (Caute, et al., 2016; Cherney, et al., 2011; Marshall, et al., 2018; Routhier, et al., 2016; Wenke, et al., 2014). Two studies reported this information elsewhere (Amaya, et al., 2018; Galliers, et al., 2017), two studies briefly described participants as owners of computers but provided little other information on participants' ICT skills (Albright and Purves, 2008; Bruce, et al., 2003) and one study reported that none of the participants had used a computer prior to study enrolment (Cherney, et al., 2008). Three studies investigated the participants' pre-stroke computer skills (Mallet, et al., 2016; Marshall, et al., 2013; Wade, et al., 2003). Within two of these studies, the recruited participants were at least 2 years post-stroke onset (Palmer, et al., 2013; Wade, et al., 2003), the third study examined the feasibility of mobile tablet-based rehabilitation in the acute care setting (Mallet, et al., 2016) so participants were answering questions on their

computer and mobile technology experience during their hospital admission with acute stroke. An additional three studies investigated computer and or tablet technology usage among participants without reference to pre-stroke skills (Brandenburg, et al., 2017; Choi, et al., 2016; Hill and Breslin, 2016). In one study exploring patient perspectives of computer-delivered aphasia rehabilitation, the researchers used a visual analogue scale to ask participants about their previous experience of using a computer during the interviews (Palmer, et al., 2013), and two studies examined if participants had previous experience of computer-based aphasia rehabilitation (Hill and Breslin, 2016; Wade, et al., 2003). There was wide variation among participants' rating of ICT experience and skills, see Table 4.1.

4.4.8 Summary of Study Findings

A summary of the findings of the studies exploring self-reported feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation is outlined below and an overview is presented in Table 4.2. Positive and negative factors relating to ICT-delivered aphasia rehabilitation were reported by a number of studies and Table 4.3 provides a visual summary of this information. Some of the studies provide information on the number of participants' responses and others do not. Where it is possible to identify the number of participants who provide an account on a particular phenomenon, this is reported in the findings below. The findings are grouped under three categories: perceived gains, usability and engagement with the mode of rehabilitation.

Table 4.2. Summary of Information Investigated in Studies

Study	Improvement in language skills	Increase in confidence & independence	Patient satisfaction	Frustration	Ease of Use of software / hardware	Learnability	Accessibility features	Suitability of treatment targets	Impact of concomitant disabilities	Training and introduction sessions	Training manuals	Training time	Recommend for others	Face-to-face or ICT-delivered therapy	Age	Support	Usage data	Time commitment	Social Attitude
Albright and Purves (2008)						x				x						x			
Amaya, et al. (2018)	x	x			x								x			x		x	
Brandenburg, et al. (2017)					x					x	x				x	x		x	x
Bruce, et al. (2003)		x		x		x				x						x		x	
Caute, et al. (2016)	x	x		x	x		x						x						
Cherney, et al. (2008)	x	x	x	x		x													
Cherney, et al. (2011)	x	x	x		x								x					x	
Choi, et al. (2016)			x		x			x		x							x		
Galliers, et al. (2017)		x	x	x						x						x	x		
Hill and Breslin (2016)	x	x	x		x	x		x		x	x			x	x	x		x	
Mallet, et al. (2016)					x	x						x				x	x	x	x
Marshall, et al. (2013)			x		x			x		x						x	x		
Marshall, et al. (2018)	x		x		x			x					x						
Palmer, et al. (2013)	x	x							x	x				x			x	x	
Routhier, et al. (2016)			x		x					x	x							x	
Wade, et al. (2003)	x	x						x		x			x	x		x			
Wenke, et al. (2014)	x	x	x										x						

Table 4.3. Summary of Positive and Negative Factors that Influence Experience

Study	Improvement in language skills	Increase in confidence and independence	Patient satisfaction	Frustration	Ease of Use of software / hardware	Learnability	Accessibility features	Suitability of treatment targets	Impact of concomitant disabilities	Training manuals	Training time	Recommend for others	Face-to-face or ICT-delivered therapy	Age	Level of Support	Time commitment	Social Attitudes
Albright and Purves (2008)						+									+		
Amaya, et al. (2018)	+ *	+ *			+ -							+			+	-	
Brandenburg, et al. (2017)					+ -					+				-	+	-	-
Bruce, et al. (2003)		+		-		+									+ -	+ -	
Caute, et al. (2016)	+ *	+		-	+		+ -					#					
Cherney, et al. (2008)	+	+	+	-		+											
Cherney, et al. (2011)	+ *	+	+		+							+ *				+ -	
Choi, et al. (2016)			+		+			+									
Galliers, et al. (2017)		+	+	-											+		
Hill and Breslin (2016)	+	+	+		+ -	+		+ -					+	-	+	-	
Mallet, et al. (2016)						+					-				+ -	-	-
Marshall, et al. (2013)			+ *		+ ~			+							+		
Marshall, et al. (2018)	+		+		+			+ -				+					
Palmer, et al. (2013)	+ *	+							-				+ -			-	
Routhier, et al. (2016)			+		+											-	
Wade, et al. (2003)	+	+						+ -				#	+ *		+		
Wenke, et al. (2014)	+	+	+									+ *					

*+ positive influence, - negative influence, * neutral influence, # information investigated but findings not reported in the study, ~ reported by family; more than one symbol indicates a mix of views*

4.4.9 Perceived Gains

4.4.9.1 Improvement in Language Skills

A number of studies explored the perceived benefits of ICT-delivered aphasia rehabilitation (Amaya, et al., 2018; Caute, et al., 2016; Cherney, et al., 2008; Cherney, et al., 2011; Hill and Breslin, 2016; Marshall, et al., 2018; Palmer, et al., 2013; Wade, et al., 2003; Wenke, et al., 2014). Four of these studies also report the therapeutic outcomes in addition to participants' feedback (Caute, et al., 2016;

Cherney, et al., 2008; Marshall, et al., 2018; Wenke, et al., 2014). Therapeutic outcomes are not reported in two of these studies (Cherney, et al., 2011; Hill and Breslin, 2016) or are reported elsewhere (Amaya, et al., 2018; Palmer, et al., 2013; Wade, et al., 2003). In general, where perceived benefits were explored, most participants reported improvements in language skills. In the studies that did not report therapeutic outcomes, all participants in two studies perceived improvements after therapy (Cherney, et al., 2008; Wade, et al., 2003) and at least half or more of the participants reported perceived improvements in three studies (18 of 20 participants in Galliers, et al. (2017); 20 of 23 participants in Cherney, et al. (2011) and 7 of 14 participants in Palmer, et al. (2013)). Other participants reported no change after therapy and there are no reports of perceived negative change in language skills after therapy in any of these studies. Where therapeutic outcomes are also reported these indicate some variation between perceived and actual measured improvements in some studies. All three participants in a study exploring script training reported perceived improvements in verbal communication after therapy, with two participants presenting with clinically significant improvements as measured on the Western Aphasia Battery (Cherney, et al., 2008). A feasibility study of different models of care evaluated the implementation of three intensive therapy models: computer therapy, group therapy and therapy with a speech and language therapy assistant (Wenke, et al., 2014). Participants in all models of care reported seeing improvements in themselves after therapy. This is accompanied by a statistically significant improvement in spoken language outcomes after therapy for the computer therapy group as measured on the spoken language subtests of the Comprehensive Aphasia Battery (Swinburn, Porter, & Howard, 2004). Both participants in a study exploring the impact of two different therapies delivered in a

virtual world, reported improvements in their communication after intervention. This was accompanied with significant improvements in naming of treated words for one participant and a small, but not statistically significant, increase in naming following therapy for the other participant (Marshall, et al., 2018). A study exploring whether e-reader training can improve reading comprehension found no improvement in reading comprehension as measured by the Gray Oral Reading Test (Wiederholt and Bryant, 2001) following training (Caute, et al., 2016). However, only one of the four participants reported no perceived benefit after e-reader training with three demonstrating significantly improved reading confidence as measured by the Reading Confidence and Emotions Questionnaire (Cocks, Pritchard, Cornish, Johnson, & Cruice, 2013).

4.4.9.2 Increased Confidence and Independence

Participants in 14 of the studies were expected to independently engage with, and self-manage, some or all of their ICT-delivered aphasia rehabilitation at home or during their hospital admission (Albright and Purves, 2008; Brandenburg, et al., 2017; Bruce, et al., 2003; Caute, et al., 2016; Cherney, et al., 2008; Cherney, et al., 2011; Choi, et al., 2016; Galliers, et al., 2017; Hill and Breslin, 2016; Mallet, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003). Increased confidence was reported by 41 of the 70 participants in 6 studies (Amaya, et al., 2018; Caute, et al., 2016; Cherney, et al., 2008; Cherney, et al., 2011; Palmer, et al., 2013; Wade, et al., 2003) and many of the participants in two studies (Galliers, et al., 2017; Hill and Breslin, 2016) when considering their skills and use of the target programmes. In three studies participants described benefits obtained from participating in the research outside of the perceived therapeutic benefits of the target programme. These benefits included increased confidence in non-computer

communication activities e.g. wanting to go out more (Caute, et al., 2016), as well as increased independence with activities of daily living and/or increased participation in community activities e.g. going to the library and/or shopping, after participating in the research (Amaya, et al., 2018; Cherney, et al., 2011). Participants valued the independence and autonomy that computer-delivered therapy offered (Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003) and 10 participants were noted to be able to use the programme independently after training even with limited or no basic pre-stroke computer skills (Bruce, et al., 2003; Palmer, et al., 2013). The ability to work independently on therapy tasks at home and with high levels of repetitive practice was noted as a valuable benefit of asynchronous telerehabilitation (Hill and Breslin, 2016).

4.4.10 Usability

4.4.10.1 Patient Satisfaction

Nine studies asked participants about their satisfaction or enjoyment with the programme/device, and 83 of 85 participants within the studies responded positively and rated their satisfaction and/or enjoyment with the programme as high (Cherney, et al., 2008; Cherney, et al., 2011; Choi, et al., 2016; Galliers, et al., 2017; Hill and Breslin, 2016; Marshall, et al., 2018; Marshall, et al., 2013; Routhier, et al., 2016; Wenke, et al., 2014). Three of these studies used questionnaires with Likert scale responses (Choi, et al., 2016; Routhier, et al., 2016; Wenke, et al., 2014) and the combined results from the 23 participants indicate highly favourable scores on questions related to satisfaction and/or enjoyment of engaging in ICT-delivered aphasia rehabilitation. Obviously, such a method provides little information on factors that influenced satisfaction and/or enjoyment. Within the studies that

explored this concept in participant interviews, there are similar favourable responses among participants (Cherney, et al., 2008; Cherney, et al., 2011; Galliers, et al., 2017; Hill and Breslin, 2016; Marshall, et al., 2018; Marshall, et al., 2013) and one participant's report of their perceived progress made in therapy is explicitly identified as a source of satisfaction (Cherney, et al., 2008). Other studies do not explicitly report on the source of satisfaction but participants have also reported perceived benefits (Cherney, et al., 2011; Hill and Breslin, 2016) and mastery of the programme among the majority (6/8) of the participants (Marshall, et al., 2013). However, some participants expressed individual dislikes or displeasure with an aspect of the programme e.g. dislike of a particular object in the virtual world (Galliers, et al., 2017), and some reported they felt the purpose of the tasks within the programme was unclear (Hill and Breslin, 2016). Eight of nine participants, in a study of gesture production, rated their enjoyment highly or very highly, and the one participant who did not provide positive feedback on the enjoyment of the programme indicated a discrepancy between their rehabilitation goals and the programme target e.g. the participant signalled their goal for speech production while the research programme targeted gesture learning (Marshall, et al., 2013).

4.4.10.2 Frustration and Negative Affect

There were some reports of negative aspects of engaging in ICT-delivered therapy including experiencing frustration when engaging in ICT-delivered therapy and frustration with particular programme processes (Bruce, et al., 2003; Caute, et al., 2016; Cherney, et al., 2008; Galliers, et al., 2017; Palmer, et al., 2013). Frustration was the most frequently occurring sub-code of negative affect among participants in one study examining the experience of users in a multi-user virtual world (Galliers, et al., 2017). The findings suggest that much of the frustration was

language related e.g. participants unable to find a word during a conversation. This is also reflected in the study of computer-delivered word finding therapy where three respondents expressed frustration and the supporting example provided for this subtheme highlights one participant's feeling of frustration at not being able to find a word that had previously been retrieved (Palmer, et al., 2013). The virtual therapist, which acted as the agent of therapy, caused both frustration and enthusiasm at different times in a script training programme (Cherney, et al., 2008). The participant in a case study exploring if voice recognition software could result in improved written output, experienced frustration when attempting to correct mistakes (Bruce, et al., 2003); the correct word would sometimes appear in a list of choices but if it did not appear the participant could attempt to type it, which was a longer process and resulted in frustration. In the study by Galliers, et al. (2017) aspects of the programme caused frustration when expected responses did not occur after the participant attempted a particular action within the programme e.g. the participant wished to stop an action on the screen but instead pressed the wrong button and indicated frustration with the response. A key strength of this study is that it provides one of the most in-depth investigations of both positive and negative affect observed by the researchers and reported by 20 people with aphasia. The authors coded 19 instances of frustration over the two observed sessions, with a total of 40 incidents of negative affect including 9 instances of displeasure, 5 instances of negative passivity, 3 instances of both irritation and negative surprise and 1 instance of worry. However, there are significantly more behaviours coded for positive than negative affect at both time points, with a total of 165 incidents of positive affect reported including 95 instances of pleasure/fun, 50 instances of playfulness/making a joke, 12 instances of pride, 5 of positive surprise and 3 of relief.

4.4.10.3 Other Usability Factors: ease of use, learnability, training and support manuals

In addition to satisfaction and negative effects, other aspects of programme usability including ease of use and learnability were explored. Where explicitly investigated it was noted that participants were able to learn how to use a new therapy programme (Albright and Purves, 2008; Bruce, et al., 2003; Cherney, et al., 2008; Hill and Breslin, 2016; Mallet, et al., 2016) but there was variability in the use of accessibility features that were introduced to participants in one study (Caute, et al., 2016). The initial introduction and training of the ICT-delivered aphasia rehabilitation programmes were referenced in a number of studies (Albright and Purves, 2008; Brandenburg, et al., 2017; Bruce, et al., 2003; Caute, et al., 2016; Choi, et al., 2016; Galliers, et al., 2017; Hill and Breslin, 2016; Marshall, et al., 2013; Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003). Some studies reported that participants were provided with aphasia-accessible manuals, developed for the research study, in order to guide the participant with aphasia when engaging in the ICT-delivered programme (Brandenburg, et al., 2017; Hill and Breslin, 2016; Routhier, et al., 2016). Participants' feedback on the support manual was highly positive in one study and they were observed to depend on it during training and when using the device at home (Brandenburg, et al., 2017). Most reported that they used the manual only in the first few days, although some continued to use it throughout the duration of the research. Insufficient training is a barrier to successful implementation of ICT-delivered aphasia rehabilitation when training time is limited (Mallet, et al., 2016). Usability and ease of use of specialised therapeutic software were reported in nine studies (Amaya, et al., 2018; Brandenburg, et al., 2017; Cherney, et al., 2011; Choi, et al., 2016; Hill and Breslin,

2016; Mallet, et al., 2016; Marshall, et al., 2018; Marshall, et al., 2013; Routhier, et al., 2016) and this was also investigated in the study of e-reader usage for reading comprehension (Caute, et al., 2016). Participants with aphasia were generally positive about the efficiency and usability of the programmes (Amaya, et al., 2018; Brandenburg, et al., 2017; Caute, et al., 2016; Cherney, et al., 2011; Choi, et al., 2016; Hill and Breslin, 2016; Mallet, et al., 2016; Marshall, et al., 2018; Routhier, et al., 2016) and this was supported by carers' reports in two studies (Cherney, et al., 2011; Marshall, et al., 2013) and observation data (Caute, et al., 2016; Marshall, et al., 2013). Mixed views were reported in some studies with respect to aspects of ease of use (Amaya, et al., 2018; Brandenburg, et al., 2017; Hill and Breslin, 2016; Mallet, et al., 2016). In a study of iPad use in acute hospital admission post-stroke, one participant reported it was "not at all" easy to hold the iPad and two of the 25 participants responded "not at all" when asked about how clear were the instructions to use the apps on the iPad (Mallet, et al., 2016). In the study by Amaya, et al. (2018) two of the 20 participants found the virtual world complicated. Other technical issues reported by participants in the two case studies in Marshall, et al. (2018) included the computer crashing and the input device freezing. However one participant with moderate/severe aphasia indicated how he re-started the programme when this happened and both participants rated enjoyment as high (Marshall, et al., 2018). Hill and Breslin (2016) reported that some of the participants in their study of asynchronous telerehabilitation had difficulty using an on-screen keyboard and struggled with a tablet computer's responsiveness to touch; these difficulties and the number of participants who experienced them are not discussed in detail. Brandenburg, et al. (2017) explored ease of use of a Bluetooth headset and iPhone application to increase talk time. They reported that eight participants who

completed the ease-of-use ratings ranked the ease of use of the steps related to the headset e.g. wearing it and pairing it to the iPhone, lower than other steps e.g. turning on the iPhone, starting the application (Brandenburg, et al., 2017).

4.4.10.4 Personalisation of Therapy and Programme Content

There were mixed views within studies that investigated the participants' perspectives on the suitability of treatment targets and the flexibility of tasks to suit their needs (Choi, et al., 2016; Hill and Breslin, 2016; Marshall, et al., 2013; Wade, et al., 2003). In a study investigating individualised language treatments delivered via iPad and an application developed by the researchers, the participants indicated very favourable scores when asked if they received sufficient treatment and if the programme provided an on-target service for them (Choi, et al., 2016). As noted earlier, one participant in a study of gesture therapy indicated a discrepancy between her priority for rehabilitation and the programme target (Marshall, et al., 2013). Within the study of asynchronous telerehabilitation the five participants indicated mixed views on the grading of tasks with some reporting tasks were too difficult and others considering them too simple; further details are not reported (Hill and Breslin, 2016). One participant in a study of word retrieval therapy, using a protocol combining cued picture naming tasks and a modified version of Semantic Feature Analysis delivered in a virtual world, rated 3 out of 5 for the formal word finding tasks and the authors suggest that seemed to be due to the "*challenging nature of the tasks and his own difficulties with speech*" (Marshall, et al., 2018, p. 1060).

4.4.10.5 Impact of Concomitant Disabilities

One study reported that 5/14 participants experienced problems with ICT-delivered aphasia rehabilitation. These were due to software errors, poor memory

when attempting to use the computer, or difficulties accessing a computer for practice (Palmer, et al., 2013). The authors also reported that fatigue and anxiety were observed in the study but this was only expressed by one participant as a disadvantage of self-managed rehabilitation. In the study by Mallet, et al. (2016) one participant also reported having difficulty holding the iPad.

4.4.11 Engagement with the mode of rehabilitation

4.4.11.1 Preference for Face-to-Face or ICT-delivered Therapy

Three studies examined participants' preference for face-to-face or ICT-delivered therapy when engaging in aphasia rehabilitation (Hill and Breslin, 2016; Palmer, et al., 2013; Wade, et al., 2003). Hill and Breslin (2016) reported that participants in their study on asynchronous telerehabilitation identified a range of advantages related to remotely-monitored therapy when compared to face-to-face therapy, including the ability to provide more intensive and high levels of repeated practice using the telerehabilitation platform. This was considered by participants to be a significant advantage of that mode of therapy (Hill and Breslin, 2016). There were mixed views among participants in a study of computer-based word finding therapy, with some participants identifying the perceived advantages of self-managed computer therapy and others preferring the social contact that comes about with face-to-face therapy (Palmer, et al., 2013). This variation was also noted in an earlier study, where four participants expressed a preference for computer therapy but under the assumption it was monitored by an SLT, and one had no clear preference, expressing a preference for a combination of both (Wade, et al., 2003). The combination of both face-to-face and computer therapy was echoed as a desirable option in two studies of computer-based word finding therapy (Palmer, et

al., 2013; Wade, et al., 2003). The concern regarding the monitoring of self-managed aphasia rehabilitation also emerges in two other studies (Brandenburg, et al., 2017; Hill and Breslin, 2016). The authors, who investigated the barriers and facilitators to use of an iPhone and application to increase talk time, reported that face-to-face contact is essential for training and troubleshooting issues that may emerge (Brandenburg, et al., 2017). Interestingly, the findings of the study by Marshall, et al. (2013) showed gains were made only on items practised with regular therapist's support and using the programme entirely independently did not result in significant improvements.

4.4.11.2 Recommend for Others

Participants were asked in six of the studies if they would recommend the programme or consider it appropriate for others (Amaya, et al., 2018; Caute, et al., 2016; Cherney, et al., 2011; Marshall, et al., 2018; Wade, et al., 2003; Wenke, et al., 2014). The results are not reported in two of these studies (Caute, et al., 2016; Wade, et al., 2003). Where reported, participants appear to recommend the programme, i.e. there is a strong positive response of *yes* from 22/23 participants who participated in computer-delivered script training (Cherney, et al., 2011) and all 22 participants would recommend the multi-user virtual world to other people with aphasia (Amaya, et al., 2018; Marshall, et al., 2018). It was also noted that 12 of the 13 participants assigned to a computer therapy group would recommend that mode of therapy; this is comparable to all 11 of those assigned to group therapy and all 6 of those assigned to speech and language pathology assistant therapy within a sub-acute setting (Wenke, et al., 2014). One study asked participants to consider what they would be willing to pay for the software programme (Choi, et al., 2016). This is not investigated in any of the other studies however Palmer, et al. (2013) noted

that two participants referenced the costly nature of face-to-face therapy when asked if they preferred face-to-face or computer-based therapy (Palmer, et al., 2013).

4.4.11.3 Time

The time commitment while engaging in ICT-delivered rehabilitation was perceived by participants in three studies to be a disadvantage or a challenge (Amaya, et al., 2018; Palmer, et al., 2013; Wade, et al., 2003) with the time spent on ICT-activities meaning less time available for other activities (Amaya, et al., 2018; Wade, et al., 2003). This was considered especially relevant for individuals post-stroke if sitting too long without stretching, particularly for those with hemiplegia (Wade, et al., 2003). Time constraints were also recognised as a barrier within one study where participants had to turn on and off a device and some who were slower using the technology found this time demand to be a source of difficulty (Brandenburg, et al., 2017). The time demand was also reported as a factor in participant attrition within that study (Brandenburg, et al., 2017). In addition, time was reported as an important aspect for training a voice recognition software system (Bruce, et al., 2003) and troubleshooting issues e.g. unable to log into the application (Brandenburg, et al., 2017). The authors in one study reported that training time within the study protocol was minimal and concluded that this was a barrier to the feasibility of mobile technology in acute aphasia rehabilitation (Mallet, et al., 2016).

4.4.11.4 Social Attitudes

Two studies reported that participants had expressed concerns with respect to using the target device in public with one participant feeling embarrassed talking to the tablet computer in public; this was resolved using a headset (Mallet, et al., 2016).

In a separate study, one participant did not wish to wear a headset to the shops and would not use the device in public (Brandenburg, et al., 2017).

4.4.11.5 Age as a Factor of Acceptance and Usage

Two studies referenced age as a potential factor in the acceptance and usage of technology (Brandenburg, et al., 2017; Hill and Breslin, 2016). A study investigating the barriers and facilitators to using an iPhone and application developed to increase talk time identified a relationship between age and ease-of-use ratings; as the age of the participant increased the ease-of-use scores were rated as harder to use (Brandenburg, et al., 2017). This was echoed by the perception of one participant in a study of asynchronous telerehabilitation who reported that age was a limiting factor for acceptance and usability (Hill and Breslin, 2016). However, the relationship between age and variables such as usage, reports of ease of use and satisfaction is not explicitly examined in the included studies. Three studies (Choi, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013) provide individual usage data and the corresponding ages of participants. The age range of participants in these studies is between 31 and 90 years of age. There did not appear to be an emerging pattern with respect to age and usage, but sample sizes are small and no statistical analysis were completed in these studies.

4.4.11.6 Level of Support

A number of studies reported on the support structures that were available and utilised by the person with aphasia while engaging in computer therapy. This support frequently came from family members of the person with aphasia (Albright and Purves, 2008; Brandenburg, et al., 2017; Wade, et al., 2003) and also from the research team (Amaya, et al., 2018; Brandenburg, et al., 2017; Galliers, et al., 2017;

Hill and Breslin, 2016; Marshall, et al., 2013). When this support was missing it was identified as a barrier for acceptance and usage (Bruce, et al., 2003; Mallet, et al., 2016).

4.4.11.7 Usage Data

Five studies reported on usage data within the research (Choi, et al., 2016; Galliers, et al., 2017; Mallet, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013). Three of these studies provided the participants with specific targets for time spent working on the programme (Galliers, et al., 2017; Mallet, et al., 2016; Palmer, et al., 2013). There was variation in recommended dosage and intensity within the studies that reported this information. One study asked participants to spend at least one hour per day each day during their time in the study (Mallet, et al., 2016). In another study, participants were asked to complete at least three sessions per week over the five months of the study (Palmer, et al., 2013). In the third study investigating the experience of a multi-user visual world, participants were asked to spend one hour a day for five days a week during the five weeks of the study when they linked with a support worker in the virtual world; they had unlimited access to the programme outside of this time (Galliers, et al., 2017). In these studies where participants were asked to spend a minimum amount of time using the programme, there was variation noted with respect to adherence to these practice times, with 60% (Palmer, et al., 2013) and 83% (Mallet, et al., 2016) of participants completing the recommended practice times. The third study reported that the average time spent by the group outside of scheduled sessions was 16.9 hours with a range of 1.0 to 76.8 hours (Galliers, et al., 2017). One study recommended that participants spend "as often as possible for as long as possible" over the period of the study (Choi, et al., 2016). The final study did not report this information, however, the authors reported they

were interested in dosage in the study introduction (Marshall, et al., 2013). Two studies examined the impact of programme usage on outcomes and one study found a strong correlation between usage of the programme and improvements in language skills as measured by the Western Aphasia Battery-Korean Version (Choi, et al., 2016). However, in the second study, there was no significant correlation between usage and gesture gains (Marshall, et al., 2013). The authors of this study identify that this is not surprising due to the small sample size of the study (Marshall, et al., 2013). Three of the studies provide individual usage data and the gender of participants (Choi, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013). The authors do not comment on any gender differences in terms of programme usage and the sample sizes are small in both studies. However, it is possible to identify that both male and female participants are equally represented at both ends of the spectrum of usage from least to most programme usage within the study.

4.5 Discussion

4.5.1 A Growing Research Topic

This review has identified studies that explore self-reported feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation. These included studies employed a variety of methods to gather this information. A range of factors have been identified that influence participant experience. Research exploring the perspectives of people with aphasia engaging in ICT-delivered aphasia rehabilitation is gaining momentum. Patient satisfaction is important for quality health care, and as participants with aphasia may have different requirements and expectations that influence satisfaction with ICT-delivered aphasia rehabilitation (Tomkins, et al., 2013), it is reassuring to note that this area of research is growing.

The first search strategy yielded 10 studies and the updated search completed 46 months later generated an additional 7 studies, indicating a significant increase in interest within the research topic. This trend is continuing with recent studies exploring feasibility (Pugliese et al., 2019) and patient experiences (Mallet et al., 2019) of mobile tablet-based stroke rehabilitation for people with communication, fine motor and cognitive/perceptual deficits as single or combined conditions. These studies present collective findings from all participants with communication, fine motor and cognitive/perceptual deficits and as such it is not possible to identify the responses from those with only aphasia. However, the findings suggest similar positive experiences with respect to increased confidence, ease of use and enjoyment of the mobile tablets and applications (Mallet, et al., 2019) as well as challenges including the impact of hemiplegia (Mallet, et al., 2019) the appropriateness of the level of difficulty of prescribed tasks (Mallet, et al., 2019; Pugliese, et al., 2019) and issues with respect to participants requiring additional support and finding the time to complete the prescribed activities (Mallet, et al., 2019; Pugliese, et al., 2019).

4.5.2 Factors relating to Usability, Feasibility and Acceptance of ICT-delivered Aphasia Rehabilitation

There are significant variations with respect to the research designs, data collection methods and research aims among the studies examined in this review. However, it is possible to identify a number of key issues that are emerging within the available research examining usability, feasibility and acceptance of ICT-delivered aphasia rehabilitation. These shared areas of investigation within the studies reflect constructs of usability and acceptance as outlined in Nielsen's Model of System Acceptability (Nielsen, 1994) and the UTAUT (Venkatesh, et al., 2003). These were previously highlighted by Mortley *et al.* as important components for a

system delivering remote aphasia therapy (Mortley, et al., 2004). The most common areas that were investigated within the included studies were: ease of use of the application and/or device, patient satisfaction, perceived benefits, and confidence with the application and/or device. These can be seen to relate to the constructs of performance expectancy and effort expectancy within the UTAUT model. As these constructs are significant predictors of intention to use technology it makes sense that they are being explored in the research studies (Venkatesh, et al., 2003). These constructs examine how the participants interact and relate to the ICT programme and devices within the studies. The findings suggest overall positive experiences and satisfaction with this mode of rehabilitation but it is important to note there is variation among these personal experiences. This is especially noted where a participant's own therapy goal was not targeted by the intervention being investigated (Marshall, et al., 2013). This not only highlights the importance of personalising therapy to make it relevant and meaningful for each person with aphasia, but the importance of choosing the appropriate intervention itself when planning ICT-delivered aphasia rehabilitation (Tomkins, et al., 2013). Issues with respect to accessibility and ease of use of programmes and devices have been identified within the studies, including remembering how to use the programme (Palmer, et al., 2013), holding an iPad (Mallet, et al., 2016), accessing touchscreen devices (Hill and Breslin, 2016) and pairing Bluetooth devices (Brandenburg, et al., 2017). These challenges must be considered and addressed so as to increase digital inclusion for people with aphasia (Menger, et al., 2016) and feedback from participants with aphasia can assist researchers in the design (Galliers, et al., 2017; Marshall, et al., 2013) and refinement process for future research of ICT-delivered aphasia rehabilitation (Brandenburg, et al., 2017; Hill and Breslin, 2016).

4.5.3 Personal Factors

The participants in the included studies represent a heterogeneous group. There was a broad age range among participants within and between the included studies, as well as a diverse spectrum of time from onset of aphasia to recruitment to the research. The participants also presented with a range of aphasia types and severities. Participants' ratings of experience and skills with respect to ICT usage, although not all studies reported on participants' ICT experience, reflected a wide range. The authors of one study identified that limited or no ICT experience is not a barrier to engaging in ICT-delivered aphasia rehabilitation (Cherney, et al., 2008), however, two participants in another study felt their limited experience impacted on their ability to use the programme (Hill and Breslin, 2016). Amaya, et al. (2018) reported that all but two participants had prior computer experience and suggest that their positive findings may not be replicated in an older group or those with less computer experience. This is also reflected in related findings reported by Marshall, et al. (2016) who found that those with higher levels of prior computer experience spent more time in the virtual world. When applying the UTAUT model and its constructs to the review findings it is not possible to comment on the impact of mediators such as age, gender and experience of ICT within the findings of the studies included in this review due to the sample size and data provided. However, it is noteworthy that Marshall, et al. (2016) identified that neither age or gender were found to influence the amount of time spent logged into the virtual world in their study. As participants consent to participate in these research studies it can be difficult to anticipate the impact of voluntariness when considering how it would be experienced within clinical practice. Prior experience of ICT may provide additional confidence and those with limited experience may be more likely to question their

ability to engage in ICT-delivered aphasia rehabilitation (Hill and Breslin, 2016). However, ICT-delivered aphasia rehabilitation can be feasible for individuals with all levels of experience from beginner to skilled (Cherney, et al., 2008; Choi, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013). It is clear that the provision and availability of support from family and/or clinicians (Albright and Purves, 2008; Brandenburg, et al., 2017; Marshall, et al., 2013; Palmer, et al., 2013) is a key factor reported among some participants and where experience is limited this may be an important mediator for ICT use and acceptance (Wade, et al., 2003).

4.5.4 External Supporting Factors

In addition to the interaction between the participant and ICT programme and device, many studies identify factors external to the participant and the ICT system that have an influence on the participants' usage and acceptance of ICT-delivered aphasia rehabilitation. In particular the supports provided by the research team (Brandenburg, et al., 2017; Palmer, et al., 2013) and family members of the person with aphasia (Albright and Purves, 2008; Brandenburg, et al., 2017; Marshall, et al., 2013; Palmer, et al., 2013; Wade, et al., 2003) are identified as positive influencers in many of the studies as well as the impact of training (Albright and Purves, 2008; Brandenburg, et al., 2017; Bruce, et al., 2003; Caute, et al., 2016; Choi, et al., 2016; Galliers, et al., 2017; Hill and Breslin, 2016; Mallet, et al., 2016; Marshall, et al., 2013; Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003) and support manuals (Brandenburg, et al., 2017; Caute, et al., 2016; Hill and Breslin, 2016; Routhier, et al., 2016). This contrasts with participants' reluctance to use ICT devices in public in two studies due to embarrassment (Mallet, et al., 2016) and feeling uncomfortable when asked about the device (Brandenburg, et al., 2017). Brandenburg, et al. (2017) suggest this may be related to perceived social stigma of

using a visible device and attribute social attitudes as a possible barrier to ICT use. These important factors can be considered as reflecting the constructs of social influence and facilitating conditions of the UTAUT model (Venkatesh, et al., 2003). The availability of aphasia accessible support manuals and face-to-face support was noted by researchers to be important for introducing and maintaining ICT-delivered aphasia rehabilitation (Brandenburg, et al., 2017; Hill and Breslin, 2016). Indeed the level of support provided is an important factor in patient satisfaction with their health care (Tomkins, et al., 2013). Kelly, Kennedy, Britton, McGuire, & Law (2016) recommend that training of basic computer skills may be an important precursor to enable people with aphasia to access ICT-delivered aphasia rehabilitation and advocate for targeted follow-up support to maintain these ICT skills. The provision of support is critical (Marshall, et al., 2016) and can ultimately result in greater independence as was noted by the participants' positive feedback on, and use of, the support manual in the study by Brandenburg, et al. (2017). Most identified that they used it in the first few days only which may reflect how it served its purpose and autonomous use of the ICT devices occurred in a short timeframe. Time, both for engaging within the research and the time commitment for ICT activities was identified as a factor among participants with aphasia (Brandenburg, et al., 2017; Wade, et al., 2003). Allocating sufficient time for training was highlighted as a key component of a successful training programme and where time was limited this was seen as a barrier (Mallet, et al., 2016). The construct of time for both the participant with aphasia and also the clinician (Liu, et al., 2015) reflects an important facilitating condition for usage and acceptance of ICT-delivered aphasia rehabilitation (Venkatesh, et al., 2003).

4.5.5 Challenges when Seeking Feedback

Most self-reported feedback was positive throughout the included studies with few negative effects reported. However, when considering the generally positive responses reported within the studies it is important to note that Cherney and colleagues suggest there may be several reasons for this positive feedback (Cherney, et al., 2011); the interview questions may focus more on the positive aspects of the programme, participants may be reluctant to provide negative feedback or they may find it more difficult to formulate negative comments compared to positive feedback. Some questionnaires in the included studies posed questions in a manner that may positively bias the responses e.g. asking how easy, rather than how difficult, a task was within the study (Mallet, et al., 2016) and phrasing the question statement in a positive manner "the programme has good readability" (Choi, et al., 2016). Indeed, it may be that participants' feedback is positive as it reflects a positive experience. It is interesting to note that the study that provided the most in-depth investigation of negative affect had the third largest sample size and collected a large amount of observation and interview data (Galliers, et al., 2017). The negative affect theme that was reported in this study was identified after a thematic analysis of the participants' data from two observation sessions and post-observation interviews. This observation data included video and screen capture and therefore simultaneously recorded the participants using the programme and their interactions in the virtual world. This in-depth qualitative analysis of video data has not been replicated in other studies and may have resulted in a greater understanding of positive and negative aspects of programme usage. It is important to note that overall the participants' experiences of this programme were strongly associated with positive affect. The authors provide a broad understanding of the experience of

the participants, both positive and negative and engaged researchers with expertise in Human-Computer Interaction research in the interdisciplinary research project (Galliers, et al., 2017).

4.5.6 Future Research

Wade, et al. (2003) identified that qualitative methodologies can generate variables for further investigation using quantitative methods. The studies included in this review highlight that interviews with people with aphasia, especially when combined with observational data, can provide rich data on their perspectives of ICT use and acceptance in aphasia rehabilitation. As no consensus measure of feedback is currently being used it is difficult to compare findings between studies. Future studies may benefit from a combination of mixed methods to gain greater insight into positive and negative aspects of ICT-delivered aphasia rehabilitation especially if using a common quantitative tool to aid comparison among studies. In order to improve the quality of research, it is important that questionnaires and interview questions are framed in a non-biased manner. Many of the studies included in this review reported on both clinical outcomes and participant perspectives of engaging in ICT-delivered aphasia rehabilitation, others reported only the participants' views but not the therapeutic outcomes. Future research should systematically report therapeutic outcomes and participant feedback in order to provide a comprehensive overview of the ICT-delivered rehabilitation.

4.5.7 Implications for Clinical Practice

The studies included in this review provide support for the use of ICT-delivered aphasia rehabilitation as an acceptable mode of rehabilitation for people with aphasia. However, it is important to note that individual variation was present

in the studies' findings. It is important to obtain feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation as this will provide insights into their experiences of this mode of rehabilitation. This information may guide clinicians when collaboratively planning and monitoring ICT-delivered aphasia rehabilitation and may also facilitate the improvement and development of ICT-delivered interventions.

4.5.8 Limitations of Included Studies

There are a number of limitations noted in this review. Firstly, some studies did not fully describe their methods of data collection. Some included studies have not provided sufficient information on the role of the researcher who gathered the data from participants which may lead to potential bias within study designs. Other studies have not provided a topic guide for interviews or where it was provided, they have not reported findings on all information within the topic guide. In some of the studies the data is reported for the group as a whole without a clear indication of individual variations of the phenomenon. There is limited reference to theoretical frameworks from the field of Human-Computer Interaction (HCI) within many of the studies. However, where interdisciplinary research has been completed engaging researchers with aphasia expertise and HCI skills there is a deeper insight into the factors that may influence individual experiences in ICT-delivered aphasia rehabilitation (Amaya, et al., 2018; Caute, et al., 2016; Galliers, et al., 2017; Marshall, et al., 2018; Marshall, et al., 2013). There is no consensus measure of self-reported feedback to examine perspectives of acceptability, usability and experience of engaging in ICT-delivered aphasia rehabilitation within the included studies and the heterogeneous nature of the study designs did not facilitate meta-analysis of the findings.

4.5.9 Limitations of the Current Review

Unfortunately, due to resource constraints, the PhD researcher completed the screening, data extraction and quality review for all studies and a second researcher (with experience of conducting systematic reviews) completed the data extraction and quality review for all 10 studies in the first search. The methodological quality of the included studies was not evaluated in detail, as this was not the scope of this literature review. Instead, this review aimed to broadly identify and describe the current research with respect to participants with aphasia and their perspectives of engaging in ICT-delivered aphasia rehabilitation. Therefore, no studies were excluded based on quality due to the broad nature of the review question and future studies should include challenges of appropriate methodological approaches.

4.6 Conclusions

This review of the literature identified that there is no consensus measure currently within research investigating self-reported feedback by participants with aphasia engaging in ICT-delivered aphasia rehabilitation. Interviews, observations and questionnaires designed for the individual research studies are most commonly used. It was noted that a number of key concepts related to usability, feasibility and acceptance were being probed within the research, and a variety of different methods were being employed. Patient satisfaction, ease of use of technology as well as perceived improvements and benefits of ICT-delivered aphasia rehabilitation are most commonly explored. The findings suggest mostly positive responses and indicate that ICT-delivered aphasia rehabilitation is considered an acceptable mode of rehabilitation for people with aphasia but with noted variation among participants. Indeed, it is likely that a balance of face-to-face and ICT-delivered aphasia rehabilitation may be most appropriate but further research is indicated in this

regard. There is limited reference to theoretical frameworks of Human-Computer Interaction, and future studies would benefit from consideration of potential benefits to employing such models and engaging in interdisciplinary research.

4.7 Chapter Summary

This chapter presented the methods and findings of a literature review which explored the current research on perspectives of people with aphasia engaging in ICT-delivered aphasia rehabilitation. Most of the feedback reported by people with aphasia on this mode of intervention has been positive with some variations noted within the studies. A variety of data collection techniques have been used to record participants' feedback. A number of questionnaires were developed for individual studies but the development processes are not described and there is no consensus measure for recording feedback from people with aphasia who engage in ICT-delivered aphasia rehabilitation. Chapter Five will present a co-design research study which involved the collaborative development of an ICT-feedback questionnaire. This development process was carried out as part of Research Strand Two which aims to develop a questionnaire in collaboration with people with aphasia to facilitate self-reported feedback from people with aphasia on their experience of ICT-delivered aphasia rehabilitation.

Chapter Five

Chapter Five – Co-design of a Feedback Questionnaire

5.1 Introduction to Chapter

This chapter provides an overview of a study that was completed as part of Research Strand Two. This study is a participatory research project that was carried out in collaboration with people with aphasia. This chapter reports on the background information to set the scene for the collaborative development of a feedback questionnaire *with* people with aphasia *for* people with aphasia (5.2). The co-design process was carried out within six workshops and employed public patient involvement (PPI) in health research (5.3). A detailed, descriptive and critical overview of the co-design process is presented and the experiences of the co-designers are explored (5.4). The final questionnaire provides an outcome measure that investigates cognitive workload, satisfaction, programme functionality and ease of use and the level of assistance required when engaging in ICT-delivered aphasia rehabilitation (5.5). It was used in a feasibility study which was carried out as part of Research Strand Three. The findings of this feasibility study are described in Chapter Eight.

5.2 Background

As described previously, aphasia is a significant issue for many people post stroke with consequences that can impact on well-being and social inclusion (Chapter One - 1.2). Intensive rehabilitation is important for successful outcomes. Information and Communication Technologies (ICT) may provide an option for intensive rehabilitation for individuals with post-stroke aphasia (Code and Petheram, 2011) but consideration must be given to the feasibility and acceptance of this mode of rehabilitation.

Self-management of chronic conditions post stroke has been proposed as one way of improving long term outcomes including quality of life, depression and activities of daily living (Jones et al., 2016; Jones and Riazi, 2011). Positive results have been reported for participants undertaking computer-delivered therapy, including a statistically significant improvement in naming ability after 5 months of therapy using a computer-based programme targeting word finding difficulties (Palmer, et al., 2012) and statistically significant improvements in naming accuracy of treated items after exposure to a speech programme targeting apraxia of speech (Varley, et al., 2016). These findings suggest there is scope for using information and communication technologies (ICT) to self-manage communication rehabilitation. In addition to treatment efficacy, it is important to investigate patient satisfaction with ICT-delivered rehabilitation to ensure high-quality health care provision.

The literature review presented in Chapter Four described the synthesised findings of the available research exploring the experiences of people with aphasia engaging in ICT-delivered aphasia rehabilitation. Patient satisfaction, ease of use of technology and the perceived benefits of ICT-delivered aphasia rehabilitation were most commonly explored in the included studies. A range of key concepts related to usability, feasibility and acceptance were probed and a variety of different data collection methods were employed. The most commonly used methods are interviews, observations and questionnaires designed for the individual research studies. There is no consensus measure currently within research investigating self-reported feedback by participants with aphasia engaging in ICT-delivered aphasia rehabilitation. In addition, there was limited reference to theoretical frameworks of human-computer interaction. The findings suggest mostly positive feedback from

people with aphasia engaging in this mode of rehabilitation and suggest that ICT-delivered aphasia rehabilitation is considered an acceptable mode of rehabilitation but with noted variation among participants.

Wade, et al. (2003) provide one of the earliest reports investigating the views and experiences of people with aphasia who engaged in computer-delivered therapy for word retrieval difficulties. They used in-depth interviews and qualitative data analysis to explore the "*expectations, experiences, effects and views*" of six participants engaging in remote-based computer therapy (Wade, et al., 2003, p. 1039). They suggest that one application of a qualitative approach to research is the identification of variables for further investigation using a quantitative methodology. The authors concluded that the data obtained from their small-scale study was potentially too limited to develop a self-rating scale which can provide a quantitative measure to investigate participants' views of this mode of intervention. They suggest that further qualitative investigations with a larger cohort would be required to develop such a tool. Despite an increase in research exploring this phenomenon, there is no consensus measure available for use in planning or evaluating ICT use in clinical practice or research.

Any system for ICT-delivered aphasia rehabilitation should be "*accessible, usable and acceptable to people with aphasia*" (Mortley, et al., 2004, p. 207). This reflects the principles of human-computer interaction and introduces the concept of usability to aphasia rehabilitation. Usability is defined as the "*extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*" (ISO, 2018). Usability has multiple dimensions and can be systematically studied, measured and evaluated (Nielsen, 1994). Methods of usability testing can include logging usage data,

observations, completing questionnaires, thinking aloud while performing tasks, interviews and focus groups. One such measurement tool is the Systems Usability Scale (SUS) which is a 10 item questionnaire that can be used to measure the usability of a product or system (Brooke, 1996). The SUS has been used to examine the subjective experience of undertaking Virtual Reality based telerehabilitation for balance recovery post stroke (Lloréns, Noé, Colomer, & Alcañiz, 2015) and also in a study on Internet-based anomia rehabilitation (Simic, et al., 2016). Alternatively, the NASA Task Load Index (NASA TLX) is a subjective measure of workload and consists of six subscales: Mental, Physical, and Temporal Demands, Frustration, Effort and Performance (Hart and Staveland, 1988). It can facilitate subjective feedback on the measure of task difficulty and is used in a range of arenas including aviation, teleoperation and health (Hart, 2016). This tool has been used in stroke rehabilitation research to evaluate an augmented feedback application in upper limb rehabilitation (Zimmerli et al., 2012) and with adults with Alzheimer's Disease to rate the degree of difficulty of mobile technology use to promote independence with activities of daily living (Zmily, Mowafi, & Mashal, 2014). The NASA TLX is more appealing than the SUS, with only six question domains, quicker administration, and provision of additional descriptors for each subscale to assist the responder. The NASA TLX could be combined with additional probing questions on usability and programme functionality for ICT-delivered aphasia rehabilitation. However, in its current format it is not aphasia-accessible.

There is an inherent challenge when using general language-based questionnaires with people with aphasia as modifications of existing tools may be required to incorporate additional visual stimuli (Simic, et al., 2016), or studies may simply exclude participants with severe aphasia (Zimmerli, et al., 2012). However, a

more appropriate approach is to engage the users of ICT-rehabilitation programmes (i.e. people with aphasia) in the collaborative development of a feedback questionnaire. This questionnaire development should draw on their personal experiences and incorporate the findings from the literature on participant views of ICT-delivered aphasia rehabilitation as well as principles of usability. Public and Patient Involvement (PPI) in research incorporates meaningful engagement and active collaboration such that research is carried out by people with an understanding of the issue at the focus of the research e.g. aphasia (INVOLVE, 2012). Involving people with aphasia as co-researchers in the research process is not a new concept in aphasia research. Examples of participatory research include, the use of a Participatory Learning and Action approach to explore participants' experiences of a conversation partner programme (Mc Menamin, et al., 2015), and Community-Based Participatory Research to identify and incorporate views of people with aphasia on current research needs (Hinckley, Boyle, Lombard, & Bartels-Tobin, 2014). Participatory design has emerged as a viable method for people with aphasia to be involved in designing software intended for use by this population (Moffatt, et al., 2004; Wilson, et al., 2015), and in a recent study co-designing accessible and acceptable information material for and in collaboration with people with aphasia (Herbert, Gregory, & Haw, 2018). Wilson, et al. (2015) provide a comprehensive overview of techniques used in two design projects. These projects involved people with aphasia in all stages of the development of two computer-based therapy tools. The authors recognised that in order to facilitate the engagement of people with aphasia in the design process, new design techniques, and the adaptation of existing techniques, were required.

Harrison and Palmer (2015) employed qualitative research methods to explore the experience of being involved in PPI research with 11 stroke survivors and carers; two of the participants reported they had aphasia after stroke. Participants identified the supportive relationships that developed during the research process, and the intellectual stimulation acquired as part of it, as positive impacts of being involved in PPI research. They described how they felt they brought a different perspective to the research, through their lived experiences, and that the interaction between expertise from stroke survivors, clinicians and researchers benefitted the process. Some participants reported that they were "sceptical" about the true value placed on their involvement by researchers (Harrison and Palmer, 2015, p. 2180) although many felt that they had an equal relationship with the professionals. A number of potential barriers to participation were identified by participants and included transport and location issues, cognitive deficits, fatigue and communication difficulties. However, facilitators of participation were also reported including the provision of transport, accessible environments, supportive group facilitators and supportive group dynamics.

As previously discussed, there is no consensus measurement tool for reporting feedback on user experience of ICT-delivered aphasia rehabilitation. There are three aims in this study:

1) To develop a feedback questionnaire, in collaboration *with* people with aphasia, *for* people with aphasia who undertake ICT-delivered aphasia rehabilitation.
2) To describe the collaborative co-design process to develop this questionnaire.
3) To explore the experiences of the co-designers in this collaborative design process.

The questionnaire developed in this process will focus on the accessibility, functionality and ease of use of an aphasia rehabilitation programme, taking into consideration usability attributes (Nielsen, 1994) and the cognitive load of engaging with the rehabilitation software programme.

5.3 Methods

This is a *collaborative* research activity (INVOLVE, 2012) which aims to bring people with aphasia and Speech and Language Therapist (SLT) researchers together in an equal partnership to develop a meaningful and relevant feedback questionnaire. This differs from *consultation* where lay people are asked for their views and opinions about a research project and researchers don't necessarily act on these suggestions, and it is not *user-controlled* research, which gives patients or members of the public the power to set the research agenda (INVOLVE, 2012). In addition to utilising expert patient involvement within the design process, the study aims to explore the co-design researchers' experience in the PPI activities. Ethical approval was obtained from the local clinical research ethics committee (Appendix 7). Participants were recruited through local speech and language therapy services for adults with aphasia. Individuals who were at least 6 months post stroke and with no known cognitive comorbidities were invited to participate. Individuals were provided with an aphasia-accessible information sheet (Appendix 8) and consent form (Appendix 9) and given the opportunity to discuss the research before providing informed consent. As this study was unfunded, individuals were advised that they would not receive payment or compensation for attendance, when provided with information about the study.

5.3.1 Initial Session

The PhD researcher visited each participant in their own home prior to the workshops in order to establish the type and severity of aphasia (Western Aphasia Battery - Revised (WAB-R), Kertesz, 2007) and determine communication supports that each individual required to ensure full participation in the workshops. In addition, a technology screening questionnaire was completed (Czaja et al., 2006; Roper, Marshall, & Wilson, 2014) which provided information on current and pre-stroke use of a range of everyday technologies and facilitated discussion of individuals' experiences with technology.

5.3.2 Co-design Workshops

The workshops aimed to define and refine the questions and structure of the questionnaire being developed through a collaborative co-design process. Co-design refers to the shared creativity across the whole design process (Sanders and Stappers, 2008). Due to the iterative nature of this design process, the focus and aims of each workshop were established as the design process progressed. Initially, three weekly 90 minute workshops (with 30-minute tea break) were planned for the co-design process. However, three additional workshops were required in order to complete the research process, resulting in a 4-week break between workshop 3 and 4 while waiting for ethical approval for the additional workshops. Figure 5.1 provides an overview of the focus of each workshop.

Figure 5.1. Workshop Topics and Primary Focus

Workshop	Focus
1	Introductions & discussion on “good” and “bad” aspects of technology
2	Review discussion on technology from session 1; establish key questions and determine how best to ask and answer questions
3	Refine questions, consider aphasia-accessible format and create supporting visual stimuli
4	Further refine visual stimuli for each question
5	Prototype questionnaire and refinements based on feedback from trialling it within the group
6	Trial final draft questionnaire and finalise

Wilson, et al. (2015) implemented a co-design project with people with aphasia and used a range of techniques suitable for adults with aphasia to facilitate their engagement in the design process. Planned techniques for this study included: visual analogue scales, ranking tasks, photo-diaries, and use of prototypes. Supported conversation strategies were implemented throughout the workshops to facilitate engagement in the design activities (Kagan, 1998). Aphasia-accessible information was prepared before each workshop (Rose, Worrall, Hickson, & Hoffmann, 2011a; Rose, Worrall, Hickson, & Hoffmann, 2011b; Rose, Worrall, Hickson, & Hoffmann, 2012) and supplied in paper and/or online format depending on the target activity. Techniques such as visual analogue scales and ranking tasks were primarily used in the initial workshops and prototype testing was used in the final three sessions. Photo-diaries were suggested to the group as a means of recording ideas; however, they were not used by any individual. As questions and visual supports for the questionnaire were discussed in the workshops a measure of the agreement for each item was recorded during the session. This was achieved using ranking tasks where each co-designer indicated their preferences and the

facilitator made field notes of all the decisions made in the sessions. When consensus agreement was reached this was recorded and the item was maintained for use in further iterations of the co-design process. When consensus was not reached, the percentage of agreement was recorded, and field notes were written. This noted the item and the issues in relation to the disagreement. A plan was devised following this discussion and this was also recorded in field notes. Such plans included reviewing the item from a new perspective at the next workshop or excluding the item from the process. All sessions were video-recorded and the recordings were reviewed after each workshop to ensure that no information was overlooked during the session and to cross-reference the field notes with the video recordings.

5.3.3 Co-designers

Six co-design researchers with aphasia (five male, one female) were recruited (see Table 5.1). The group ranged in age from 43 to 76 years with a mean of 60.7 years (SD = 11.3). The co-designers were between 1.9 – 11.4 years post-stroke with a mean of 5.8 years (SD = 3.8) and presented with mild to severe aphasia (WAB-R AQ range 24.4 - 83, mean 64.7 (SD = 23.05)). Individuals in the group differed in their technology use and ability. Five of the co-designers used ICT devices (smartphone, tablet, laptop or computer) whereas the sixth person used a Nokia non-smartphone, only to make phone calls. Of the five who used internet-enabled ICT devices, the most popular online uses included: information searches (n=3), entertainment (n=3) email (n=2), video-chat (n=2), banking (n=2), shopping (n=2), diary/reminders (n=2) and speech and language therapy (n=2). Only one co-designer used social media and gaming applications. One group member had previously worked as a computer programmer before his stroke but was not working in that role

at the time of the research. During the initial individual sessions with the researcher, the co-designers outlined challenges they experienced when accessing ICT devices, sometimes experiencing frustration with the device. The primary causes of these difficulties included: anomia (n=2) e.g. word finding difficulties preventing the input of content for internet searches, acquired dysgraphia (n=2) resulting in spelling errors or an inability to spell words for text input, memory difficulties (n=1) when attempting to remember phone numbers etc., hearing aids (n=1) impacting on ability to use mobile phones, and hemiplegia (n=1) restricting the use of devices that require use of both hands.

The PhD researcher, a speech and language therapist experienced in working with people with aphasia and who has a research interest in ICT-delivered aphasia rehabilitation, facilitated the workshops (facilitator). Given the additional collaborative role with the co-designers with aphasia in the development of the questionnaire, she is considered to have a role as a co-designer in the design process. Experience of these roles in the co-design process was recorded in a Reflective Diary and is reported in the Results section.

Table 5.1. Co-designer Details

Co-design researcher	Age	Gender	Time post CVA (years)	Location of CVA	WAB AQ	Aphasia Type	Aphasia severity	Summary of ICT ownership and use
A	65	m	11.4	(L) parietal lobe	24.4	Global	Severe/ very severe	Newly acquired tablet computer used for gaming, rarely uses mobile phone and for calls only, no text messaging. Requires assistance from family to set up.
B	43	m	4	(L) MCA	51.8	Broca's	Moderate	Independently uses laptop, iPad daily and smartphone daily for electronic schedule, information searches, speech and language therapy applications and communication including emails, text messenger applications e.g. Viber, phone calls and text messages. Sometimes uses internet banking.
C	64	m	1.9	(L) MCA	67.1	Broca's	Moderate	Independently uses an iPad and smartphone daily for entertainment and phone calls, does not use text messages.
D	53	m	6	(L) MCA	83	Conduction	Mild	Independently uses a smartphone and laptop daily for information searches, online entertainment, phone calls and text messages. Uses social media and online shopping occasionally.
E	76	f	9	(R) temporo-parietal lobe	79	Anomia	Mild	Owns a Nokia phone which is used on a daily basis for phone calls only. Does not own any other ICT device.
F	63	m	2.4	(L) MCA	82.6	Anomia	Mild	Owns a laptop, PC, iPad and smartphone and independently uses his phone to make calls daily, never used text messages. Frequently uses email, online information searches, speech and language therapy applications and occasionally uses internet banking.

5.3.4 Exit Interviews

After the final workshop co-design researchers with aphasia were invited to give feedback on their role in the research and explore their experience of the co-design process. The interviews were video recorded and facilitated by an independent speech and language therapist, experienced in working with adults with aphasia, who was not involved in the research. The interviews were directed by a question guide with supporting visual content (see Appendix 10). The PhD researcher transcribed the interviews and analysed the data using Braun and Clarke (2006) six phases of thematic analysis. In the initial step, the video data was reviewed alongside the written transcripts to ensure that all verbal and non-verbal information was recorded and the transcripts were read through for a sense of the whole. Next, the dataset was read and a process of familiarisation took place when initial codes, representing units of meaning, were written up and points of interest identified. When the initial coding was completed a list of codes was generated. Discussion of the codes with a second researcher occurred at this point and candidate themes and subthemes were identified. Following this phase, the themes were further reviewed and refined and subsequently, the scope and context of each theme was summarised before final analysis and write up of the thematic analysis (Braun and Clarke, 2006).

5.3.5 Reflexivity

The PhD researcher facilitated the workshops and completed the initial individual sessions. It was important that she remained conscious of bias throughout the whole process. In addition to reviewing the video recordings, a reflective journal was completed after each session and reviewed prior to the next session. This

allowed the researcher to critically reflect on her role in the research and identify how her clinical background, position, behaviours and assumptions may have influenced the research process (Finlay and Gough, 2003). Any issues that emerged were discussed with the second researcher and recorded within the reflective journal.

5.4 Results

The collaborative co-design process will firstly be outlined, followed by a description of the co-design feedback questionnaire, and then the experiences of being involved in the co-design process.

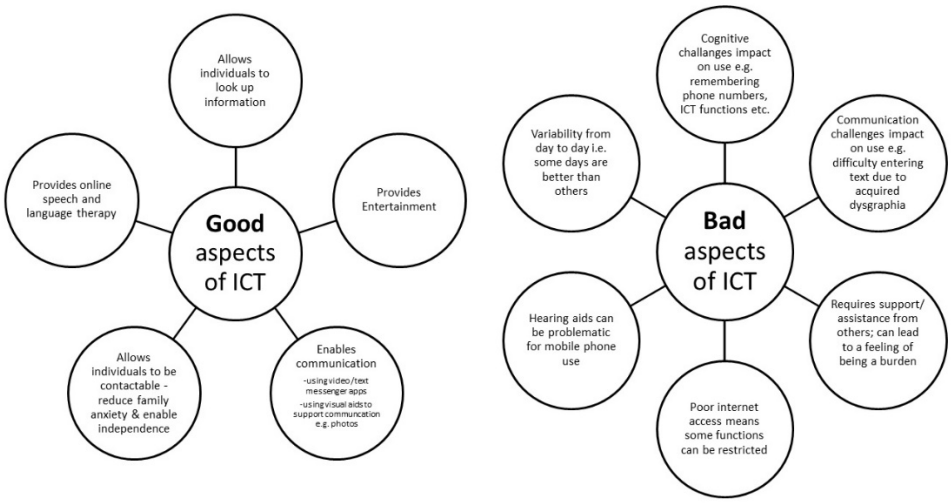
5.4.1 Collaborative Co-Design Development Process

5.4.1.1 Workshop 1: Introductions and Setting the Scene

In order to set the scene two brainstorming activities were carried out in the first workshop: consider both the "good" and the "bad" aspects of technology. This built on the discussions from the individual sessions and the co-designers' references to ICT challenges. This concept of challenge and potential frustration was used as a scaffold to encourage the group to explore their views and opinions of ICT. The facilitator wrote each co-designer's contribution on post-it notes and stuck them onto a large whiteboard in front of the group. This allowed for ideas to be tracked and grouped during the discussion. Participation was encouraged with supported conversation techniques and multi-modal communication. These activities allowed each co-designer to express their views about technology and allowed the group to identify accessibility issues that may be related to aphasia. For example, one co-designer reported that he was unable to spell, impacting on his ability to complete text messaging tasks. This discussion also highlighted accessibility issues not

related to aphasia, e.g. poor Internet infrastructure impacting on smartphone function for speech-to-text. A summary of the discussion generated during the session is represented in Figure 5.2. (A larger representation of Figure 5.2 is available within Appendix 2). The final task in the initial workshop explored the concept of questions and the structure of questions e.g. written question, visual stimuli and visual analogue scales. It was important to highlight the function of the design workshops i.e. the development of a questionnaire for people with aphasia to report feedback when engaging in ICT-delivered aphasia rehabilitation and re-orientate the co-designers to the aim of the research. The initial session drew on their combined views and experiences of ICT use. Subsequent workshops would develop questions for the feedback questionnaire while drawing on the co-designers' experiences and available literature that the facilitator brought to the process. Following the workshop, the facilitator prepared a set of sample questions based on the issues that emerged in this session, as a starting point for the design process in the next workshop.

Figure 5.2. Summary of Discussion in Initial Workshop



5.4.1.2 Workshop 2: Review Brainstorm Activities from Session 1 and Introduce Questions

A summary of the initial workshop activities was visually displayed at the start of the session, providing a reminder to participants about the previous workshop discussions and allowing for new ideas to be added. The facilitator introduced the idea of the questionnaire as a computer-based activity using PowerPoint on a laptop with examples of possible questions based on the previous workshop. A set of sample questions, prepared by the facilitator after the previous session, were introduced. These related to aspects of usability of computer-based activities including concepts such as ease of use, frustration, satisfaction, and level of assistance required to complete ICT tasks. The group discussed the questions and ranked corresponding images that were intended to support comprehension of the questions. These were images that the facilitator had accessed online before the workshop and added to the initial sample questions. However, it became clear that the online images did not fully represent, or support comprehension for many of the question concepts related to ICT use. For example, images may clearly represent frustration but did not have a computer present to link the relationship between them. The group unanimously agreed that a clear representation of the relationship between the concept, e.g. an emotional response of frustration, and the precipitating action, using the computer, was essential for a person with aphasia. Therefore, before the next workshop, the facilitator was photographed while acting out these ICT-related scenarios, to be discussed and evaluated at the next workshop.

5.4.1.3 Workshop 3: Ranking Images of the Concepts

A range of photographs, with the facilitator acting out scenarios associated with computer usage were introduced to the group. These photographs related to an initial set of 16 concepts of usability that would be refined and explored in the questions e.g. satisfaction, frustration, tiredness, and needing help with the computer. See Figure 5.3 for the development of the question topics throughout the process. These images were intended to support respondents' understanding of the questions when completing the questionnaire. The co-designers first determined what aspect of usability the photograph might represent. Where there was more than one image to represent the concept, they were asked to rank their preferences of the most appropriate image. There was consensus agreement for 44% of the images with a minor suggestion for editing one of the agreed images. Five co-designers agreed on the suitability of an additional 25% of the images used to represent aspects of usability. However, concepts such as anxiety, satisfaction, disinterest, the pace of tasks and remembering computer functions were challenging to represent in the images. The group discussed the use of a single image versus a binary choice of two images to support understanding of questions (see examples in Figure 5.4). The group was divided, some felt that only one image was required to express the concept and others felt that a binary choice aided understanding of the images. There was agreement among co-designers that an independent person rather than the facilitator should be in the images if she was using the questionnaire with people with aphasia. Following this recommendation, a model was recruited to re-enact the images which would be evaluated in the next workshop.

Figure 5.3. Question Development Process

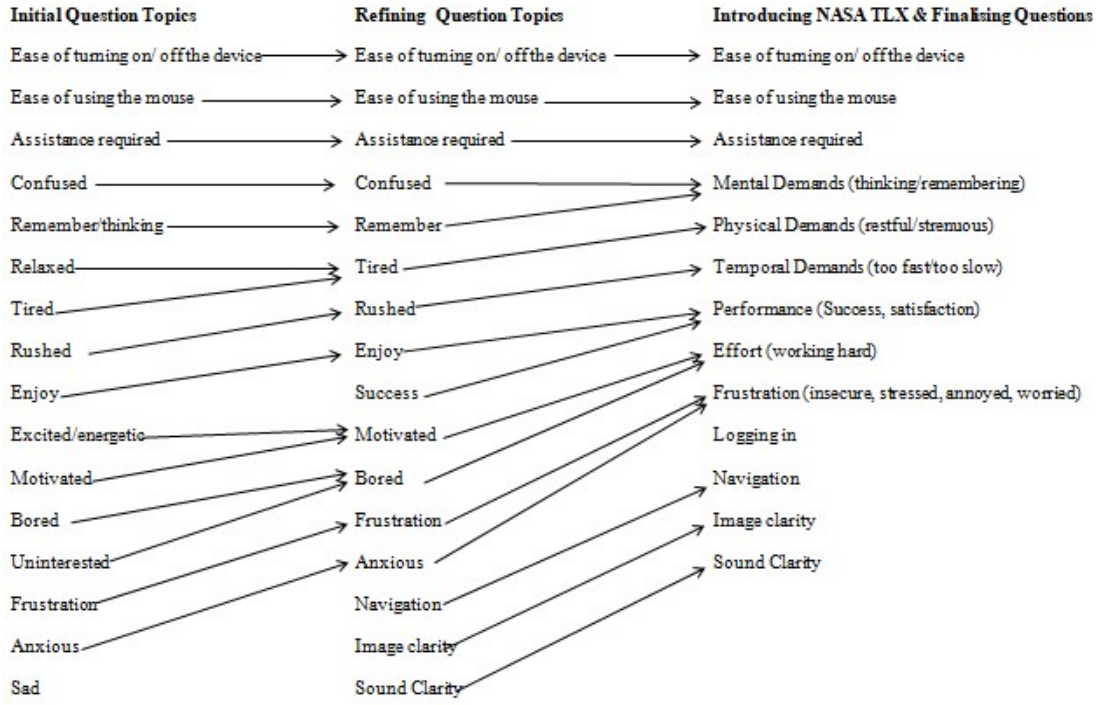


Figure 5.4. Single versus Binary Choice



5.4.1.4 Workshop 4: Ranking Images with a new Model

The four-week break between workshops 3 and 4 (while awaiting ethical approval to increase the number of workshops) provided the opportunity to engage a model to pose for photographs, as per the recommendations of Workshop 3. In Workshop 4, concepts of *mental, physical and temporal demands*, as well as *performance, effort and frustration* from the NASA TLX, were introduced. Some of these concepts had already emerged in the discussions about usability and

technology use and the NASA TLX provided a neat structure to present these questions and refine them to single key concepts (see Figure 5.3). For example, using the NASA TLX construct of *mental demand* allowed for the inclusion of *thinking* and *remembering* and *confusion*, under one question heading. All potential questions and related visual stimuli to support communication were reviewed in Workshop 4. Nine of 20 images were agreed by all co-designers and an additional seven images were agreed with minor changes to aid understanding e.g. addition of an egg timer to indicate the concept of time. Following these discussions, it became apparent that some questions benefitted from the binary choice format. For example, when probing *satisfaction* on performance, the visual stimuli accompanying the question presented two images on the screen. One image was a successful, cheering actor with the written cue "good" underneath it, representing *satisfied*; the second image depicted an actor with head lowered and the written cue "poor", representing *unsatisfied*. Other questions used a simple question structure with one supporting image to aid comprehension.

5.4.1.5 Workshop 5: Prototype Testing

Between workshop 4 and 5, the facilitator refined the question statements and used an online survey tool to create a draft questionnaire which was introduced to the co-designers during Workshop 5. In order to trial the prototype, each co-designer completed a computer task of their choice. These tasks varied from online therapy activities targeting auditory memory, visual matching and auditory comprehension to online gaming and tic tac toe. After the task, each co-designer then completed the questionnaire with some assistance from the facilitator. The facilitator observed any issues that emerged and the co-designers gave feedback on the questionnaire as they used it. Feedback was documented and plans for final refinement were discussed.

5.4.1.6 Workshop 6: Final Testing

The online questionnaire was further refined following the feedback generated in Workshop 5 and re-introduced to co-designers at Workshop 6. Again, each co-designer completed a computer task and then answered the questionnaire and provided feedback on it. A small number of minor edits were required after this session and the questionnaire was considered ready for use. Co-designers expressed satisfaction with their final product and the work they completed over the previous five workshops.

5.4.2 Description of the Co-designed ICT Feedback Questionnaire

The finalised co-designed feedback questionnaire consists of 15 questions (see Figure 5.5). Six questions relate to the NASA TLX, which probes features of cognitive workload and satisfaction on a sliding scale from low to high level of workload (see Figure 5.6). Seven questions relate to ease of use and function of the programme being tested as well as the level of assistance required (see Figure 5.7). Responses to these questions are presented on a 5-point visual analogue scale with graded 'smiley faces'- a large smile indicates "very easy" / "no help" and a large frown indicates "very hard" / "a lot of help" with a neutral face to represent a neutral or "OK" response. There is one identifier question, and one question relates to the time point which allows for easy tracking of questionnaire responses over a number of time points. The questionnaire will facilitate user feedback on usability and cognitive workload.

Figure 5.5. Overview of the Final Questionnaire

Ease of Use and Functionality items	**NASA TLX items** Subscale, question and additional prompt
Identifier *Timepoint* How much help did you need when using the computer/laptop? How easy was it for you to turn on/off the computer/laptop? How easy was it for you to use the mouse? How easy was it for you to log into the programme? How easy was it for you to find the right level? How easy was it for you to understand the pictures? How easy was it for you to hear the sentences?	Mental Demand: How mentally demanding was the task? *How much thinking/ remembering was involved?* Physical Demand: How physically demanding was the task? *How restful or strenuous was the task?* Time Demand: How hurried or rushed was the pace of the task? *Was it too fast or two slow?* Performance: How successful were you in achieving your goals? *Were you satisfied with your work?* Effort: How hard did you have to work to achieve your goals? *How much effort did you have to put in?* Frustration: How insecure, discouraged, irritated, stressed and annoyed were you?

Figure 5.6. Sample question from NASA TLX

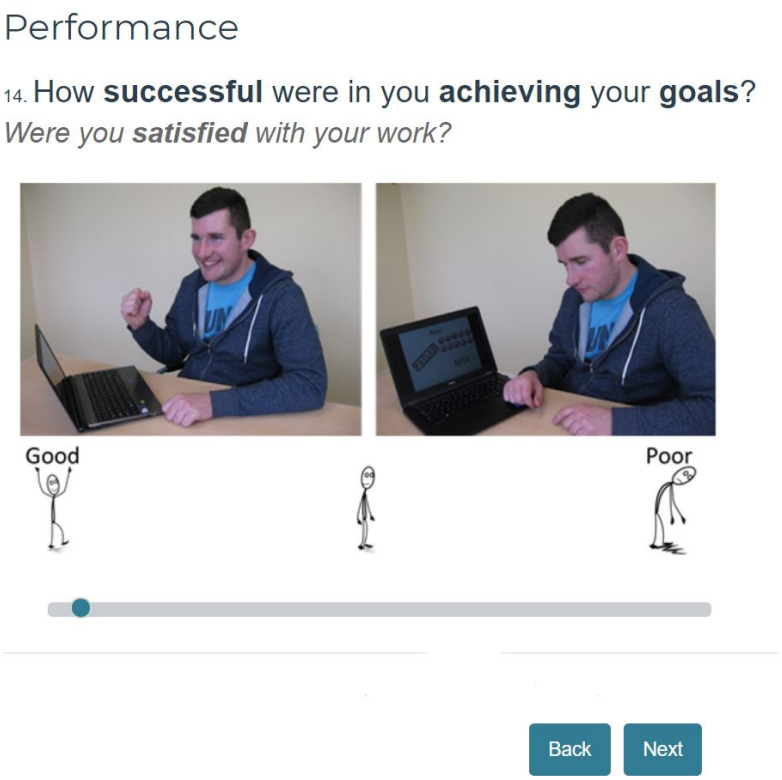
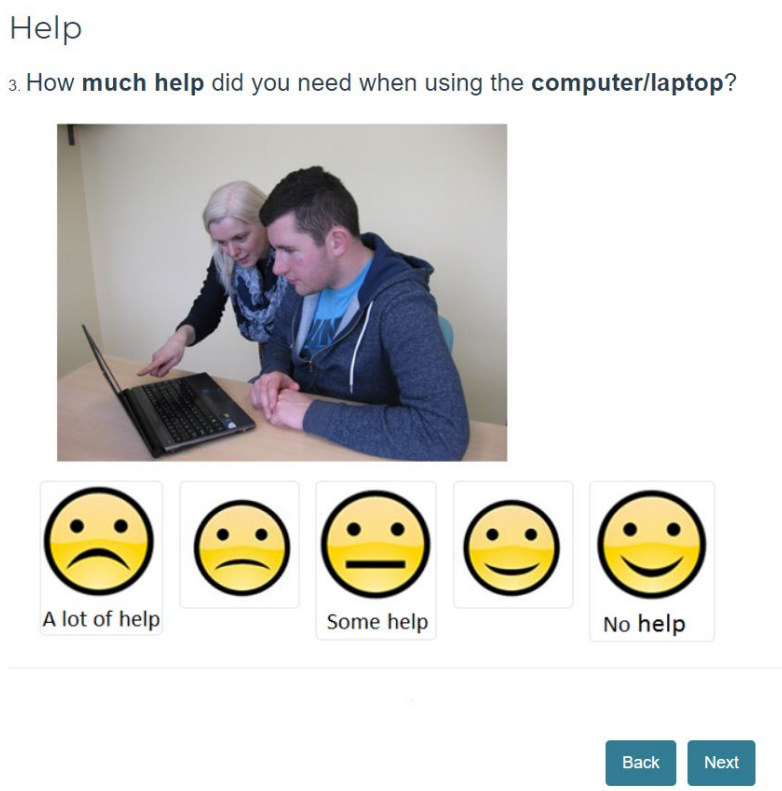


Figure 5.7. Sample question regarding assistance



5.4.3 Experience of Collaborative Co-design Research

The experiences of co-designers will be discussed with reference to the exit interviews of the co-designers with aphasia as well as the Reflective Diary of the Facilitator.

5.4.3.1 Exit Interviews

Four of the six co-designers attended the exit interviews completed within 3 weeks from the final workshop. One co-designer was unable to attend due to illness and the other due to time constraints and other commitments; he had returned to work after his stroke. Four themes were identified within the interview data: Group Dynamics, Balance of Complexities of Tasks, Reflection on Abilities and Positive Experience. These are discussed individually below with supporting quotations.

Group Dynamics: Although not asked specifically about the group interactions during the interviews all four participants discussed the make-up of the group. Two reported that 4-5 people were optimum for this activity, one favoured 2-4 people and one preferred a larger group. Three spoke about "meeting people", "talking" and every day social conversations as aspects they liked about the research process. Co-designer C spoke about needing time to develop rapport to be able to give his views: *"I have to, you have to get nobody, see you have to be, know, you have to know somebody before you say anything".*

One co-designer suggested that consistency in attendance was best. This was not always the case in this design process as not all members were able to attend all 6 sessions.

Balance of Complexities: When initially asked about aspects of the workshops that were difficult all four responded that they had no problems with the

content. Co-designer F reported: *"no eh…I…pictures…and computers…happy with having how much was in it".*

One co-designer referenced the use of the large circular table, which was utilised following the first session, as well as the use of name badges as important for supporting interactions. Another pointed out that supporting visual materials were beneficial. One co-designer who presents with auditory comprehension difficulties on the WAB-AQ and also wore hearing aids reported that he could hear everything except one day when his hearing aids were not functioning. One co-designer commented on the timing of the group, suggesting that the time between one week and the next caused issues with remembering the content covered. This wasn't reported by others.

Reflection on Abilities: Three of the four co-designers commented on their own communication abilities, recognising their own strengths and challenges. Co-designer C spent some time comparing himself to others in the group. He was 2.5 years post stroke, the earliest of all in the group, and this may have prompted him to consider his abilities against others with aphasia. He noted: *"..was, four or five people, I was the only one who wasn't talking right … you know the people better off, were better off with me… no not me ehm,… ehm, I thought I was bad but….but I wasn't too bad".*

Another advised the interviewer of his prior knowledge of computers, which was utilised within the design process. Two discussed their own potential for continued improvement in both learning and communication skills.

Positive Experience: Each co-designer was asked what they did not like about the workshops and all indicated they enjoyed the process and didn't have

anything negative to report. For example, when Co-designer A was asked about things he liked and disliked he stated: *"tell the truth I liked everything"*

They were also asked to suggest changes to consider for future research which reiterated previous comments on logistics such as, badges, larger table, and group size. One co-designer emphasised that there should be more opportunities like this and appreciated the optimum environment of the workshops e.g. room location was close to toilet facilities. He also noted one challenge in terms of the cost of a taxi in order to attend one workshop; this differed to his normal routine.

5.4.3.2 Reflexivity in Action

A review of the reflective journal written by the facilitator presents a number of recurring issues throughout the research process. The facilitator identified the importance of the social interaction within the group from early in the process, noting that the coffee break was a powerful time for people to chat and support each other. In addition, she observed that some tasks allowed a diversion from established roles within the group e.g. testing the questionnaire on a game activity allowed one member to teach another how to complete tic tac toe on the iPad and provided some humour in the process. This appeared to further strengthen the relationship between co-designers. The facilitator was preoccupied with the level of difficulty of tasks and the abstract nature of some of the usability concepts and how these could be made accessible to all. There were frequent diary entries referring to the "tough" and "tiring" nature of the work involved in making the information accessible. A sense of relief was noted when reviewing the interview transcripts where co-designers reported no problems with accessibility of information. The facilitator was new to participatory research but was completing a university training module on community-based participatory research at the time of the study. This

was seen as vital in appraising her own role and developing research skills within the PPI process. She identified the challenge of establishing an equal partnership working in a collaborative, rather than a user-controlled, research process. Here, the goal of the research process was defined at the outset by the facilitator. Through reflective questioning, she negotiated the challenges she faced of ensuring a collaborative rather than consultative process. This encouraged her to embrace the collaborative nature of the research and be ever mindful to avoid tokenism (Arnstein, 1969).

5.5 Discussion

The collaborative research outlined above identified the iterative nature of the design process for the development of this ICT feedback questionnaire, aimed to provide a greater understanding of the experience of a person with aphasia when engaging with ICT rehabilitation programmes. The questionnaire explores the accessibility, functionality and ease of use of an aphasia rehabilitation programme as well as the level of assistance required as reported by the person with aphasia. It incorporates a measure of cognitive workload and satisfaction using an aphasia-accessible version of the NASA TLX (Hart and Staveland, 1988) and integrates usability principles (Nielsen, 1994) as relevant to ICT-delivered aphasia rehabilitation (Mortley, et al., 2004). It is presented as an online survey in an aphasia-accessible format with supporting visual aids (Rose, et al., 2011a; Rose, et al., 2011b).

Research exploring feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation has grown since Wade, et al. (2003) explored this topic and proposed the development of a self-rating scale. Despite this increase,

there is no consensus questionnaire available and a range of data collection methods have been used to gather feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation including interviews (Marshall, et al., 2013; Palmer, et al., 2013) and questionnaires (Choi, et al., 2016; Mallet, et al., 2016). Studies that employ questionnaires do not provide a description of the questionnaire development. The questionnaire development process described in this chapter takes a somewhat different approach to that proposed by Wade, et al. (2003). Our research involved people with aphasia as part of a *co-design* rather than consultation process, grounded on *collaboration* between those with a lived experience of aphasia and an SLT facilitator with expertise in ICT-delivered aphasia rehabilitation. The final product reflects the output of this collaboration and the iterative nature of the co-design process in the production of, as far as we are aware, the first co-design measure available for use in planning or monitoring ICT-delivered aphasia rehabilitation.

The co-designers in this PPI research had a range of experience and views of ICT use that they brought to the design process. Reports of challenges when using ICT emerged in the initial individual sessions. This was a common narrative among the co-designers and has been reported in studies of ICT use in aphasia rehabilitation (Brandenburg, et al., 2017; Galliers, et al., 2017) so it was discussed in the first workshop. The concept of *frustration* was identified by many of the co-designers irrespective of ICT experience and was therefore a good starting point to begin discussing usability and user experience of ICT devices and applications. The workshops provided a supportive environment for all co-designers to express their views on ICT and questionnaire development and each person was provided with the opportunity to give an opinion, rank preferences, etc. The process of consensus

agreement was not always easy during the workshops. In many cases, a consensus was not obtained and the question was parked for a period of time and then returned to with new information and consensus attempted again. If consensus could not be achieved then a majority vote was considered a successful outcome. The need for compromise was discussed and agreed within the group in order to progress the design process. Offering a comprehensive co-design process resulted in a time and labour intensive journey which has also been recognised in other research involving collaborative design with people with aphasia (Herbert, et al., 2018). The final questionnaire was realised with the use of modified design techniques (Wilson, et al., 2015) and taking into account existing guidelines for aphasia-accessible information and supporting visual aids (Rose, et al., 2011a; Rose, et al., 2011b). The questions are presented in text format with bold font for keywords above a relevant, related photograph to aid comprehension. Throughout the design process, it became apparent that the supporting photographs needed to be bespoke for the questionnaire being developed, reflect realistic situations and accurately represent the concept addressed in the question. When attempting to probe feelings of success or satisfaction in the context of using an ICT device, the emotion and the context i.e. a person experiencing satisfaction when using a laptop computer, needed to be clearly identified in the image. This preference for concrete images has also been identified by people with aphasia in other collaborative design activities (Herbert, et al., 2018).

The facilitator came to this design process with a very specific goal to collaboratively develop a questionnaire *with* people with aphasia for use *by* people with aphasia in future research. This was probably not the same for the co-designers in the process who were recruited from local SLT services. Despite the provision of the research information prior to recruitment, they were unlikely to have had the

same goals as the SLT researcher. However, after a small number of sessions, there was a clear consensus of a shared goal: the aim to explore the challenges and benefits of ICT-delivered aphasia rehabilitation by developing the feedback questionnaire (INVOLVE, 2012). This cemented the working relationship and drove the development process. The facilitator's reflective journal entries note concern about the complex and abstract nature of concepts related to usability that were being explored. However, the use of aphasia-accessible information (Rose, et al., 2012), as well as simple ranking tasks and trialling prototypes (Wilson, et al., 2015), facilitated the iterative design process and became just part of the development process. Some co-designers had more experience of ICT use than others, each bringing their own shared, and varied, experiences to the group which also facilitated the research process. It was possible to recognise individuals' expertise, not just their lived experience of aphasia when considering the social model of disabilities (Byng and Duchan, 2005), but also their life experience.

The satisfaction of seeing an end product was important. Although this wasn't explicitly focused on in the exit interviews, this was obvious from the positive responses to the final product in the final workshop. Interestingly, the social opportunity the group provided for each member with aphasia was very apparent in the exit interviews. All four co-designers identified the opportunity to talk with others with aphasia as a positive aspect of the process. This may echo people with aphasia's focus on improved communication and life participation as important outcomes in aphasia rehabilitation (Wallace et al., 2017). Alternatively, it may also reflect the development of supportive relationships as a key benefit of PPI research (Harrison and Palmer, 2015).

A number of key learning points emerged from this experience with respect to the logistics of running co-design workshops. It is important to be mindful of the accessibility of the workshop location in terms of ramps, accessible toilets etc. There is also a challenge with respect to balancing timing and frequency for all involved for example, one co-designer reported a preference for less time between sessions as he found it difficult to remember all the information from one week to the next. The facilitator needed to prepare a substantial amount of aphasia-accessible materials between workshops in order to facilitate workshop discussions. This was labour intensive and the time commitment cannot be underestimated (Herbert, et al., 2018). This preparation between sessions necessitated the weekly schedule. Reviewing the previous session at the start of each workshop helped to remind co-designers about the discussions and decisions made. The use of name badges and a large circular table for group activities within the workshops were considered beneficial. Although there was no consensus from the exit interviews, it would appear that a group with 4-6 people is ideal for this type of collaborative activity. A relaxed and lengthy coffee break during the workshops allows for social conversation and rapport building as well as a reprieve from workshop activities. The design process, including the interactions, the aims and the workload involved, may have been an engaging experience for the co-designers, reflecting a contribution that was valued and considered worthwhile (Byng and Duchan, 2005).

In addition to the points of learning highlighted above, researchers who are planning future co-design activities with people with aphasia should consider how best to facilitate collaborative working within design groups that include members with communication difficulties. In order to ensure each co-designer with aphasia has an opportunity to contribute within the workshops, it is important to actively

provide opportunities for each member of the group to convey their opinion and engage in the process. The co-design workshops in this research were facilitated by a single researcher who was also an experienced SLT. Ideally, two researchers with experience in support communication strategies would be optimum in a group with four to six people with aphasia. This would facilitate one researcher supporting an individual to express their message while the second researcher monitors the group to see if others wish to follow up on this point. In this current co-design activity, the researcher was conscious to ensure that each co-designer had an opportunity to engage in the process and actively provided these opportunities for turns. She facilitated this by checking with each co-designer, one by one around the table, to see if they wished to contribute to the discussion. Thus, ensuring each individual was provided time and support to express their opinions. This required a slow pace within activities and additional time is necessary in such collaborative design activities. This is particularly important when engaging co-designers with communication impairments within collaborative design.

5.5.1 Future Work

The feedback questionnaire was developed for use as an outcome measure in a subsequent research study investigating ICT-delivered aphasia rehabilitation targeting auditory sentence comprehension in conjunction with other outcome measures. The questionnaire will provide relevant and meaningful feedback as reported by people with aphasia who engage in ICT-delivered aphasia rehabilitation and will provide a mechanism for reporting feedback on their experience of this mode of rehabilitation. Future work will involve psychometric testing of this co-designed feedback tool.

5.5.2 Limitations

The PhD researcher was an integral part of the co-design, execution and evaluation of the workshops, therefore it was important that she remained reflexive and recognise her role in the whole research process (Finlay and Gough, 2003) while attempting to minimise any potential bias. A reflective journal was completed and reviewed after each session. The facilitator completed the initial individual sessions, facilitated the workshops, transcribed and analysed the final exit interviews. However, an independent speech and language therapist not involved in the research completed the exit interviews and the thematic analysis was discussed at each step with the second researcher. Four of the 6 co-designers attended the exit interviews. Unfortunately, the only female co-designer was unable to be interviewed due to illness, therefore, the views expressed may not be representative of the group as a whole. The feedback questionnaire was not validated as part of the development process outlined above. The next planned phase will include testing the questionnaire within a pilot study exploring the feasibility of ICT-delivered aphasia rehabilitation. This will allow for further refinement of the questionnaire following feedback from a larger cohort of people with aphasia. This was an unfunded study and co-designers were not compensated for their time, however it is good practice to offer payment whenever possible (INVOLVE, 2012).

5.6 Conclusions

Information and communication technologies have become a fact of everyday living and can provide opportunities for cheap and easy access to communication, media and potential therapeutic activities. This opportunity should be considered in the context of the users' preferences to ensure optimal engagement. Currently, there is no consensus measure to record user feedback within research

exploring ICT-delivered rehabilitation among people with aphasia. The development of a feedback questionnaire, in collaboration with people with aphasia, for use by people with aphasia, was an iterative process. The iterative design process was time and labour intensive but was an appropriate and feasible approach that was valued by all involved. The resultant questionnaire will provide feedback on usability, functionality and level of assistance required to complete ICT-delivered aphasia rehabilitation tasks and incorporates an aphasia-accessible version of the NASA TLX, providing a measure of cognitive workload and satisfaction. This product will be tested in a subsequent feasibility study. This research illustrates that people with aphasia can, and should, be included in all stages of the aphasia research process and especially in the development and design of evaluation measures for use by people with aphasia.

5.7 Chapter Summary

This chapter provides an overview of a collaborative design process that was carried out as part of Research Strand Two. The process is described in detail with particular attention to the roles of the co-designers and the PhD researcher. The co-designers are patient experts with a lived experience of aphasia. People with aphasia can, and should, be included in all stages of the aphasia research process and especially in the development and design of evaluation measures for use by people with aphasia. Their unique contribution to this co-design process allowed for the development of a relevant, meaningful and aphasia-accessible questionnaire. The final questionnaire provides an outcome measure that investigates; cognitive workload, satisfaction, programme functionality and ease of use, and the level of assistance required when engaging in ICT-delivered aphasia rehabilitation. It was

used in a subsequent research activity in Research Strand Three. This study is described further in Chapter Seven and Chapter Eight.

Chapter Six

Chapter Six - ICT-delivered Aphasia Rehabilitation for Auditory Language Comprehension Deficits: a Literature Review

6.1 Introduction to Chapter

This chapter provides an overview of the background literature relevant to Research Strand Three. A literature review employing restricted systematic review principles was carried out. The aim of this review was to synthesis the available evidence investigating the effectiveness of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment. This chapter will describe the background to the review and its aims (6.2), the methods undertaken to answer the review questions (6.3), the findings of the search strategies and included studies (6.4), and the implication of these findings as relevant to Research Strand Three (6.5).

6.2 Background

The prevalence of stroke and post-stroke aphasia and the potential consequences of aphasia were described in Chapter One (1.2). Intensive rehabilitation is important for successful outcomes. Information and Communication Technologies (ICT) may provide an option for intensive rehabilitation for individuals with aphasia (Code and Petheram, 2011).

Evidence has emerged to support the effectiveness of computer-based aphasia rehabilitation for anomia (Lavoie, et al., 2017) and as an option for self-administered aphasia rehabilitation (Palmer, et al., 2012; Varley, et al., 2016). However, the focus of much of this research remains heavily placed on expressive language impairments. Only two of the seven studies in the recent systematic review

of computer therapy in aphasia (Zheng, et al., 2016) reported providing therapy targeting auditory comprehension impairments.

Thompson, Choy, Holland, & Cole (2010) tested the efficacy of Sentactics®, a programme which combines Treatment of Underlying Forms (TUF) protocols in an interactive computer system run on a laptop computer. TUF is a linguistically-based treatment targeting improvements in agrammatic sentence deficit. All six participants in the Sentactics® group presented with agrammatic Broca's aphasia and were provided one-hour sessions of computer-based therapy, four times per week, up to a maximum of 20 sessions or until 80% correct performance on the daily production probes were noted for 4 consecutive sessions. The participants in this study demonstrated statistically significant improvements in the production of trained object relatives *(p=0.027)*, untrained object wh-questions (*p=0.043*) and the production of object relatives on the Sentence Production Priming Test (SPT) of the Northwestern Assessment of Verbs and Sentences (NAVS) (*p=0.*041). Participants also demonstrated improved comprehension of trained object relatives (*p=0.043*) and mean length of utterance (MLU) in narrative sample (*p=0.043*), when compared to baseline scores. However, non-significant differences were noted for a number of measures including comprehension and production of trained and untrained items on the SPT. There was also no difference in words per minute (WPM), noun:verb ratio or proportion of verbs produced with correct arguments in narratives following intervention (Thompson, et al., 2010; Zheng, et al., 2016). When comparing the outcomes after the intervention to the control group, there was a statistically significant improvement in the comprehension of trained object relatives (*p=0.041*) and on comprehension of trained object relatives in the SCT (*p=0.014*), as well as improvements in some of the production tasks. There

were no significant differences for the production or comprehension of sentence types among the computer-delivered group and the clinician-delivered group. The authors conclude that the findings support the efficacy of TUF and demonstrate the viability of computer-delivered therapy for TUF.

Cherney (2010) evaluated the efficacy of Oral Reading for Language in Aphasia (ORLA). This computer-based programme was developed to improve reading comprehension in individuals with aphasia by providing practice in the phonological and semantic reading routes. It is also reported to improve auditory comprehension (Cherney, 2010). The outcomes measured in this study included the Western Aphasia Battery – Aphasia Quotient (WAB AQ) and the WAB reading and writing subtests. However specific outcome measures of auditory language comprehension and the individual subtest scores of the WAB are not reported.

This literature review aims to synthesise the recent, available evidence investigating the efficacy of ICT-delivered aphasia rehabilitation specifically targeting auditory comprehension impairment. The research questions in this review examined what is known about the effect of:

1) ICT-delivered therapy targeting auditory comprehension impairments for persons with aphasia when compared to no therapy/usual care
2) ICT-delivered therapy targeting auditory comprehension impairments for persons with aphasia when compared to clinician-delivered therapy
3) self-administered ICT-delivered therapy targeting auditory comprehension impairments

6.3 Methods

6.3.1 Structure of the Review Question

This review aims to build on the evidence presented in the existing review by Zheng et al. (2016). For this reason, a similar search strategy was completed; however, the approach was modified so as to explicitly include ICT-delivered therapy for auditory language comprehension impairments in the eligibility criteria. The three review questions are examined within the literature using the Participant, Intervention, Comparison, Outcome, and Study Design (PICOS) components as presented in Table 6.1.

Table 6.1. Inclusion and Exclusion Criteria

	Inclusion	Exclusion
Population	Aphasia post-stroke Adults > 18 years of age	Language impairment associated with any other condition (e.g. primary progressive aphasia, traumatic brain injury)
Intervention	Therapy targeting auditory language comprehension as part or all of a language rehabilitation programme Includes a form of ICT as a key component of therapy (e.g. personal / laptop / tablet computer, smartphone	Therapy delivered as synchronous telerehabilitation Therapy aimed at compensation of language impairment (e.g. alternative, augmentative communication)
Comparison	Control group comparison or, Within case control comparison	
Outcome	Any quantitative outcome measuring auditory language comprehension	
Study Design	Group studies comparing a treatment and control group Single case studies comparing participant performance over time for treated and untreated periods Single case studies comparing participant performance over time for treated and untreated items	Non-experimental methods
Publication	Peer-reviewed publications English articles	Publications before 2013

6.3.2 Search Strategy

The search terms and databases used reflected the original systematic review by Zheng et al. (2016) and are outlined in Table 6.2. In August 2018 searches were

completed on four online databases: Medline, PsycInfo, CINAHL and Embase. This was repeated in February 2019. The data was restricted to include articles from January 2013 in order to retrieve articles published since the searches were completed for the previous systematic review (Zheng, et al., 2016). The search terms were not modified to include language comprehension as a search term. This was to ensure that no articles were excluded from the search based on variations in terminology used to reference auditory comprehension impairments. Instead, all retrieved references were screened against the eligibility criteria to determine if intervention targeted auditory comprehension impairments.

Table 6.2. Search Terms and Databases

Database	Search terms
CIHANL	(language impairment OR (rehabilitation, speech and language) OR language disorder* OR aphasia: (Broca, Wernicke, Transcortical sensory, Transcortical motor, Conduction, anomia) AND (technology OR iPad OR tablet OR (Computers portable) OR information technology OR computer* OR computers and computerisation) AND (therapy OR rehabilitation OR Computer therapy OR computer-assisted therapy)
Medline	(language impairment OR (rehabilitation of speech and language) OR language disorder* OR aphasia: (Broca, Wernicke, Transcortical sensory, Transcortical motor, Conduction, anomia) AND (technology OR iPad OR tablet OR computer software OR portable computer OR information technology OR computer*) AND (therapy OR Computer therapy OR computer assisted therapy)
PsycINFO	(aphasia OR Wernicke's syndrome OR dysphasia OR language disorders OR communication disorders OR language impairment) AND (technology OR information technology OR tablet OR iPad OR handheld computers OR portable computers OR computer OR computers OR computer applications OR computer software OR computer assisted therapy) AND (therapy or treatment OR rehabilitation)
Embase	((language AND disorder) OR language impairment OR aphasia OR dysphasia OR anomia OR broca OR conduction OR transcortical motor OR transcortical sensory OR dysgraphia OR dyslexia) AND (technology OR iPad OR tablet OR computer software OR portable computer OR information technology or computer or computers or handheld computer or microcomputer) AND (therapy OR rehabilitation OR computer assisted therapy)

6.3.3 Screening and Data Extraction

Titles and abstracts were screened against the criteria outlined in Table 6.1. The full-text review was completed where studies met the inclusion criteria or

sufficient information was not provided in the abstract to determine eligibility. Quality assessment was carried out using a quality assessment checklist for both randomised and non-randomised studies (Downs and Black, 1998). Summary information is available in Appendix 11. Data were extracted using a template and entered into an Excel sheet. The following information was collected for each study: study aims, design, subject details, intervention details, comparator details, outcome measures, and a summary of key findings.

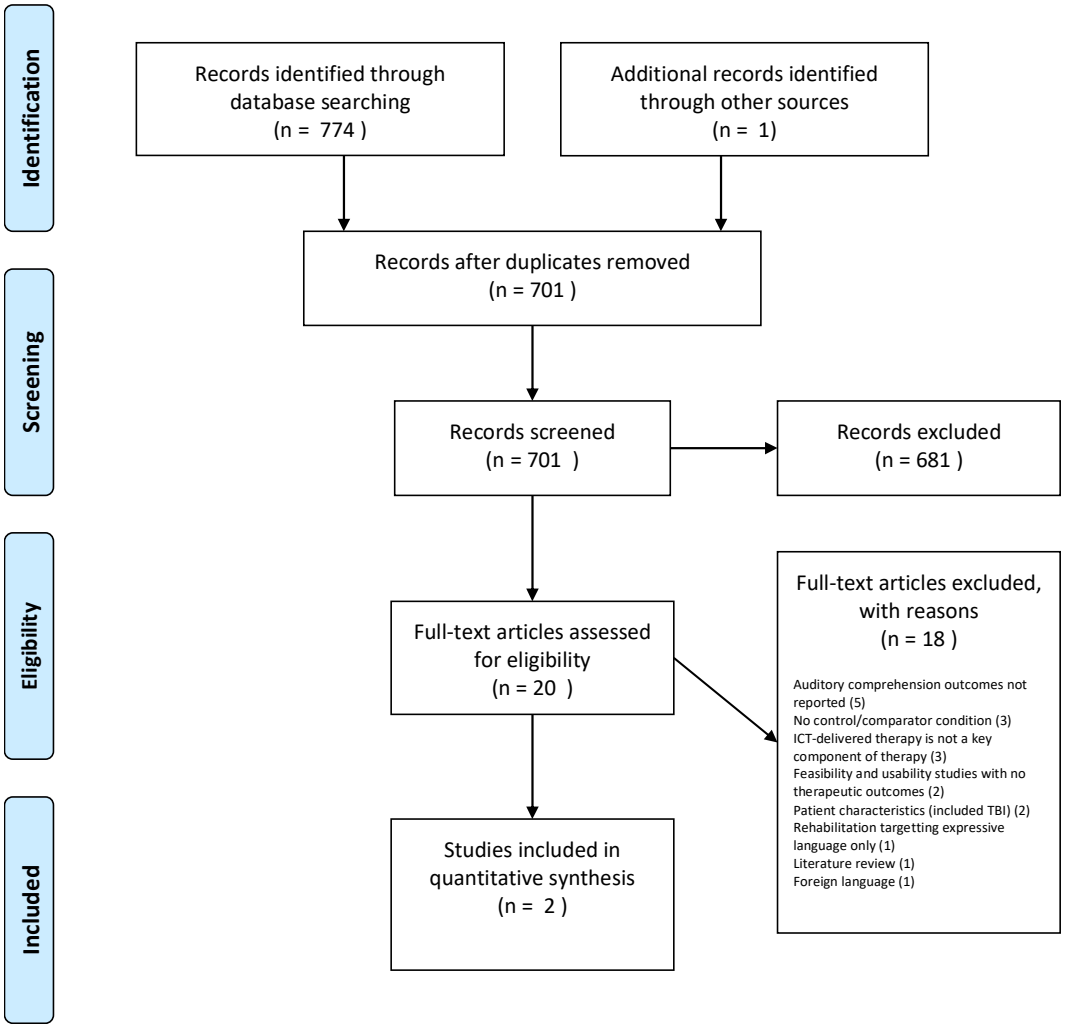
6.4 Results

6.4.1 Study Selection and Inclusion

A total of 772 records were identified following database searching and one record was retrieved through serendipitous discovery (Greenhalgh and Peacock, 2005). This occurred when discussing the review topic at an aphasia research meeting with a researcher who was involved in a study examining computer-based aphasia rehabilitation. See Figure 6.1 for further details of the search strategy results. The titles and abstracts of the retrieved references were screened for eligibility, following the removal of duplications. Full-texts were sought for 20 articles of which 18 were excluded. Reasons for exclusion included: auditory comprehension outcomes not reported (5), no control or comparator condition (3), ICT-delivered therapy was not a key component of therapy (3), feasibility and usability studies with no therapeutic outcomes (2), patient characteristics (2), rehabilitation targeting expressive language only (1), review paper (1) and foreign language (1). In the case of the review paper, the references were searched and checked against the eligibility criteria and no new records were obtained. Two

studies were included in this review (Woodhead et al., 2017; Zakariás, Keresztes, Marton, & Wartenburger, 2016).

Figure 6.1. Search Strategy Results for Literature Review (Research Strand Three)



6.4.2 Study Design

One study was a randomised control trial with a crossover design (Woodhead, et al., 2017). The study was conducted in the United Kingdom. Participants were assigned to one of the two crossover groups using a computer-generated block randomisation technique. Both participants and assessors were blind to the allocation. Twenty participants completed the study in which each participant received four 5-week blocks of treatment. The four blocks included: drug

only (donepezil), drug and computer-based therapy, placebo only and placebo and computer-based therapy. The study investigated if phonological training improved speech comprehension and the impact of donepezil on outcomes. There were two crossover groups. Group 1 received the four blocks in the following order: 1) drug, 2) drug and Earobics, followed by a washout period, 3) placebo, 4) placebo and Earobics. Group 2 received the four blocks in the following order: 1) placebo, 2) placebo and Earobics, followed by a washout period, 3) drug and 4) drug and Earboics.

The second study included in this review was a case-controlled research design comparing the outcomes following computer-based treatment for three individuals with aphasia, to the average of a control group with five people with aphasia who did not receive the intervention (Zakariás, et al., 2016). The study was conducted in Hungary. The research investigated if training focused on working memory (WM) and executive function processes resulted in an improvement on the same processes, as measured by tasks not practised during the training session, and improvements in spoken sentence comprehension.

6.4.3 Intervention

Phonological training was provided to the participants in the study by Woodhead, et al. (2017) using a software programme called Earobics Version 1. This programme cycles through six independently adaptive tasks. The tasks include: auditory short-term memory training with environmental sound-to-picture matching, grapheme-to-phoneme mapping, auditory segmentation of non-speech and speech sounds, word-to-picture matching to train phonological blending, rhyme detection and auditory discrimination using phoneme and word pairs. There was no information on the hardware required to run to the programme. Participants were

asked to complete 10 hours of training each week over the 5-week training blocks. Participants were also asked to record the time spent in training with help from their partner or carer in a self-report diary. It is not explicitly stated that the training was carried out in the participants' homes but it would appear that this is the case.

The intervention in the second study involved an "n-back" task which is defined as a "*complex task involving multiple processes (e.g., encoding incoming stimuli, monitoring, maintaining, and updating WM representations, establishing and maintaining bindings between memory contents and their temporal context)*" (Zakariás, et al., 2016, pp. 372-373). This was combined with lures or distractor items which were intended to target inferential skills, thus potentially recruiting brain areas known to be involved in spoken sentence processing. Participants were presented with a stream of letters which run in Presentation® software (Version 14.1) on an IBM T40p ThinkPad® at a rate of 3 seconds. The participants were asked to press a button when a letter was the same as the one appearing n trials prior to this presentation. Lures were also incorporated into this task; these were letters that were the same as the one presented n−1 or n+1 (but not n) trial before. Participants responded to the target item by pressing the SPACE bar. Training sessions were approximately 20 minutes and participants completed 13 training sessions over a 4-week period. Each session was conducted by an experimenter.

6.4.4 Summary of Participants

The study by Woodhead, et al. (2017) sought to recruit 20 participants. Twenty-seven participants were enrolled in the study. Three participants withdrew after the baseline measurements. The trial's time demands were noted as the reason for withdrawal. Four participants were excluded from the analysis due to the extensive left auditory cortex damage which made them unsuitable for dynamic

causal modelling analysis which was carried out in addition to behavioural outcome measures. The twenty participants who completed all phases of the crossover included three females and 17 males. All participants had left hemisphere strokes and normal hearing. The mean age was 62.4 years with a range of 44 – 90 years. The average time post stroke was 3.3 years with a range of 0.6 - 8.6 years. Eleven participants presented with Wernicke's aphasia and nine presented with Global aphasia. Seven participants had severe aphasia and the remainder had moderate aphasia.

The study by Zakariás, et al. (2016) included three people with aphasia in the treatment group with an age range of 57-64 years and five people in the control group, age range 35-75 years. The treatment group time post onset of stroke ranged from 8-12 months. Two of the participants presented with transcortical motor aphasia and one presented with anomic aphasia. The WAB AQ ranged from 57-71.3. The control group time post onset of stroke ranged from 8-180 months. Two presented with transcortical motor aphasia, two with Broca's aphasia and one with anomic aphasia. The WAB AQ ranged from 62.7-96.3.

6.4.5 Summary of Study Findings

The primary outcome measure, in the study by Woodhead, et al. (2017) was the speech comprehension scale of the Comprehensive Aphasia Test (CAT) (Swinburn, et al., 2004). Phonological training was noted to significantly improve speech comprehension as indicated by a significant main effect of time ($F_{(1,16)}$=6.56, p<0.05). The authors note that this effect, though significant, was clinically small. This study also sought to determine if the drug (donepezil) facilitated phonological training effects and the results suggest that there was a converse significant main effect of the drug with lower scores on the drug compared to the placebo

($F_{(1,16)}$=11.60, p<0.005). These effects were larger in the severe patient group. They responded better to the phonological training and worse to the drug than the moderate group. As therapy was carried out in two blocks there was a total of 40 completed training blocks carried out in the study. Twenty-eight self -report diaries were completed out of a possible 40. These provide information on the training duration and the average training dose was noted to be 36 hours 38 minutes per block with a range of 6 hours 20 minutes to 65 hours 5 minutes. There was no statistically significant difference between the mean training time for block 1 and block 2 ($t_{(26)}$=0.37, p=0.71).

In the findings reported by Zakariás, et al. (2016), they presented the difference between pre and post intervention outcomes for each participant compared with the mean pre-post difference in the control group on all measures. Following the intervention, Participant 1 (P1) showed a statistically significant increase in performance on the training task (r = .701, p < .01), while Participant 2 (P2) showed some improvement without statistical significance (r = .501, p = .08) and Participant 3 (P3) did not demonstrate increased performance (r = .220, n.s.). Two participants (P1 and P3) improved significantly on comprehension of spoken sentences as measured by the Hungarian version of the Test for Reception of Grammar (TROG-H), (t = 4.07, p=0.008 and t=6.04, p=0.002), while P3 showed no statistically significant change. The Boston Naming Test was completed as a non-target outcome measure. Interestingly, one participant (P2) showed some improvement on the Boston Naming Test and a tendency for an increase in naming after the intervention (t=1.67, p =0.083). This was not expected to change following the intervention.

6.4.6 Summary of the Findings in Relation to the Review Questions

When returning to the questions posed for this literature review and considering the limited available evidence it can be seen that it is not possible to conclusively answer any of the three literature review questions with the available evidence.

What is known about the effect of ICT-delivered therapy targeting auditory comprehension impairments for persons with aphasia when compared to no therapy/usual care? The double-blind randomised control trial carried out by Woodhead, et al. (2017) provides a single, good quality study (Downs and Black, 1998) to support the use of Earobics, a computer-based phonological training programme in aphasia rehabilitation. The findings suggest that this programme provides a small but statistically significant change in CAT comprehension scores. While acknowledging the effect is small, the authors highlight the "*clinical importance*" of this finding and note that therapeutic interventions for people with aphasia who have severe speech perception impairments have largely been written off in textbooks and systematic reviews (Woodhead, et al., 2017, p. 592). The case series study by Zakariás, et al. (2016) included in this review reflects a poor quality score (Downs and Black, 1998). This is due to the inability to blind participants and experimenters, lack of randomisation and limited information about recruitment procedures and timelines. In addition, there is limited information on the clinical history of the participants and no attempt to establish a stable baseline prior to intervention. The findings of this study, although they indicate improvements among two of the three participants cannot be generalised. The included studies represent a small body of evidence that supports ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment when compared to no therapy.

However, the findings are limited to the Earobics software programme which demonstrated a small effect following intervention and the n-back tasks programme for which two of the three participants made treatment gains.

What is known about the effect of ICT-delivered therapy targeting auditory comprehension impairments for persons with aphasia when compared to clinician-delivered therapy? There are no studies available to provide support for or against ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment when compared to clinician-delivered rehabilitation.

What is known about the effect of self-administered ICT-delivered therapy targeting auditory comprehension impairments? The participants in the study by Zakariás, et al. (2016) completed training sessions in the presence of one of three experimenters. The experimenters were two trained SLTs and one trained nurse. The training sessions were distributed between the three experimenters depending on their work schedule availability. There was no report of self-administered sessions occurring in this study and so this study does not provide information relevant to the research question on self-administered ICT-delivered therapy. The participants in the study by Woodhead, et al. (2017) were asked to complete the Earobics training in two of the four blocks of the crossover research design. It is not explicitly stated in the study that this training was carried out at home. However, it is possible to infer this was the case as participants were asked to complete self-report diaries to record their training duration with some help from partners or carers. Only 28 out of a total of 40 diaries were returned and these indicate an average training dose of 36 hours 38 minutes. The participants were asked to complete 10 hours of training per week over the 5-week training block which totals 50 hours per block. The average training time was just under 13 hours less than the recommended training time. The findings

indicate a small, statistically significant effect of computer-based phonological training on comprehension scores of the CAT. The relationship between training dose and outcomes is not explored. The positive effect of phonological training on CAT comprehension scores is reported as a group analysis. There is no individual outcome or usage data provided. This good quality study provides high-level evidence to support the use of Earobics software for phonological training, which appears to be self-administered. However, further information is required to understand the relationships between adherence, dose, intensity and outcomes of self-administered aphasia rehabilitation.

6.5 Discussion

The main objective of this review was to investigate the effectiveness of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments. A systematic search yielded two studies for inclusion in this review; this indicates that little attention has been paid to this specific research topic. ICT-delivered aphasia rehabilitation has been shown to be effective for other acquired language impairments such as word-finding difficulties, and reading (Lavoie, et al., 2017; Zheng, et al., 2016) but there is limited research available that investigates ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments. The following discussion provides a narrative overview of the current, available evidence for ICT-delivered aphasia rehabilitation as relevant to auditory comprehension impairment as an individual rehabilitation goal and as part of a broader programme of rehabilitation.

6.5.1 ICT-delivered Aphasia Rehabilitation Targeting Auditory Comprehension Impairments for Persons with Aphasia compared to No Therapy/Usual Care

The two studies included in this review have examined two different ICT-delivered aphasia rehabilitation programmes. One aims to provide phonological training through six adaptive tasks (Woodhead, et al., 2017) and one aims to train working memory and executive function in order to improve sentence comprehension as measured by the TROG-H (Zakariás, et al., 2016). This latter study suggests that clinician-supervised, computer-based training on working memory and executive function may improve sentence comprehension in adults with aphasia. However, a caveat is indicated as the quality of the research design is poor and the generalisation of these results is limited with improvements in sentence comprehension noted in two of the three participants. The study by Woodhead, et al. (2017) provides evidence to support the use of a phonological training programme, namely Earobics, to improve comprehension scores, as measured by the CAT. There are also a number of recent studies that have included components of therapy targeting auditory comprehension impairments as part of a broad ICT-delivered aphasia rehabilitation programme (Des Roches, Balachandran, Ascenso, Tripodis, & Kiran, 2014; Kiran, Des Roches, Balachandran, & Ascenso, 2014; Stark and Warburton, 2018). These programmes include a variety of impairment-based activities including auditory comprehension, naming, reading, writing and calculation, and the findings indicate positive change after ICT-delivered aphasia rehabilitation. Des Roches, et al. (2014) reported improvements as measured on the WAB-AQ (t=-2.89, p=<0.01) among 42 adults with acquired language impairments due to stroke ($n=37$) and traumatic brain injury ($n=5$) after engaging in rehabilitation using an iPad and Constant Therapy app. Similarly, significant improvements in the

CAT Expressive language scores were noted among 10 adults with chronic aphasia after self-administered rehabilitation using an iPad and Tactus Therapy Language App (Stark and Warburton, 2018). Neither of these studies specifically examined the change in auditory comprehension impairments after training. Although the eligibility criteria for one study excluded participants with auditory comprehension impairments, the usage data that was retrieved for seven of the ten participants in the study indicates that six participants worked on auditory comprehension impairment activities (Stark and Warburton, 2018).

There are also a number of studies that have investigated the outcomes of rehabilitation programmes that combine a variety of rehabilitation modalities including individual therapy, group therapy, and computer-assisted therapy (Breitenstein et al., 2017; De Luca et al., 2014; Kesav, Vrinda, Sukumaran, Sarma, & Sylaja, 2017; Rodriguez et al., 2013; Wenke, Cardell, Lawrie, & Gunning, 2018) as well as synchronous telerehabilitation with additional ICT-based homework activities (Meltzer, Baird, Steele, & Harvey, 2018). It is not possible to compare these studies as the intensity, dosage and duration of the rehabilitation programmes varied greatly between studies. In addition, the time spent on additional independent ICT-delivered activities varied between studies: 12 hours over 4 weeks, 3 times weekly (Kesav, et al., 2017), 15 hours over 3 weeks, usually 5 hours per week (Breitenstein, et al., 2017), 8 hours over 8 weeks, 1 hour per week for one treatment group and 16 hours over 8 weeks, 2 hours per week for the second group (Wenke, et al., 2018) and 72 sessions, with no time measured, delivered in 6 sessions/weeks for 3 months (De Luca, et al., 2014). This was also noted to vary within studies where usage data was recorded and time spent on homework activities ranged from 5.3 to 64.7 hours over 10 weeks of the study (Meltzer, et al., 2018).

Improvements in measures of auditory comprehension impairments including the Token Test and the auditory comprehension subtest of the Aachen Aphasie Test were noted after intensive computerised language rehabilitation in one case study (De Luca, et al., 2014). However, there was no statistical analysis or comparator condition for this case study. Improvements in spoken language comprehension, as measured by the CAT, were noted for six of the nine participants who completed the hybrid service delivery combining individual, group and computer therapy (Wenke, et al., 2018). The group analysis showed no statistically significant difference immediately after rehabilitation (p=0.028) but a statistically significant difference at follow up, 4 weeks after treatment (p=0.020) when adjusted for an alpha level of 0.25 and multiple comparisons (Wenke, et al., 2018). Statistically significant improvements were also noted for spoken naming and aphasia severity after treatment and at 4-week follow up (p<0.025). Meltzer, et al. (2018) found no significant difference in improvement between the telerehabilitation and in-person conditions for rehabilitation. Interestingly, both groups were provided with ICT-delivered homework activities and the authors note a positive correlation between time spent on homework activities and gains in WAB AQ ($r_{(17)}$=0.51, p=0.027) and a slight tendency for participants in the in-person group to do more hours of homework but the difference was not significant ($t_{(16.9)}$=-1.06, p=0.31). Three other studies report significant improvements after rehabilitation; with respect to the effectiveness of verbal communication as measured by the ANELT (p=0.0004) when compared to the control group (Breitenstein, et al., 2017), significant improvement in aphasia severity as measured by the WAB-AQ (p=0.001) (Kesav, et al., 2017) and significant change in naming as measured by the Boston Naming Test (Z=2.25, p=0.024, ES = 0.10) but no significant change measured on the CAT Naming

Subtest (Z=1.01, p=0.311) (Rodriguez, et al., 2013). Scores related to auditory comprehension are not reported in these studies, but interestingly in one study the group who received the more intense treatment arm with an additional 12 hours of supervised computer-based language rehabilitation, in addition to the 12 hours of conventional speech and language therapy also received by the comparator group, demonstrated less robust improvements (Kesav, et al., 2017). As noted in each of these studies, the ICT-delivered rehabilitation is combined with another mode of intervention (individual therapy sessions, group therapy sessions, synchronous telerehabilitation or a combination of these) so it is not possible to state the effectiveness of these ICT-delivered rehabilitation programmes as a mode of intervention on its own.

6.5.2 ICT-delivered Aphasia Rehabilitation Targeting Auditory Comprehension Impairments for Persons with Aphasia compared to Clinician-delivered Rehabilitation

Since the publication of the review by Zheng, et al. (2016) there have been no new studies investigating ICT-delivered compared to clinician-delivered aphasia rehabilitation targeting auditory comprehension impairment. Zheng, et al. (2016) identified three studies comparing computer-delivered therapy with clinician-delivered therapy that also report on auditory comprehension outcome measures. Among these three studies, Thompson, et al. (2010) suggest that computer-delivered TUF in the form of Sentactics® is a viable option for the delivery of this treatment with observed improvements in production and comprehension of sentences noted in both the clinician- and computer-delivered interventions. The computer-delivered TUF outcomes did not differ significantly from those resulting from clinician-delivered TUF for any of the trained sentence types (Thompson, et al., 2010). This

finding was supported by the positive observations of two other studies Cherney (2010) reported no statistically significant difference between computer- and clinician-delivered Oral Reading for Language in Aphasia (ORLA) on all outcome measures. Similarly, improved language functioning, as measured by the Porch Index of Communicative Ability (PICA), in 18 of 21 participants following Cued Verb Treatment was reported in a study by Loverso, Prescott, & Selinger (1992). However, this study does not distinguish between therapy groups and no statistical analysis is reported. None of the interventions in these three studies target auditory comprehension alone. The therapy targets also include reading comprehension (Cherney, 2010) as well as oral expression and generation of simple and complex sentences (Cherney, 2010; Loverso, et al., 1992; Thompson, et al., 2010). Considering the paucity of available evidence investigating computer-delivered therapy targeting auditory comprehension alone, it is not possible to determine if this mode of rehabilitation is as effective as clinician-delivered rehabilitation.

6.5.3 Self-administered ICT-delivered Aphasia Rehabilitation Targeting Auditory Comprehension Impairments

One study was identified to provide support for what appears to represent self-administered ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments (Woodhead, et al., 2017). The study does not use the term self-administered but the description of the therapy procedure suggests that participants self-administered the intervention. The findings from this good quality study, provide evidence to support the use of Earobics for ICT-based phonological training. The results indicate the programme provides a clinically small but statistically significant improvement in comprehension scores. However, there is variation among the self-reported hours spent on the programme and the average

usage time is 13 hours below the time that participants were asked to spend on the programme in each block. This indicates that adherence to the recommended time spent on programmes as part of self-administered therapy may be variable. However, individual data was not presented and further analysis on the relationship between the time spent and participants' clinical outcomes was not reported.

As noted earlier, Stark and Warburton (2018) reported on a combined pilot study and crossover design which aimed to investigate the effectiveness and feasibility of self-administered aphasia rehabilitation using an iPad and app. The app targeted four areas of language therapy: reading, naming, comprehension and writing. The ten participants in the study, seven male and three females, were between 12 and 67 months after their stroke with an age range of 54 – 87 years. The participants were advised to self-select their own therapy tasks and they completed the activities at home over a 4-week time period. Due to issues with logging data remotely, the numbers of exercises completed from each category are presented for only seven of the ten participants. All but one of these participants worked on comprehension tasks. However, the study aimed to investigate self-administered rehabilitation for expressive aphasia and patients were considered for inclusion only if their comprehension scores were above the aphasia cut-off scores on the CAT. The findings indicate a significant effect after self-administered therapy as measured on the expressive CAT total score after therapy (t=6.58, p=0.001).

As highlighted earlier, a number of studies have also investigated independent, rather than clinician-supervised, use of ICT-delivered aphasia rehabilitation in conjunction with face-to-face treatment sessions (Des Roches, et al., 2014) or as an adjunct to intensive rehabilitation programmes with individual therapy sessions (Breitenstein, et al., 2017) or combined individual and group-based

activities (Rodriguez, et al., 2013). However, due to the combined nature of these study designs, it is not possible to comment on the efficacy of these programmes for the provision of independent, self-administered aphasia rehabilitation targeting auditory comprehension impairments.

The findings of this literature review, completed as part of Research Strand Three, suggest that Earobics can be self-administered and is effective when compared to no therapy. However, the evidence to support ICT-delivered aphasia rehabilitation as an effective mode of aphasia rehabilitation for auditory comprehension impairments when compared to clinician-delivered therapy is limited.

6.5.4 Limitations

It was only possible to include studies published in English in this review and this may have ruled out evidence from non-English studies. The screening and data extraction were completed by one researcher alone, although all decisions were carefully recorded and tracked using EndNote and Excel.

6.6 Conclusion

This review highlights the limited evidence currently available to support ICT-delivered aphasia rehabilitation targeting auditory language comprehension either as part of a combined programme with face-to-face speech and language therapy or as a self-administered rehabilitation programme completed in the persons' own home. A single, good quality, randomised control trial provides evidence to support a small effect on spoken comprehension using a computer-based programme of phonological training when compared to no training. No recent studies were found that compared ICT-delivered and clinician-delivered auditory comprehension

therapy. The findings from the review by Zheng, et al. (2016) suggest that results from computer-delivered therapy appear equivalent to results following clinician-delivered therapy for adults with chronic aphasia. There is a paucity of research investigating ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments, compared to the availability of research supporting ICT-delivered aphasia rehabilitation for post-stroke anomia. This suggests a gap in the evidence base and further research is indicated.

6.7 Chapter Summary

This chapter presented the methods and findings of a literature review which investigated the efficacy of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments. This review is relevant to Research Strand Three. The chapter highlights there is a growing body of research examining the effectiveness of ICT-delivered aphasia rehabilitation focused on expressive language impairments. However, there has been less attention on the outcomes of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments. Only two studies met the inclusion criteria for the review and there is currently only one randomised control trial that provides support for ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment. In this crossover study, a clinically small but statistically significant effect on comprehension scores was reported after phonological training when compared to placebo. The findings highlight that further research is indicated in order to examine the effectiveness of this mode of rehabilitation as well as the participants' experiences of engaging in ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment. Chapter Seven will explore the methods employed in an experimental two-phase crossover research design with random allocation to phase. This was carried out as part of Research

Strand Three. This crossover study will investigate the feasibility of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment at sentence level. This mixed methods feasibility study will explore the potential gains, usability and participant engagement with ICT-delivered aphasia rehabilitation. The findings of this feasibility study are presented in Chapter Eight.

Chapter Seven

Chapter Seven – Exploring Methods for a Feasibility Study

7.1 Introduction to Chapter

This chapter will provide information on the research design of a mixed methods feasibility study that was carried out as part of Research Strand Three. A number of additional activities were carried out in preparation for the research study and these are described in the first section of this chapter. These include the modification of an eye-tracking test (7.2.2), the development of a control programme for the crossover study (7.3) and the refinement of a questionnaire to screen technology use (7.5). The second section in the chapter provides a description of the feasibility study (7.6). The feasibility study is a two-phase experimental case series employing a crossover research design with random allocation to phase. Both qualitative and quantitative data collection methods were employed in the study. The methods of data collection and analysis are defined. Finally, the recruitment (7.10) and participant flow through the study (7.11) are described at the end of the chapter.

Section One – Preparation Activities for the Feasibility Study

7.2 Eye-tracking Methodologies

This section provides an overview of the background information on eye-tracking research and its potential use in aphasia rehabilitation. This is followed by a description of the development of an eye-tracking language battery test used in this research.

7.2.1 Background

Eye tracking has been used in studies to explore information processing within auditory language comprehension tasks among people with aphasia (Dickey, Choy, & Thompson, 2007; Dickey and Thompson, 2009; Laurinavichyute, et al., 2014) and is emerging in research examining change in online sentence processing before and after rehabilitation (Mack and Thompson, 2017). Eye-tracking can provide a measure of real-time information processing during a particular behaviour (Horsley, Eliot, Knight, & Reilly, 2013). The information processing required to match an auditory stimulus, such as a spoken sentence, to a single target image within a set of images is an example of this kind of behaviour. Eye-tracking does not identify the participant's decision making within the cognitive process of an auditory comprehension task; however, it will provide insight into the visual strategy used by the participant when completing the task (Bojko, 2013). This can allow for comparison between groups completing the same task, for example comparing individuals with and without a brain injury to determine similarities and differences in eye gaze patterns (Meyer, et al., 2012; Schumacher et al., 2015). It is also possible to compare the same participants over time, for example, to determine if change has occurred following intervention targeting sentence processing and comprehension among participants with aphasia (Mack and Thompson, 2017).

Adults with aphasia have been shown to present with slower reaction times while processing online information in sentence comprehension tasks when compared to unimpaired participants (Meyer, et al., 2012; Schumacher, et al., 2015). Studies have also noted that participants with aphasia do not employ an online agent-first processing strategy (Mack, Wei, Gutierrez, & Thompson, 2016; Meyer, et al., 2012; Schumacher, et al., 2015). This contrasts with unimpaired adults who employ

an agent-first processing bias; a tendency to initially fixate on the image in which the subject noun is the agent unless there are following morphological cues to suggest a passive sentence structure (Meyer, et al., 2012). Other spatial strategies including left-right sentence interpretation have been described in sentence processing and participants with aphasia have been noted to present with a prolongation in the tendency to fixate on the left-most picture early in a sentence (Mack and Thompson, 2017). Finally, Mack, et al. (2016) examined the test-retest reliability of visual-world eye-tracking for investigating online language processing. They used sentence-picture matching tasks with active and passive sentences. The test sentences included postverbal noun phrase and prepositional phrase targets. The results suggest that adults without brain injury make more target fixations in the postverbal noun phrase/prepositional phase when compared to the aphasia group.

7.2.2 Development of the Tests for the Eye-Tracking Paradigm

The eye-tracking test materials that were used in this research were originally developed in a previous study. This study was part of a final year project with two speech and language therapy students under the supervision of Dr Helen Kelly. The original study design, the modifications to that assessment battery and the reasons for the modifications are described below.

Overview of the Original Eye-Tracking Test (Kelly & Burke, 2016; Kelly & Duffy, 2016)

The study completed in 2016 recruited adults over 18 years of age with no history of neurological impairment. Participants completed a hearing screening and language assessment to assess eligibility for the study. Auditory comprehension language tasks were administered using a Tobii T120 eye tracker monitor. The Tobii

T120 has a 17-inch screen with 1280 x1024 pixels and a sample rate set at a 60Hz. The unit has a tracking distance between 50 – 80 cm and participants sit approximately 65cm from the screen. Automatic calibration, as per Tobii studio default calibration procedure, takes place prior to each subtest. A fixation was defined as a gaze of at least 60 milliseconds.

The assessment tasks examined auditory comprehension at three levels: sentence, paragraph and conversation. There were 64 auditory comprehension tasks at sentences level, 14 questions after five short spoken paragraphs and 10 questions after three conversation level tasks. For the sentence comprehension test, images are presented on the eye tracker monitor. The sentence is played automatically so that the participant hears an auditory stimulus. Images are presented horizontally on the screen. There are sixteen levels in the test and 15 of the levels have four images and Level 2 has five images. Only one image matches the target sentence and the other images include a variety of grammatical, lexical and non-related foils. The participant can listen to the target sentence a second time if needed. The participant uses a wireless mouse to click on the image that matches the target sentence. No feedback is provided on their response.

The paragraph test is administered in a similar manner; however, the spoken paragraph is played first with no images on the screen. Following this, the question screen appears in a similar format to the sentence task, with four images displayed horizontally on the screen. The question is played automatically after the paragraph is finished and the participant answers in the same manner as the sentence task. The final conversation test is similar to the paragraph, but instead of a blank screen with the spoken information, a pre-recorded video of a conversation between two students is presented on the screen. This is followed by the question screen with three images

displayed horizontally and again the participant answers the question using the wireless mouse as in the previous tasks.

The visual stimuli for these tests were developed with permission from a commercially available aphasia rehabilitation programme. A set of rehabilitation tasks in this commercially available programme, targeting auditory comprehension at sentence level, were used as the intervention programme in the crossover design. The sentence stimuli for the sentence level test were chosen from these rehabilitation tasks. However, in the eye-tracker test, the spoken stimulus was recorded by a female speech and language therapy student with an Irish accent. This differs from the programme stimuli which are spoken by a female with a British accent.

Modifying the Test - Rationale

The initial sentence level test created in 2016 had 64 sentence items. The mean accuracy score for the group was 61.2 (SD=2.35). Following feedback from the participants and analysis of the data, it was noted that some of the image items, in the sentence level assessment, caused confusion. This confusion was primarily due to the image quality, or rather ambiguities regarding what was depicted in the image, and not the sentence complexity. For example, with some items it was difficult to determine if the image represented a man or a boy where one agent matched the target sentence and the other acted as a foil. There was also confusion regarding the nature of the action in some images, for example, the target verb in one task was *falling* but the participants reported that the images did not clearly represent this action. All test items were reviewed and where a pattern emerged in which a number of participants inaccurately answered the same test item, this item was highlighted for further consideration regarding appropriateness for the test in the feasibility study.

Modifying the Test - Process

The Tobii studio software programme allows researchers to generate visualisations and complete statistical analysis with eye gaze data. Heat maps are one example of visualisations that can be created and these are a representation of the data displayed as colours in which the amount of "heat" is proportional to the level of the measure therefore, a hotter colour display is equivalent to more attention on that area (Bojko, 2013). It was possible to generate a composite heat map for all participants in the original study of typical adults. Where there was no confusion and an accurate response, the target stimuli was clearly marked with a "hot" coloured heat map, see Figure 7.1.

Figure 7.1. Heatmap with Target Image Clearly Highlighted and No Confusion



This is in clear contrast with an ambiguous set of stimuli where more than one stimulus image is marked in the heat map, indicating attention was divided between the target and the stimulus that caused confusion, see Figure 7.2.

Figure 7.2. Heatmap indicates Divided Fixations and Confusion with respect to Target Image



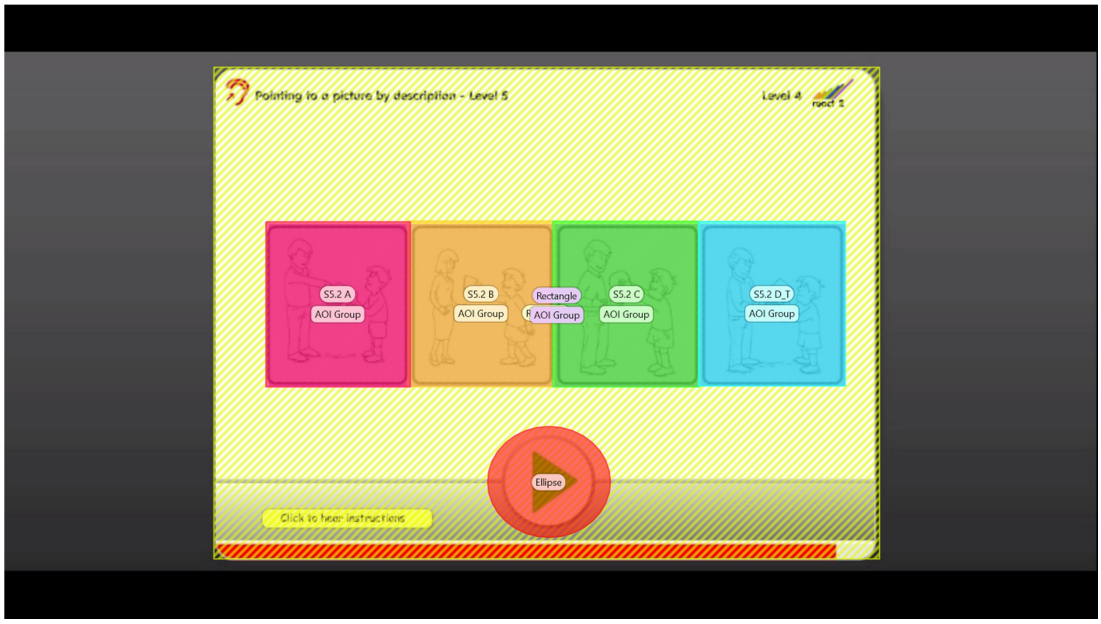
The data obtained in the 2016 study was examined using the accuracy measures obtained and by generating heat maps. This facilitated the removal of any items that caused confusion among typical adults in the original study. This resulted in a refined, final test which was used in the feasibility study in Research Strand Three. There are 48 sentences grouped into 16 levels with 3 sentences in each level. The paragraph and conversation tests remain unchanged. This test will be referred to as the eye tracker auditory comprehension test or e-ACT throughout the rest of this thesis (Appendix 12).

7.2.3 Eye Tracking Metrics used in the Feasibility Study

In addition to visual maps, it is possible to generate statistics from a variety of eye-tracking metrics in the Tobii Studio eye-tracking software. In order to use eye-tracking metrics with the eye-gaze data, Areas of Interest must be defined. An Area of Interest or AOI is created by the researcher and is defined in relation to the stimulus being presented (Holmqvist et al., 2011). In this study, the AOIs were drawn so as to border and include the stimulus images presented horizontally on the

screen. In addition, the play button at the bottom centre of the screen was also marked as an AOI. Figure 7.3 presents the AOIs created for one sentence level task in the e-ACT battery.

Figure 7.3. Sentence Task with Areas of Interest (AOIs) highlighted



Two eye tracking metrics were used in this research study: fixation duration and fixation count. Fixation duration measures how long the eye stays still in a position and is likely the most used measure in eye-tracking research (Holmqvist, et al., 2011). Fixation durations are associated with processing information and measuring the fixation duration on an AOI can provide information on the level of information-processing difficulty (Bojko, 2013; Holmqvist, et al., 2011). Longer fixation durations may indicate increased cognitive processing demands (Bojko, 2013). Fixation duration has been used in a recent study examining the change in online sentence processing among individuals with aphasia following sentence production and comprehension training (Mack and Thompson, 2017). The second metric is the fixation count on an area of interest. Fixation count is an indicator of search efficiency; larger fixation counts may represent less efficient search strategies (Holmqvist, et al., 2011).

The Test for Reception of Grammar (TROG) was also administered on the Tobii T120 eye tracker. However, only the accuracy scores and not the eye gaze data will be presented in this thesis, as the data will be analysed at a future date (see Chapter 10 for details on future research).

7.3 Development of a Control Programme for Use in a Crossover Study

The following section will outline the development of a non-language software programme that was created as a control programme. This programme was used during the feasibility study, in the alternate phase to the intervention programme.

7.3.1 Background

A crossover research design is a robust methodology that has been used to evaluate rehabilitation software targeting speech production impairments post-stroke (Varley, et al., 2016). In a crossover design, each participant receives both the intervention programme and the non-intervention alternative in random order and therefore acts as their own control. In ICT-delivered aphasia rehabilitation research an appropriate control programme must be used, ensuring every effort is taken to blind participants to the intervention and control phase. The control programme should be distinct to the intervention (i.e. language rehabilitation) programme in relation to the content (Brady et al., 2018), but must not be easily distinguished as the "sham" programme. It should have a similar layout, interface and levels of challenges within the task items as the intervention programme but distinct content. In order to use a crossover research design to investigate the feasibility of ICT-delivered aphasia rehabilitation using a commercially available programme, a distinct non-language programme must be used to act as the control programme.

This was not available and necessitated the design and development of a control programme as described below.

7.3.2 Programme Design and Development

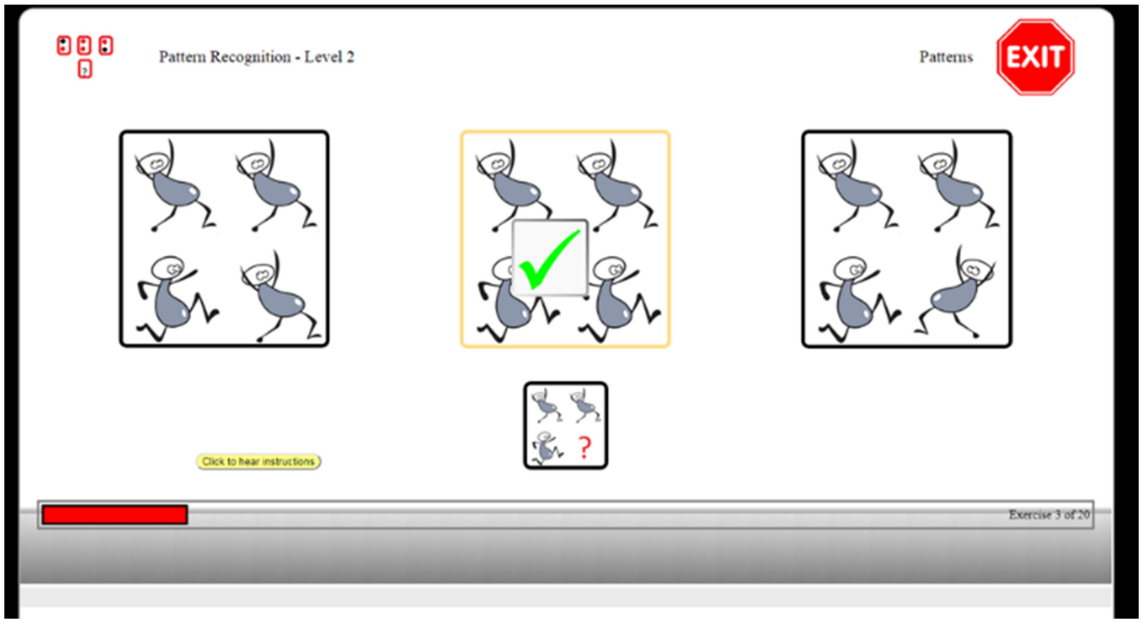
The language programme that was used in this feasibility study provides the participant with a simple interface; images are presented in the top half of the screen in a horizontal line and a button at the bottom centre of the screen presents the question. When the participant clicks the button an auditory sentence stimulus will play. This sentence matches one of the image stimuli in the top half of the screen; all others are semantic or grammatical foils. Visual and auditory feedback is provided on accuracy. When participants choose an incorrect stimulus, they are provided with feedback on this and an opportunity to try again. The participant can listen to the auditory stimulus as often as they want. The programme is available both as an iPad app and a website.

The research team which included the PhD researcher, PhD supervisor Dr Ian Pitt who is a Computer Science lecturer and a final year Computer Science student, set about designing and developing a control programme with a similar layout to the target language programme but with non-language activities. Visual matching tasks were initially considered followed by pattern recognition tasks and visual memory tasks. These non-language cognitive tasks were considered appropriate as they could fit a similar screen layout and interface to the language programme but were distinct cognitive tasks not expected to effect change in language skills. A large assortment of copyright-free images were downloaded and modified as needed under Creative Commons CC0 in order to populate the stimuli.

The stimuli were organized into corresponding items for each of the three tasks (visual matching, pattern recognition and visual memory). Each of the three

tasks was subdivided into a number of levels with 20 question items in each level. A JSON (JavaScript Object Notation) array was constructed. This allowed the PhD researcher, who has limited programming experience, to structure and store task information in an organized and easily accessible format.

Figure 7.4. Example of Pattern Recognition Task with Correct Answer Feedback



A PHP (PHP:Hypertext Preprocessor) script was run on a secure website which hosted the programme. Programme usage and accuracy data were recorded using MySQL, a database management system. Simple usernames and passwords were set up to allow researchers to identify individual participant data. This data is used to monitor participant progress in the crossover study. Figure 7.4 provides a screenshot of one of the programme tasks. This interface is similar to the language rehabilitation programme. The programme runs via a weblink on computer, laptop or tablet devices. Participants tap or click on the image to choose their answer to the question at the bottom and are provided with visual and auditory feedback on their accuracy in a similar manner to the language programme. When completed the programme had 16 levels; the same number as the intervention programme. However, it became necessary to add five new levels during the feasibility study

because two participants, who received the control programme in the second phase of the crossover study, completed the activities before the end of the phase. The additional five levels included two new pattern recognition levels and three visual memory levels. The format remained unchanged but additional stimuli with more complex visual features were added to the programme.

7.4 The Intervention Programme

The programme used as the intervention programme in the feasibility study was a commercially available rehabilitation software programme that can run on a variety of operating systems and can be used on personal, laptop and tablet computers, including iPads. It is an online Cloud-based software called React 2 that allows SLTs to remotely monitor time spent working on the therapy exercises as well as the progress in terms of accurate responses within therapy tasks. The version for iPad was an iTunes application available on the iTunes store and the version for all other ICT devices ran via a web-based online platform. All versions required the user to log in using a user name and password. As with the control programme, these were personalised to each participant and developed in a simplified form e.g. using a single letter or number that was meaningful to the participant, if possible. The therapy targeted auditory comprehension in a "*wider sense*" and was not informed by language processing models (Morris and Franklin, 2012, p. 124). In this way, the tasks were presented within 16 levels with progressive levels of comprehension difficulty and various sentence structures. There are between 20 and 22 sentence items in each level. Each level provides sentence stimuli that reflect a specific sentence structure. Initial levels reflect simple sentence structures which include 2 or 3 elements within the sentences using present progressive subject verb structures (e.g. The Cat is Sleeping - Level 1) and intransitive verbs with subject

pronouns (e.g. He is crying - Level 4). The levels progress to include larger numbers of elements as well as more complex sentence constructions including wh- questions (e.g. Where do Children Play? - Level 9) and negatives (e.g. The Bird is Not Flying - Level 11). A full description of the intervention and sentence structures within the programme is provided in a TiDier checklist (Hoffman, et al., 2014) in Appendix 13.

The stimulus images were presented on the screen with the target image and associated grammatical, semantic and non-related foils. A play button in the bottom middle section of the screen was activated to play the sentence stimulus. The participant then chooses the picture that matches the sentence stimulus. The sentence stimulus can be repeated as many times as required and feedback is provided on the accuracy of the answer. Where answers are incorrect, this is identified as inaccurate and the participant is given another opportunity to listen to the sentence and answer again. If incorrect a second time the correct answer is provided. The overall success score is provided at the end of each level in order to provide feedback on performance.

The 48 items in the e-ACT sentence Test were developed using 3 sentence stimuli from each of the 16 levels of the React2 programme.

7.5 Questionnaire to Screen Technology Use

As noted in Chapter Four (4.4.7.1), prior experience of ICT has been recorded in some, though not all, studies that have examined participants' perspectives of ICT delivered aphasia rehabilitation. The UTAUT model suggests that experience can be a moderator of ICT acceptance and usage. In addition, Chapter Four (4.5.3) highlighted that prior experience of ICT may provide additional confidence and those with limited experience may be more likely to question their ability to engage in ICT-delivered aphasia rehabilitation. Therefore, it was important

to record this information. It was particularly relevant to determine what changes in usage and confidence may have occurred after each participant's stroke as this may have an impact on their views of ICT-delivered aphasia rehabilitation. Czaja, et al. (2006) reported on their findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE) which investigated factors that predict technology use. The PhD researcher contacted the CREATE and was provided with access to their questionnaire. At around the same time, the researcher became aware of the work of Dr Abi Roper (Roper, et al., 2014) who used a technology screening questionnaire in her study investigating computer gesture therapy. Following discussions with Dr Roper and a review of her questionnaire, a modified Technology Screening Questionnaire with culturally appropriate items and images for an Irish population was used in this study. This questionnaire is based on the available questionnaires (Czaja, et al., 2006; Roper, et al., 2014) and probes the use, frequency of use, and confidence in relation to use, for 25 technology items or functions; 13 everyday technology items (e.g. television, digital camera) and 12 technology functions (e.g. email, online shopping) (Appendix 14).

Section Two – Feasibility Study Design

7.6 Feasibility Study Overview

The feasibility study employed a convergent parallel mixed-methods design (Creswell and Clark, 2011) in order to answer the two research topics that emerged from the literature reviews in Research Strands Two and Three. As highlighted in Chapter Six, there has been limited research attention focused on the outcomes of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments. In addition, the findings from the literature review on participants' experiences of

ICT-delivered aphasia rehabilitation in Chapter Four (4.4.8) can be grouped under three categories: perceived gains, usability and engagement with the mode of rehabilitation. The feasibility study carried out in Research Strand Three investigated the effectiveness of ICT-delivered aphasia rehabilitation and concurrently explored the experiences of the participants who engaged in this mode of rehabilitation. In order to address both of these research topics, the two research topics were embedded within a case series experimental two-phase cross-over treatment design.

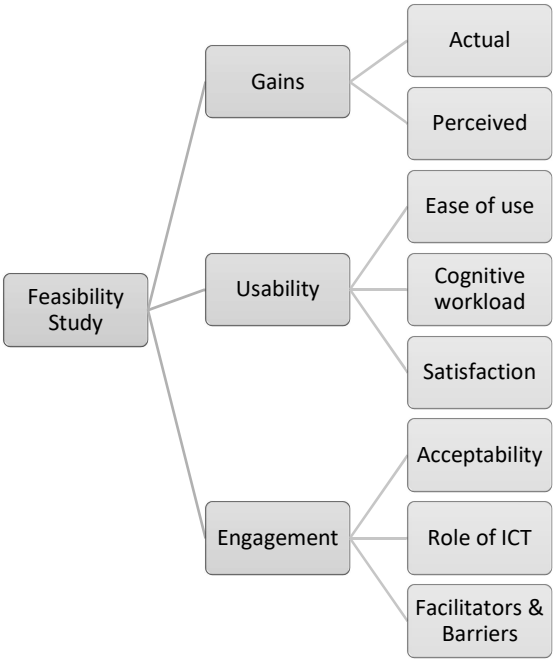
7.6.1 Research Aims of the Feasibility Study

The primary aims of this feasibility study are to evaluate the feasibility and effectiveness of ICT-delivered aphasia rehabilitation targeting auditory comprehension deficits at sentence level using an ICT device and software application, and to investigate the participants' experiences of this mode of rehabilitation, exploring perceived benefits, usability and engagement. In order to address these aims, we pose a number of research questions that need to be addressed (See Figure 7.5):

1) Is ICT-delivered aphasia rehabilitation an effective mode of rehabilitation targeting change in auditory comprehension impairments? (*actual gains*)
2) Is ICT-delivered aphasia rehabilitation perceived to provide beneficial outcomes, as perceived by people with aphasia? (*perceived gains*)
3) What are participants' perceptions regarding the usability of the ICT device and software programmes? (*usability*)
4) What are participants' experiences of engaging in this mode of rehabilitation? (*engagement*)

The research procedures and outcome measures are described further from 7.7.1 to 7.7.3. The questions of perceived gains, usability and engagement are described further from 7.7.5 to 7.7.7.

Figure 7.5. Overview of Feasibility Study Research Topics

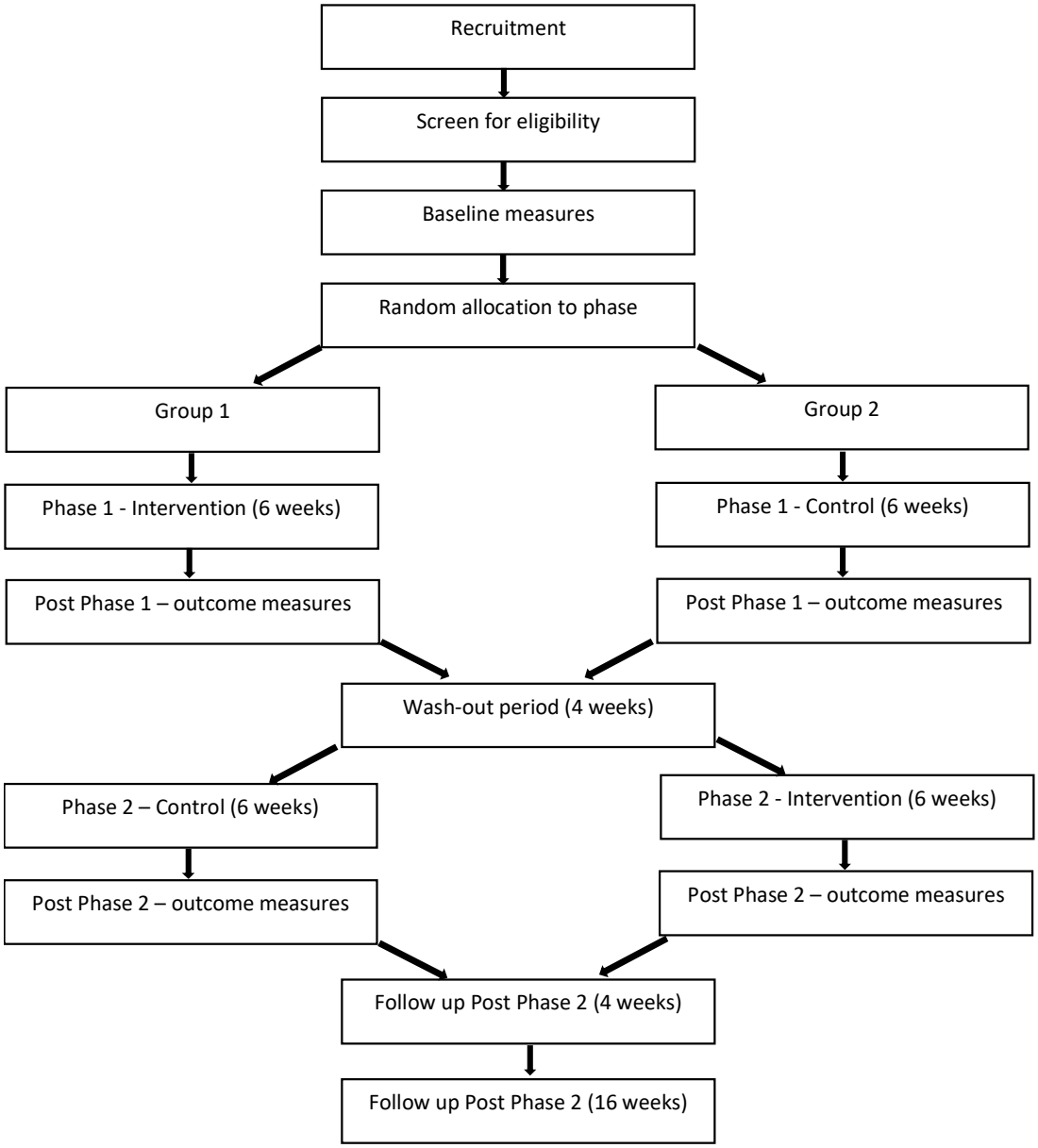


7.7 Crossover Study Design

The two-phase cross-over treatment design in Research Strand Three compared a self-administered rehabilitation programme targeting auditory comprehension language deficits experienced by people with post-stroke aphasia, and a self-administered 'sham' computer program not targeting post-stroke aphasia deficits (e.g. visual matching, pattern recognition and visual memory tasks). The two 6-week phases were separated by a 4-week washout phase. Assessment was repeated immediately following the first phase of the study, immediately following the second phase, four weeks after the second phase and finally at sixteen weeks after the second phase of the study. An overview of the crossover study design is presented in Figure 7.6. This experimental design is based on published,

methodologically robust research (Varley, et al., 2016; Whiteside et al., 2012) which evaluated post-stroke speech impairment using rehabilitation software.

Figure 7.6. Crossover study design



7.7.1 Allocation to Phase

Multiple baseline assessments of language, cognition and functional communication were carried out in order to establish the type and severity of aphasia prior to random allocation to phase of the study (described in 7.7.2.1). The research team was blind to the allocation process. Dr Nicola Bessell (NB), a lecturer at

University College Cork and not involved in any aspect of this research, managed the allocation of participants to the phase of study. A blocked randomization list was created using an online random list generator (https://www.sealedenvelope.com/simple-randomiser/v1/lists). This computer-generated list allowed for three levels of stratification of aphasia severity; mild, moderate and severe. Each entry on the list was printed individually and transferred into a corresponding numbered brown opaque envelope for the three levels of stratification. This envelope was then sealed. The original randomization list was retained in NB's office and was not accessible to any member of the research team.

7.7.2 Baseline Measures

The newly developed consensus outcome measures for aphasia research (Wallace et al., 2019) were considered when deciding on the assessments for this feasibility study. A battery of baseline assessments was completed in order to provide a comprehensive picture of the participants' cognition and language skills as well as their well-being, hearing abilities, and their use of everyday technologies.

7.7.2.1 Language Skills Assessments

The Western Aphasia Battery (WAB) (Kertesz, 2007) provided information on type and severity of the aphasia at baseline. The auditory verb comprehension subtest of the Verb and Sentence Test (VAST) was completed to record single word comprehension of verbs (Bastiaanse, Edwards, Mass, & Rispens, 2003). In addition, a number of subtests of the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) were carried out, including PALPA 47 - spoken word to picture matching to examine comprehension of nouns at single word level (Kay, et al., 2001). Three PALPA repetition subtests; PALPA 7 - word repetition, PALPA 8 -

non word repetition and PALPA - 12 sentence repetition, as well as PALPA 53 - written word naming, were completed at baseline and served as control measures.

The Test for Reception of Grammar (TROG) assesses understanding of English grammatical contrasts marked by inflections, function words and word order (Bishop, 2003) and is repeated at each assessment time point. The final language assessment is the auditory comprehension test (e-ACT) with a picture matching activity for 48 sentences, and a similar activity for 14 questions based on paragraph information and 10 questions based on conversational information. The development of this test was described in 7.2.2. Both the TROG and the e-ACT were administered on a computer using a Tobii T120 eye tracker monitor.

The intervention programme in this study employs a general approach to auditory comprehension therapy (Morris and Franklin, 2012) and is further described in 7.4 of this chapter. Using this general approach, the participant works through a series of sentence to picture matching tasks with increasing levels of comprehension difficulty. Taking this into account and considering the volume of baseline measures including assessments for hearing, technology use, language, cognition and quality of life, it was not considered appropriate to carry out additional baseline assessments to reflect individual deficits against a model of language processing.

7.7.2.2 Cognitive Skills Assessments

The Repeatable Battery of Neurological Status (RBANS) (Randolph, 1998) and the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) were carried out to provide information on participants' cognitive processing including attention and memory.

7.7.2.3 Quality of Life Measures

In order to evaluate the impact of stroke on participants' health-related quality of life, the Stroke and Aphasia Quality of Life Scale (SAQOL-39) (Hilari, Byng, Lamping, & Smith, 2003a) was administered along with an Aphasia Accessible Quality of Life (AAQoL) measure developed for the study. The AAQoL explored the impact of expressive and receptive language difficulties on quality of life in relation to everyday communication activities (Appendix15).

7.7.2.4 Technology Screen

Each participant provided information on their use of everyday household and digital technologies. A description of this tool is available in 7.5. This screening tool examined the frequency of use and each participant's self-reported confidence with respect to a variety of everyday technologies (Appendix 14).

7.7.2.5 Hearing Assessment

Participants completed a questionnaire on ear health and risk factors for hearing impairment (Appendix 16). It is possible to screen participants' hearing using web-based pure-tone audiometry (Masalski and Krecicki, 2013). A hearing screening was carried out with each participant using a software application, Hearing Test version 1.1.3 (https://www.e-audiologia.pl/HearingTest/) running on a Lenovo K50a40 smartphone operating Android version 6.0. This application screened participants' hearing at 250, 500, 1000, 2000, 4000, 6000 and 8000Hz. The application was calibrated using Sennheiser HD 4.3G over-ear headphones with a person with no prior hearing problems. The Hearing Test Application has reference sound levels for sets of mobile devices and their headphones (Masalski, Kipiński, Grysiński, & Kręcicki, 2016). The reference sound levels in this paper include only

10 devices from three different mobile phone companies. However, Masalski, et al. (2016) conclude that reference sound levels for a new device can be determined on the basis of biological calibration, as was completed. The application provided a pure-tone audiometry graph and corresponding details including time and date of the screening, the headphones used and calibration ID.

As individual frequency testing does not reflect speech, an average of the 4 relevant speech frequencies (500, 1000, 2000 and 4000 Hz) was calculated in both left and right ear. Participants with a hearing loss greater than 40dB in both ears are deemed not suitable for the study. This approach was considered most appropriate following consultation with the Audiology Department in University College Cork. This advice was provided taking into account the ability to adjust the volume of the ICT device and rehabilitation programmes used in the study in order to reduce the impact of presbycusis which may be present in an older population.

A number of assessments were repeated at baseline to establish a stable baseline for language and cognitive skills. These include the TROG, PALPA 7, PALPA8, PALPA12, PALPA 53 and the RBANS.

7.7.2.6 Repeated Outcome Measures

A number of the outcome measures were repeated immediately after Phase 1 and Phase 2, and again at 4 weeks and 16 weeks after Phase 2. Table 7.1 provides an overview of all outcome assessments along with time points. These outcomes measures were recorded in order to establish if any change occurred in self-reported quality of life or measures of language and cognitive skills.

Table 7.1. Outcome Measures and Time Points

Assessments	Baseline 1	Baseline 2	Phase 1	Phase 2	Follow up 1	Follow up 2
Language						
WAB-R	√		√	√	√	√
TROG	√	√	√	√	√	√
e-ACT (sentence, paragraph and conversation level)	√		√	√	√	√
Cognitive						
RBANS	√	√	√	√	√	√
Quality of Life						
SAQOL – 39	√		√	√	√	√
AAQo/L	√		√	√	√	√
Control tasks						
PALPA 7 word repetition	√	√	√	√	√	√
PALPA 8 non-word repetition	√	√	√	√	√	√
PALPA 12 sentence repetition	√	√	√	√	√	√
PALPA 53 written word naming	√	√	√	√	√	√

7.7.3 Blinding of Assessors

As the PhD researcher completed all the face-to-face assessments while managing the intervention study, a system for blind assessment of the outcome data was implemented. All baseline and outcome measures were audio and video recorded. When the final outcome measurement session was completed, a random number generator was used to randomise the order of the participants' tests, and any information on participant identity, allocation to the phase or time point of the assessment data was removed. Related assessment materials were redacted with no identifying information. Each test was viewed and analysed by PhD supervisor Dr.

Helen Kelly, an SLT blind to participant allocation to phase and the time of assessment. Following analysis, Dr Kelly and the PhD researcher compared scores for each assessment and recorded the level of agreement within the outcome measurements. Any differences in the interpretation of assessment scoring procedures were discussed and agreed. There were minor variations in the scoring of the spontaneous speech section on the WAB (ICC=0.92), and the Figure Copy subtest of the RBANS demonstrated moderate intrarater reliability of scoring (ICC=0.60). There was excellent intrarater reliability for all other assessments (ICC>0.97).

7.7.4 Intervention Procedure

Following baseline measurement and allocation to phase, participants were provided with individual training sessions with an accompanying aphasia-accessible manual (Appendix 20) to introduce the allocated ICT programme (e.g. rehabilitation programme or control programme) and troubleshoot any potential issues. Participants were asked to spend a minimum of 5 hours per week working on the programme during the 6-week phase of the research. They were advised that they could choose how to divide this time and this was discussed with each participant in the training session. Individual adherence and progress within the programme were remotely monitored by the research team and tasks could be adjusted in order to provide more or less challenging rehabilitation activities. The researcher arranged a follow-up home visit at the end of week 1 to provide support to participants and troubleshoot any issues they were having. Participants were also provided with a phone number for the researcher in the event that they needed additional support.

A second visit was arranged during week 3 to complete the structured observation, ICT feedback questionnaire (Chapter Five) and semi-structured

interview. In addition, and as with other studies with a self-administered rehabilitation component, the participants were advised they could contact the researcher if any issues arose (Meltzer, et al., 2018). Access to the programme was revoked at the end of each particular phase. Following the 4-week wash-out period, the training session and alternative support manual for the other programme (e.g. control programme or rehabilitation programme) were provided. The participants were asked again to spend 5 hours per week over the second 6-week phase and the programme was monitored remotely and the process was repeated as outlined above.

7.7.5 Establishing Participants' Experiences of ICT-delivered aphasia rehabilitation

As highlighted in 7.6.1, the second aim of the feasibility study is to investigate the participants' experiences of this mode of rehabilitation, exploring perceived benefits, usability and engagement. In order to achieve this, a variety of data collection methods were employed. These include structured observations, semi-structured interviews and the use of the ICT feedback questionnaire developed in Chapter Five. The use of multiple methods has been employed by other researchers (as reported in Chapter Four). The methods employed in this research are described further in this section.

7.7.5.1 Modifying Interviewing Techniques for People with Aphasia

It is important to note that a traditional open-ended questioning style may not capture the full extent of information that a participant with aphasia wishes to communicate (Luck and Rose, 2007). Modified interview techniques were required to facilitate the interviewee's participation in the process. The interviews were facilitated by the researcher who is an SLT with training and experience of using

supported conversation techniques (Kagan, 1998). The question prompts were provided in written and pictorial format, and where possible the ICT-device with the programme was close by to facilitate communication as needed. This has been reported as useful for directly indicating specific features on the device or programme (Marshall, et al., 2013). All observation sessions and semi-structured interviews were video and audio recorded. This allowed for additional verification of total communication strategies (Luck and Rose, 2007).

7.7.6 Mid-Phase Observation Session

During week 3 the researcher visited each participant and carried out a structured observation session. The sessions were video-recorded. Each participant was asked to complete at least one level of the allocated programme for that phase. The researcher followed a structured observation sheet in order to record observations of the participant's ability to use the ICT device and the allocated programme (Appendix17). This was also used to note the programme (control or intervention) that was used during the session and the tasks within the programme, the level of assistance required and accuracy scores of the observed session. Following the observed activity, the participant completed the feedback questionnaire, with assistance if needed. This recorded the participants' ratings regarding the ease of use of the programme, the cognitive workload of the tasks, the programme functionality and the participants' reported level of independence when using the programme. The session ended with a semi-structured interview (10-20 minutes) probing the participant's views on ICT-delivered aphasia rehabilitation. This explored participant's satisfaction with the programme, preferences with respect to the mode of rehabilitation, changes attributed to ICT usage and any negative impacts of ICT-delivered aphasia rehabilitation (Appendix 18).

7.7.7 Exit Interviews

The exit interviews (15- 30 minutes) were carried out 4 weeks after Phase 2 was completed (Appendix 19). As with the mid-phase interviews this explored the participant's satisfaction with both of the programmes, their preferences with respect to the mode of rehabilitation, any changes attributed to ICT usage, any negative impact of ICT-delivered aphasia rehabilitation and any suggestions for the research team.

7.8 Data Analysis

7.8.1 Quantitative Data Analysis

Being a crossover study, each participant acts as their own control allowing for single case study and group data analysis with the group analysis reflecting the sequence of the crossover phases (Group 1 = intervention/control, Group 2 = control/intervention).

Descriptive statistical analysis was carried out to examine the clinical and demographic information of the recruited participants. In addition to examining measures of centrality and spread, visual testing using Histograms and Normality Plots and statistical testing using Shapiro-Wilk statistic was carried out to determine if a normal distribution is present.

Differences between repeated baseline measures were calculated using paired sample t-tests and when data did not meet the assumption for normal distribution the Wilcoxon Signed Rank test was calculated. The self-reported change in technology use, gathered as part of the Technology screen, was calculated using the McNemar's Test for binary data and change in frequency of use and confidence of technology use was calculated using sign tests. McNemar's tests were also used to compare

item-level accuracy between time points for individual cases on language (TROG and e-ACT) and control tests (PALPA 7, 8, 12 & 53), in order to determine baseline stability and change over time between phases. Between-group difference was calculated at baseline using independent sample t-tests or Mann-Whitney U test if the assumptions for normal distribution were not met. The within-group differences over baseline, post Phase 1 and post Phase 2 were measured using Friedman's Test for non-parametric data. The Friedman test extends the Wilcoxon signed-ranks test and can be used where there are more than two time periods of data collection; it is analogous to the parametric repeated measures ANOVA without a comparison group (Pett, 2015). It was necessary to use non-parametric statistics to analyse the majority of the data in this study data. It was appropriate to use parametric analysis when comparing the eye-tracking data from the typical adults and the participants with aphasia.

In addition to these inferential statistics, it is important to calculate the effect size of the data for the case series. Effect size estimates the measure of change observed post-intervention in a variable of interest and the use of modified Cohen's *d* statistic for single-subject research studies has been advocated in order to calculate an effect size (Beeson and Robey, 2006). Calculations for Cohen's *d* statistic are dependent on non-robust measures of centrality and dispersion and are therefore not ideally suited for small sample sizes and nonparametric distributions. Due to the small sample size and nonparametric distribution within this study, it has been necessary to employ the effect size calculation for nonparametric data as proposed by (Fritz, Morris, & Richler, 2012). This can be calculated by using the *z* value from nonparametric statistical tests such as Mann Whitney and Wilcoxon tests. Dividing *z* by the square root of the total number of samples will provide an *r* calculation which

is a useful estimate of effect size with guidelines of 0.1, 0.3 and 0.5 for small-medium and large effects (Fritz, et al., 2012). Phi Φ can be used to report effect size for the McNemar test and can be interpreted with the same benchmarks as the non-parametric guidelines above (Rovai, Baker, & Ponton, 2013). This can be calculated by dividing $\chi 2$ by the sample size and taking the square root of the results (Abbott, 2016). Finally as noted in 4.4.11.7, examining the impact of programme usage on therapeutic outcome has identified mixed results. Spearman's rho will be applied to assess the relationship between the proportion of change in the outcomes of both the TROG and the e-ACT sentence level test after the intervention phase and the usage of the programme in that phase. The proportion of change will be calculated by dividing the difference between the outcomes for each assessment at the time points before and after the intervention phase. For those who were allocated the intervention in Phase 1, this is the difference between test outcome after Phase 1 and the Baseline measure. For those who completed the intervention in Phase 2 this is the difference between the outcomes post-Phase 2 and post-Phase 1.

SPSS statistics 25 (IBMCorp., 2017) was used to evaluate statistical data with the exception of effect size calculations which were completed by hand. The significance level for all tests was set at $p<0.05$ and where possible 95% confidence intervals are presented.

7.8.2 Qualitative Data Analysis

The semi-structured interviews were transcribed and analysed using Qualitative Content Analysis which allows for the reduction of the volume of text and seeks some understanding of it by identifying and grouping categories together while attempting to stay true to the text (Bengtsson, 2016). Graneheim and Lundman (2004) identify that some degree of interpretation is always present when

approaching a text for analysis due to the multiple meaning involved. Reality can be interpreted in many different ways and so the understanding of it is dependent on subjective interpretation (Graneheim and Lundman, 2004). Qualitative content analysis is not linked to any particular science (Bengtsson, 2016) and there are few systematic rules for analysing data (Bengtsson, 2016; Elo and Kyngäs, 2008). This is important when considering the trustworthiness of the findings presented in qualitative content analysis, as research findings should be as trustworthy as possible. Graneheim and Lundman (2004) provide a description of measures to achieve trustworthiness in qualitative content analysis. These are embedded in the description of the process outlined below.

This research aims to explore the perspectives of people with aphasia engaging in ICT-delivered aphasia rehabilitation with particular attention to their acceptance of this mode of rehabilitation. There is existing literature exploring the views of people with aphasia engaging in ICT-delivered aphasia rehabilitation but much of the rehabilitation was focused on therapy for expressive language impairments (Palmer, et al., 2013; Wade, et al., 2003). As such it was appropriate to use inductive content analysis within the analysis process where the categories are derived from the data (Elo and Kyngäs, 2008). This is in contrast to a deductive analysis approach where a categorisation matrix is developed based on an earlier theory or model and this is used to code the data (Elo and Kyngäs, 2008). A researcher must choose between manifest analysis, where the visible and obvious content is described, staying very close to the text; or, latent analysis which involves an interpretation of the underlying meaning of the text (Bengtsson, 2016; Graneheim and Lundman, 2004). Both manifest analysis and latent analysis deal with interpretation but differ in the depth and level of abstraction (Graneheim and

Lundman, 2004). This research applied manifest analysis or a surface structure approach to analysis and the stages of analysis include: Decontextualisation, Recontextualisation, Categorisation and Complication. They are described further below.

Stage 1. Decontextualisation

This stage involves a process of familiarization with the data. The unit of analysis is an individual transcript. Transcripts from the same participant but representing a different time of the study e.g. Phase 1, Phase 2 or Exit interview, are all identified as individual units of analysis. Transcripts are imported into NVivo 11 which allows for the storage and organisation of large amounts of data. The text was sorted into a number of content areas based on the interview questions in order to easily retrieve information on specific repeated questions, for example preference for mode of intervention, recommendations etc. All transcripts are read through several times to obtain a sense of whole. Following the process of familiarization, the unit of analysis is broken down to smaller meaning units, these are "*words, sentences or paragraphs containing aspects related to each other through their content and context*" (Graneheim and Lundman, 2004, p. 106). In this open coding process, each meaning unit is labelled with a code which represents a concept and helps to identify the meaning unit in relation to the context. Codes provide a classification system for the analysis of qualitative data. Codes were created inductively; drawn from the data. This allowed for the development of a code list which helped to organize the codes and included the code name, an abbreviated label for the code, description and sample quotes. The use of NVivo 11 allows for the automatic storage of the codebook within the programme as it was developed and also allows for refinement of codes as the analyses process evolved.

Stage2, Recontextualisation

Once all codes were identified the transcripts were re-read alongside the final list of meaning units. Any un-coded text was noted and if the text provided some answers to the research questions it was included in the analysis and as such was coded appropriately. If it did not provide any answers to the research question it was excluded.

Stage 3: Categorisation

After the process of open coding and when all relevant data were coded, the content was examined for similarities and differences. Sub-categories and categories were developed. A category refers to a descriptive level of content and represents an expression of the manifest content of the text (Graneheim and Lundman, 2004) and "*All categories must be rooted in the data from which they arise*" (Bengtsson, 2016, p. 12). A category can be identified as a thread running through the codes and answers the question "*what*?" (Krippendorff 1980, as cited by Graneheim and Lindman, 2004). A theme reflects an interpretative level and is an expression of the latent content of the text, it answers the question "*how*?". A code or a category can fit into more than one theme and a theme can be divided into subthemes (Graneheim and Lundman, 2004).

Stage 4: Compilation

In manifest analysis, the informants' words are used when reporting the process so as to refer back to the original text and stay close to the context. Qualitative research methods do not normally utilize quantification processes but Bengtsson (2016) identifies that it is possible to add information by performing some quantification in which subcategories and categories are counted. By combining the

two approaches the magnitude of the individual phenomena may be more easily visible. There are obvious limitations to such a process as all informants may not have had an opportunity to discuss all the phenomena and in such cases the variables cannot be ranked. Finally, the findings were viewed in the context of the relevant literature to establish if the results are reasonable and logical.

A number of steps have been taken throughout the process in order to ensure the trustworthiness of the research findings. The concept of credibility was explored with respect to the design of the research and the analysis procedures that were carried out. A researcher not involved in the study coded three of the interviews. This allowed for refinement of codes and any disagreements were resolved through discussion. All decisions were recorded throughout the process, any changes over time were noted, thus ensuring dependability. The participants in this study represent a variety of individuals post stroke but as they were all ICT users it is important to note the potential limited transferability of the findings to others who are not ICT users.

7.8.3 Integration of Data

As outlined in Chapter Three, a mixed methods matrix will be used to combine the quantitative and qualitative data in order to answer the research questions of this feasibility study. Each question will be represented as a column with each case represented as a row within the matrix.

7.9 Ethics

An application was sent for consideration to the Clinical Research Committee of the Cork Teaching Hospital (CREC) and ethical approval for the study was obtained in December 2016 (Appendix 21). The study was also approved by the

national office of Headway, a voluntary agency that supports adults with acquired brain injury. Recruitment began in June 2017 and data collected was finalised in October 2018.

7.10 Recruitment

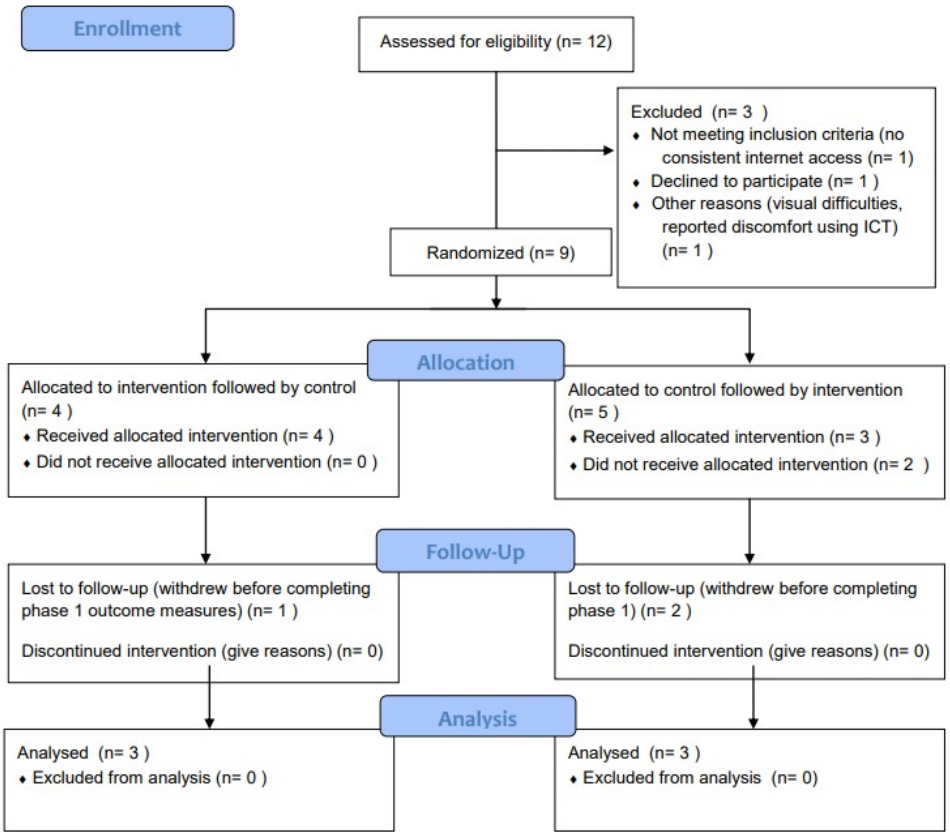
People with aphasia who were over 18 years of age and at least 6 months post-onset of stroke were invited to participate in the study. Individuals with a hearing loss greater than 40dB in both ears were deemed not suitable for the study. Due to the intensity of the therapy programme, and to maintain treatment fidelity those who were attending Speech and Language Therapy elsewhere during the study were excluded. As the programme is monitored remotely, it was necessary for participants to have access to reliable internet services to be eligible for the study. Individuals who expressed an interest in participating in the research were provided with an aphasia-accessible information sheet (Appendix 22) as well as an opportunity to discuss the research and ask questions. They were also offered the opportunity to bring along a family member, friend etc. to this initial meeting to facilitate information exchange. An aphasia-accessible consent form (Appendix 23) was provided to each participant who wished to consent to participate in the research and this was signed in the presence of the researcher.

7.11 Recruitment and Participant flow

Twelve participants with aphasia were recruited to the study between June 2017 and February 2018. Of these, nine completed all baseline measures and were randomly allocated to phase. Three participants did not complete the baseline measures: one was deemed to be ineligible for the study as she did not have consistent internet access, one withdrew due to time commitments and planned

holidays that were conflicting with the schedule of the study and the third individual withdrew due to self-reported visual strain when using a computer screen for extended periods of time. Nine participants were randomly allocated to the control or the intervention programme for the first phase. Of these, six participants completed both phases and the follow-up outcome measurement sessions. One participant withdrew from the study during the first Phase 1 outcome measurement session and so complete outcome data was not collected for Phase 1 outcomes. One participant withdrew during week 3 of Phase 1 and cited timing of the research study as an issue as he reported it was a busy time of the year for him. The third participant withdrew during the Phase 1 training session and indicated that she was unhappy with the allocated programme. She highlighted the presence of written text in the programme as a problematic feature of the programme as she could no longer read after her stroke. She was advised that all written text was accompanied with visual prompts including colour coordinated function buttons and symbols such as stop signs. However, the presence of the written text was not acceptable to her. Interestingly, during the technology screen at baseline, all three of these participants reported a negative impact of stroke on their confidence when using technology. Two also reported a reduction in frequency of use and one reported a negative change in usage pattern. See Appendix 24 for a summary of all baseline measures of all participants who were allocated to a research phase. Figure 7.7 provides an overview of participant flow through the study.

Figure 7.7. Participant flow through the study



Five of the remaining six participants completed both phases and both follow up sessions. One participant missed the outcome measurement sessions carried out post Phase 2 and this is discussed in the case series results in Chapter Eight (8.4.5). Participants presented with a median age of 54.5 (range=32-67 years), median time post-stroke of 6.17 years (range=3-8years) and WAB-R Aphasia Quotient mean of 54.2 (SD=26.0). These participants included three participants in Group 1 (intervention/control) and three in Group 2 (control/intervention). There was no statistically significant difference between groups in terms of age (U=2.00, p=0.268), aphasia severity ($t_{(4)}$0.984, p=0.381, 95%CI:-3.19 – 6.69) and time post-stroke (U=1.5, p=0.184) . Table 7.2 provides an overview of participant details and baseline measures for each participant. Each participant is provided with a pseudonym and further described in the case series.

Table 7.2. Participant Baseline Measures

Item	John	Isobel	Thomas	Damian	Gerry	Eleanor
Group		1			2	
Gender	male	female	male	male	male	female
Age (years)	32	51	58	40	67	67
Time post stroke (years)	7.8	7.9	4.7	2.8	7.7	4.7
Aphasia Type - WAB	Broca's	Broca's	Anomia	Wernicke's	Transcortical motor	Broca's
Aphasia Severity - WAB	Moderate	Severe	Mild	Moderate	Moderate	Severe
WAB AQ						
Spontaneous Speech	55.5	36.9	94.6	52.4	67.1	18.4
Auditory Verbal	10	7	19	16	11	3
Comprehension	6.05	6.85	10	5	7.95	5.1
Repetition	6.4	1.7	8.8	3	8	0.8
Naming and Word Finding	5.3	2.9	9.5	2.2	6.6	0.3
e-ACT						
Sentences (/48)	32	24	42	35	38	18
Paragraph (/14)	12	4	14	10	10	3
Conversation (/10)	7	9	10	5	9	6
TROG Blocks passed (sentences)						
Eye tracker	2 (20)	2 (21)	10 (65)	3 (23)	6 (37)	1 (14)
Paper version	2 (25)	1 (13)	10 (64)	4 (35)	8 (53)	0 (11)
Baseline Stability	*X^2=1.067, p=0.302*	*X^2=4.083,* ***p=0.039***	*X^2=0.000, p=1.000*	*X^2=8.643,* ***p=0.002***	*X^2=9.375,* ***p=0.002***	*X^2=0.308, p=0.581*
RBANS						
Baseline 1						
Total Scores	44	46	77	47	50	43
Immediate Memory	40	44	81	40	44	40
Visuospatial/ constructional	62	66	92	84	66	66
Language	40	40	79	40	74	40
Attention	43	40	85	43	46	40
Delayed Memory	49	60	71	52	56	40
Baseline 2						
Total Scores	47	45	73	47	54	42
Immediate Memory	49	40	61	40	49	40
Visuospatial/ constructional	72	78	92	78	81	58
Language	44	40	79	40	74	40
Attention	40	40	79	46	53	40
Delayed Memory	52	48	81	52	60	40
Baseline Stability	*Z=-1.761, p=0.078*	*Z=-2.72, p=0.785*	*t(4)0.650, p=0.551**	*Z=-0.447, p=0.655*	*Z=-1.826, p=0.068*	*Z=-1.342, p=0.180*
MoCA (/30)	14	10	19	11	12	1
SAQOL-39						
Total Score	3.46	4.64	3.9	3.95	2.54	3.49
Physical	4.18	4.18	4.41	4.06	3.65	3.65
Communication	2.29	5	2.86	3.57	1.14	3.57
Psychosocial	3.27	5	4.18	4.09	1.91	3.55
Energy	3	5	2.75	3.75	2	2.5

Item	John	Isobel	Thomas	Damian	Gerry	Eleanor
Group		1			2	
Aphasia Accessible QoL						
Total Score (/100)	61.07	0.3	51.9	45.7	62.7	73.3
Comprehension (/100)						
Expressive (/100)	63.1	0.4	35.9	44.1	62.7	67.3
	59	0.3	68	47.2	62.6	79.2
PALPA 47 (/40)						
	36	28	40	31	39	27
VAST – verb comprehension (/40)	27	22	40	34	30	24
PALPA 7 (/24)						
Baseline 1	24	17	24	20	23	0
Baseline 2	24	20	23	19	22	0
Baseline Stability	#	*X^2=0.800, p=0.375*	*X^2=0.000, p=1.000*	*X^2=1.500, p=0.219*	*X^2=0.000, p=1.000*	*X^2=0.000, p=1.000*
PALPA 8 (/30)						
Baseline 1	20	15	26	8	20	1
Baseline 2	19	11	26	9	20	0
Baseline Stability	*X^2=0.000, p=1.000*	*X^2=1.125, p=0.289*	*X^2=0.000, p=1.000*	*X^2=0.000, p=1.000*	*X^2=0.000, p=1.000*	*X^2=0.000, p=1.000*
PALPA 12 (/36)						
Baseline 1	3	0	33	0	12	0
Baseline 2	3	0	34	0	19	0
Baseline Stability	*X^2=0.000, p=1.000*	#	*X^2=0.000, p=1.000*	#	*X^2=3.273, p=0.065*	#
PALPA 53 (/40)						
Baseline 1	16	0	36	0	0	0
Baseline 2	19	0	38	0	0	0
Baseline Stability	*X^2=1.125, p=0.289*		*X^2=0.250, p=0.625*			
Technology Screen						
Usage change post stroke	No	No	No	No	No	Yes(*p*=.016)
Frequency of use changed	No	No	No	No	No	Yes(*p*=.008)
Confidence changed	Yes (*p*=.001)	No	No	Yes (*p*=.000)	No	Yes(*p*=.013)
Hearing Screen	WNL	WNL	**	WNL	**	**

**Meets assumptions for t-test*
#unable to compute statistic
***see note in case information regarding hearing*

7.12 Baseline Measure Stability

Table 7.2 provides the summary information of all baseline measures for the participants who completed both phases of the crossover study. All repeated measures demonstrate a stable baseline with the exception of 3 participants on the repeated TROG. This is discussed later in Chapter Eight.

7.13 Chapter Summary

This chapter provided a comprehensive description of the research design of a mixed methods feasibility study that was carried out as part of Research Strand Three. A number of activities were required in order to support the feasibility study. These included the refinement of an eye-tracking test battery for auditory comprehension assessment, the modification of a questionnaire to screen technology and the development of a control programme. These activities and their roles within the feasibility study are described in this chapter. The two-phase crossover treatment design was presented in detail with reference to the phases, the baseline and outcomes assessment and the intervention and control programmes. The methods for collecting and analysing data on participants' experiences of ICT-delivered aphasia rehabilitation during the feasibility study were defined. This data will be combined with the outcome measurement data to establish the gains, the perceived usability and the participants' engagement with the mode of intervention. The findings of the feasibility study are presented in Chapter Eight.

Chapter Eight

Chapter Eight – Findings of the Feasibility Study

8.1 Introduction to Chapter

This chapter will present the results of the feasibility study carried out as part of Research Strand Three. The results are described in five sections. The first section provides an overview of the eye-tracking data comparing the normative data with the data from the participants with aphasia (8.2). The second section provides information on the group analysis with respect to performance on repeated measures of language, cognition, well-being and control tasks as well as the usage data for the two groups (8.3). This is followed by the case series (8.4) exploring individual language outcome measures, as well as usage and acceptance of the programmes. The next section (8.5) outlines the participants' perspectives of engaging in ICT-delivered therapy as reported in the semi-structured interviews. Finally, the results are considered in the context of the research questions using a mixed methods matrix (8.6) and are discussed in relation to the available research (8.7).

8.2 Baseline Eye-Tracking Data

Eye gaze data from 32 adults without brain injury was gathered as part of a final year project carried out by speech and language therapy students in 2016. The data, gathered during a battery of auditory comprehension tasks, was described in Chapter Seven. The data from the e-ACT sentence level tasks in the e-ACT test battery was re-analysed, taking into account the 48 sentence items that were used in this feasibility study. This data was compared against the baseline data for the 6 participants who completed both phases and the two follow up outcome measurement sessions. In this study a fixation was defined as a gaze of at least 60 milliseconds and fixation duration is a measure of how long the eye stays still in a

position within an area of interest (AOI). The eye tracking data from the two groups is presented in Table 8.1.

Although the Shapiro Wilk test of normality indicates normal distribution for all eye gaze metrics, the histogram and normal Q-Q plots indicate that fixation count on target, fixation count non-target, fixation duration target, fixation duration non-target do not meet the assumptions for normal distribution and as such nonparametric analysis was carried out. The tests of normality indicated deviations from normal distribution for the normative data group with respect to age ($W_{(32)}$=0.923, p=0.25) and accuracy ($W_{(32)}$=0.320, p<0.000), so both parametric and nonparametric analysis was carried out.

The mean difference in ages between the two groups is -5.531 indicating no difference in the distribution of age for the two groups (p=0.445). Unsurprisingly, there was a difference in the distribution of accuracy scores for the e-ACT sentence level tasks (p=0.0001) with the mean score for the typical adults (mean =47.75) near the maximum score possible (maximum = 48) well above the mean score for the people with aphasia (mean=35.5). The people with aphasia presented with a larger number of fixations on combined AOIs compared to the typical adults ($t_{(5.395)}$-2.994, p=0.028). There is no statistically significant difference between the groups with respect to fixation count on the target AOIs (U=113.50, Z=0.701, p=0.493) however, there is a statistically significant difference for non-target AOIs (U=172.00, Z=3.042, p=0.001). This may indicate a less efficient search strategy within the non-target images among the people with aphasia. There was no statistically significant difference between the groups with respect to fixation durations for combined AOIs ($t_{(36)}$-1.851, p=0.72), target AOIs (U=126.0, Z=1.201, p=0.245) and non-target AOIs (U=125.0, Z=1.561, p=0.126) between the two groups.

Table 8.1. Eye tracking Metrics

	Normative Data	PwA at baseline	Difference between groups
n=	32	6	
Age in years, median (IQR)	51.0 (32-57)	54.50 (38-67)	*U*=115.5, *Z*=-0.771, *p*=0.445 *$t_{(36)}$-0.761, p=0.451* *(95%CI:-20.27 – 9.203)*
Accuracy, median (IQR) mean(SD)	48 47.75(0.88)	31.5(8.98) 33.5(22.5-39)	*U*=0.00, *Z*=0.00, ***p=0.000*** *$t_{(5.018)}$4.427,* ***p=0.007*** *(95%CI:6.824 – 25.676)*
Fixation Count, mean(SD)	6.49(0.86)	8.85(1.90)	$t_{(5.395)}$-2.994, ***p=0.028*** (95%CI:-4.345 – -0.378)
Fixation Duration in seconds, mean(SD)	0.257(0.047)	0.300(0.073)	$t_{(36)}$-1.851, *p*=0.072 (95%CI:-0.089 – -0.004)
Fixation Count target, mean(SD)	10.182(2.076)	11.184(2.473)	*U*=113.50, *Z*=0.701, *p*=0.493
Fixation Count non target, mean(SD)	5.344(0.608)	7.729(2.072)	*U*=172.00, *Z*=3.042, ***p=0.001***
Fixation Duration target in seconds, mean(SD)	0.298(0.062)	0.318(0.066)	*U*=126.00, *Z*=1.201, *p*=0.245
Fixation Duration non target in seconds, mean(SD)	0.244(0.044)	0.280(0.057)	*U*=135.00, *Z*=1.561, *p*=0.126

Group 1 received the intervention programme in Phase 1 and the control programme in Phase 2. Group 2 received the control programme in Phase 1 and the Intervention Programme in Phase 2. The eye-tracking tests were repeated after Phase 1 and Phase 2 of the crossover study and again at 4 weeks and 16 weeks after Phase 2. Examining change in fixation count over the three time points of the crossover study, from baseline to post Phase 1 and post Phase 2 revealed no statistically significant change over time in measures of combined fixation count on all AOIs for Group 1 ($\chi2$=4.667, *p*=0.097) or Group 2 ($\chi2$=4.667, *p*=0.097). Further

investigating the fixation count on the target AOIs suggests no statistically significant change over time for Group 1 ($\chi 2$=2.667, p=0264) or Group 2. Similarly, there is no significant change in fixation count on non-target AOIs for either group ($\chi 2$=4.667, p=0.097 for both groups). See Table 8.2 for summary data on fixation data over the three time-points of the feasibility study.

Table 8.2. Summary of Mean Fixation Count and Duration

		Fixation Count								
		All AOIs			Target AOIs			NonTarget AOIs		
Participant	Group	Baseline	Phase 1	Phase 2	Baseline	Phase 1	Phase 2	Baseline	Phase 1	Phase 2
John	1	8.3318	10.051	7.5973	51.833	59.976	50.047	19.071	22.553	17.126
Isobel	1	8.7872	7.8692	7.4031	52.184	50.2	45.763	19.605	17.765	16.694
Thomas	1	5.8836	6.3109	5.426	35.132	39.263	32.447	13.417	14.381	12.218
Damien	2	11.018	7.6395	9.701	70.656	45.794	57.969	24.985	17.622	21.533
Gerry	2	8.1082	7.8933	6.4615	48.231	48.857	36.128	18.122	17.891	14.717
Eleanor	2	10.769	8.8247	9.3207	70.778	52.077	52.975	24.064	19.854	19.808
		Fixation Duration*								
		All AOIs			Target AOIs			NonTarget AOIs		
Participant	Group	Baseline	Phase 1	Phase 2	Baseline	Phase 1	Phase 2	Baseline	Phase 1	Phase 2
John	1	0.372991	0.229747	0.300221	2.377769	1.406309	1.973506	0.842756	0.511445	0.677223
Isobel	1	0.187766	0.274159	0.21352	1.145771	1.802478	1.388987	0.419518	0.622703	0.490087
Thomas	1	0.27328	0.264819	0.216066	1.714258	1.680689	1.292056	0.612774	0.59879	0.495932
Damien	2	0.283588	0.148081	0.26122	1.87112	0.925878	1.669374	0.640027	0.338256	0.593442
Gerry	2	0.29433	0.218764	0.143432	1.817144	1.387841	0.790363	0.6586	0.487271	0.337251
Eleanor	2	0.388513	0.335722	0.334185	2.584074	2.137937	1.921952	0.877328	0.761198	0.704936

**Measured in seconds*

8.3 Within Group Analysis

The following section describes the repeated outcome measures for the two groups in the feasibility study. As noted above, Group 1 received the intervention programme in Phase 1 and the control programme in Phase 2 and Group 2 received the control programme in Phase 1 and the intervention Programme in Phase 2. The

following section describes the measure of change for each group on the language, cognition, quality of life and control measures. The repeated outcomes measures for each participant are presented in Table 8.3 (Group 1) and Table 8.4 (Group 2). In addition the usage data for both groups is examined (8.3.5) and presented in Table 8.5.

8.3.1 Language performance

The three participants in Group 1 received the intervention programme during the first phase of the crossover study. They presented with improvements on the e-ACT sentence level tasks following Phase 1 and a large effect size (r=0.65) when comparing baseline to outcomes following Phase 1. However, there was no significant effect of treatment over the two phases ($\chi 2$=5.60, p=0.061) or following the treatment phase (Z=-1.604, p=0.109). Two participants in Group 1 demonstrated improvements in the number of blocks passed on the TROG with a large effect size (r=0.55). This did not reflect a significant effect in treatment over the two phases ($\chi 2$=3.818, p=0.148) or following the treatment phase (Z=-0.447, p=0.665). No participants in Group 1 presented with a greater than 5-point change on the WAB AQ score which would represent a clinically significant change on that outcome measure (Katz and Wertz, 1997). There was also no statistically significant change in WAB AQ following treatment in Phase 1 (Z=0.000, p=1.000) or over the three time points ($\chi 2$=0.00, p=1.000). A similar pattern emerged among the e-ACT paragraph and conversation tests after Phase 1 (p=0.317, p=0.317, respectively) and on repeated measures over both phases of the crossover study (p=0.368, p=0.368).

Table 8.3. Repeated Outcomes - Group 1

	John					Isobel					Thomas				
Test	Baseline	Post Phase 1	Post Phase 2	Follow up 1	Follow up 2	Baseline	Post Phase 1	Post Phase 2	Follow up 1	Follow up 2	Baseline	Post Phase 1	Post Phase 2	Follow up 1	Follow up 2
WAB AQ	55.5	55.8	53.5	52.2	57.5	36.9	31	31.2	34.2	36.9	94.6	95.8	96	96.4	96.2
-SS	10	10	10	10	11	7	5	5	6	7	19	19	19	19	19
-AVC	6.05	5.9	6.55	6.1	6.25	6.85	6.3	5.9	6.55	6.45	10	10	10	9.8	9.8
-R	6.4	6.5	6	5.4	6.4	1.7	2	1.4	1.6	1.6	8.8	9.2	9.6	9.8	9.8
-NWF	5.3	5.5	4.2	4.6	5.1	2.9	2.2	3.3	3	3.4	9.5	9.7	9.2	9.6	9.5
e-ACT															
-S	32	43	43	35	40	24	33	35	36	31	42	47	47	46	48
-P	12	12	11	11	13	4	10	10	11	11	14	14	13	13	12
-C	7	10	10	10	9	9	9	6	6	8	10	10	8	10	9
TROG	2(20)	3(30)	4(31)	2(20)	4(33)	2(21)	2(17)	4(36)	2(25)	2(22)	10(65)	15(71)	14(68)	11(68)	14(71)
RBANS -TS	47	45	46	48	52	46	45	44	47	46	77	71	71	72	77
-IM	49	40	44	53	61	44	40	44	44	44	81	65	65	76	85
-VSC	72	69	78	78	78	66	72	66	72	69	92	96	84	78	84
-L	44	44	40	47	40	40	40	40	40	40	79	79	79	82	82
-A	40	40	43	43	40	40	40	40	40	40	85	79	64	82	82
-DM	52	48	48	48	77	60	48	48	60	56	71	68	94	71	75
SAQOL-39 TS	3.46	3.31	2.87	3.69	3.18	4.64	4.89	4.68	4.79	4.69	3.9	3.74	4.26	4.18	4.13
-Ph	4.18	4.06	3.88	4.24	3.94	4.18	4.71	4.47	4.76	4.76	4.41	4.44	4.41	4.59	4.53
-C	2.29	2.29	2.29	3.57	1.96	5	5	4.43	4.43	3.86	2.86	2.86	3.43	3.29	3.71
-Ps	3.27	3	2.18	3.36	3	5	5	5	5	5	4.18	3.45	4.73	4.45	4.09
-E	3	2.77	1.5	2.5	2.75	5	5	5	5	5	2.75	3.25	3.75	3.25	3.25
AAQoL	61.07	65.7	70.5	66.1	68.2	0.3	15.5	15.5	15.5	15.5	51.9	34.7	32.6	34.9	29.2
-C	63.1	63.1	65	62.1	66.4	0.4	14.3	14.3	14.3	14.3	35.9	35.9	27.1	25.7	24.3
-E	59	68.2	76	70	70	0.3	16.7	16.7	16.7	16.7	68	68	38	44	34
PALPA 7	24	24	24	24	22	17	21	21	21	20	24	23	24	23	24
PALPA 8	20	18	22	22	21	15	12	14	10	9	26	25	26	27	27
PALPA 12	3	5	1	2	1	0	0	0	0	0	33	32	30	35	34
PALPA 53	16	17	16	18	20	0	0	0	0	0	36	38	38	34	36

Table 8.4. Repeated Outcomes - Group 2

	Damian					Gerry					Eleanor				
Test	Baseline	Post Phase 1	Post Phase 2	Follow up 1	Follow up 2	Baseline	Post Phase 1	Post Phase 2	Follow up 1	Follow up 2	Baseline	Post Phase 1	Post Phase 2	Follow up 1	Follow up 2
WAB AQ	52.4	52.9	55.5	56.4	55.4	67.1	80.2		75.8	75.65	18.4	19.6	17.5	21.4	21.3
-SS	16	16	16	16	16	11	15		14	14	3	4	2	5	4
-AVC	5	5.75	6.15	6.2	5.8	7.95	8.7		8.2	8.75	5.1	5.1	5.85	5.1	5.65
-R	3	1.8	2.6	3.4	3	8	9.1		8.8	8.8	0.8	0.5	0.6	0.3	0.4
-NWF	2.2	2.9	3	2.6	2.9	6.6	7.3		6.9	6.1	0.3	0.2	0.3	0.3	0.6
e-ACT															
-S	35	31	29	37	31	38	39		43	43	18	26	19	22	26
-P	10	10	11	11	12	10	13		12	12	3	9	9	5	6
-C	5	6	5	4	6	9	10		9	8	6	5	5	5	6
TROG	3(23)	0(15)	4(38)	2(23)	1(21)	6(37)	6(41)		11(61)	9(54)	1(14)	1(16)	1(15)	0(12)	0(12)
RBANS -TS	47	47	48	47	47	50	51		51	49	43	43	43	43	44
-IM	40	40	40	40	40	44	44		44	49	40	40	40	40	40
-VSC	84	84	84	78	84	66	84		72	72	66	66	64	60	75
-L	40	40	40	40	40	74	57		74	57	40	40	40	40	40
-A	43	46	46	43	46	46	40		46	43	40	40	40	40	40
-DM	52	52	60	60	56	56	68		52	52	40	40	40	44	44
SAQOL-39 TS	3.95	4.27	3.62	4.03	4.02	2.54	2.95		3	2.9	3.49	2.62	3.36	3.1	2.95
-Ph	4.06	4.69	4	4.24	4.41	3.65	3.65		4.41	3.94	3.65	2.94	3.41	3	3.35
-C	3.57	3.14	3.14	3.57	3.43	1.14	1.14		1	1.71	3.57	2.14	3	3.29	2.43
-Ps	4.09	4.6	3.91	4.27	4.36	1.91	1.91		2.45	1.91	3.55	2.36	3.55	3.18	3
-E	3.75	3.75	2	3.25	2.5	2	2		2	3.25	2.5	2.75	3.25	3	2
AAQoL	45.7	39.9	52.8	52.8	35.2	62.7	79.3		65.4	73.7	73.3	60	39.2	54.9	47.4
-C	44.1	35.7	51.7	56.7	29.3	62.7	78.6		40.7	71.4	67.3	61.4	44.3	55.7	52.9
-E	47.2	44	54	48.8	41	62.6	80		90	76	79.2	58.6	34	54	42
PALPA 7	20	17	21	21	18	23	24		24	24	0	1	3	0	3
PALPA 8	8	9	12	12	10	20	18		22	26	1	0	2	0	2
PALPA 12	0	0	0	1	0	12	19		21	20	0	0	0	0	0
PALPA 53	0	0	0	0	0	0	0		0	0	0	0	0	0	0

The participants in Group 2 completed the control programme in Phase 1 and the intervention programme in Phase 2. Assessments carried out post-Phase 1 indicate a small effect of treatment with the control programme on the e-ACT sentence level (r=0.22), medium effect on the TROG (r=0.4) and a large effect was noted on WAB AQ (r=0.65). However, there was no statistically significant change in outcomes on the e-ACT sentence level (Z=-0.535, p=0.593), TROG (Z=-1.000, p=0.317), WAB AQ (Z=-1.604, p=0.109) when comparing measures at baseline and after Phase 1. It must be noted that the WAB-AQ score increased by 13.3 points for one participant in this timeframe (further information reported in the case series section 8.4). When comparing the outcomes following the intervention phase in Phase 2 with the outcomes post Phase 1 a small effect size is noted on e-ACT sentence level tasks (r=0.22) and WAB AQ (r=0.22) and a large effect on TROG (r=0.55). However, there is no statistically significant change in mean scores noted on the e-ACT sentence level (Z=-1.342, p=0.180) TROG (Z=-1.342, p=0.180), and WAB AQ (Z=-0.535, p=0.539) when comparing outcomes post Phase 1 with outcomes after Phase 2. When considering the repeated measures from baseline, post Phase 1 and post Phase 2 there is no statistically significant change in scores over the three repeated measures on any of the language outcome scores as measured by the Friedman Test for the e-ACT sentence level ($\chi2$=0.667, p=0.717), e-ACT paragraph level ($\chi2$=3.800, p=0.150), e-ACT conversation level ($\chi2$=2.000, p=0.368), TROG ($\chi2$=3.714, p=0.156) and WAB AQ ($\chi2$=2.667, p=0.264). One participant presents with an increase of 13.1 points on the WAB AQ score after Phase 1 which is considered a clinically significant improvement after the control phase. This finding will be discussed further in the case series section. No other participant presented with clinically significant improvements on the WAB AQ. For

summary graphs of the outcome measures for WAB AQ see Figure 8.1. Summary information for the TROG (Figure 8.2), e-ACT sentence (Figure 8.3), e-ACT paragraph (Figure 8.4) and e-ACT conversation (Figure 8.5) tests are also presented.

Figure 8.1. WAB AQ Scores

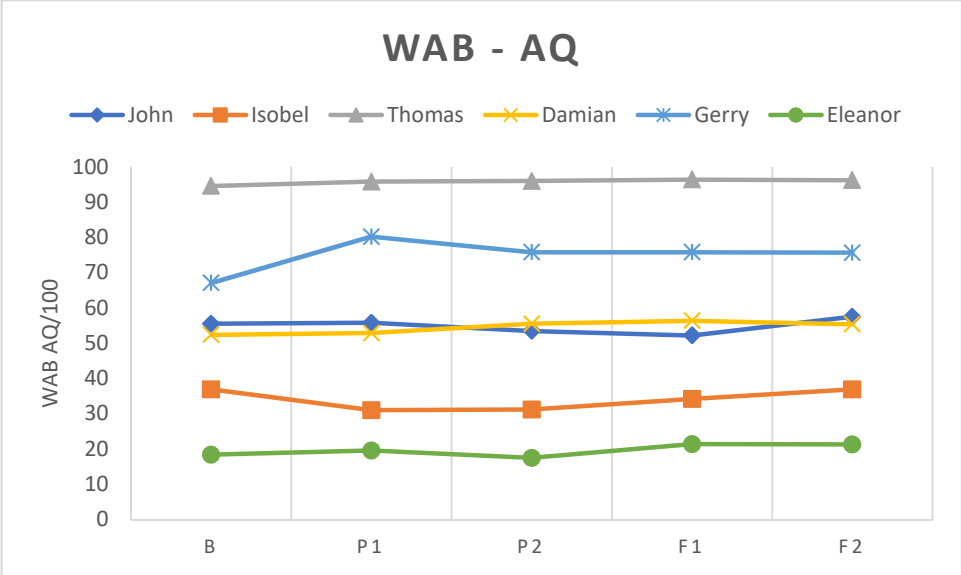


Figure 8.2. TROG Blocks Passed

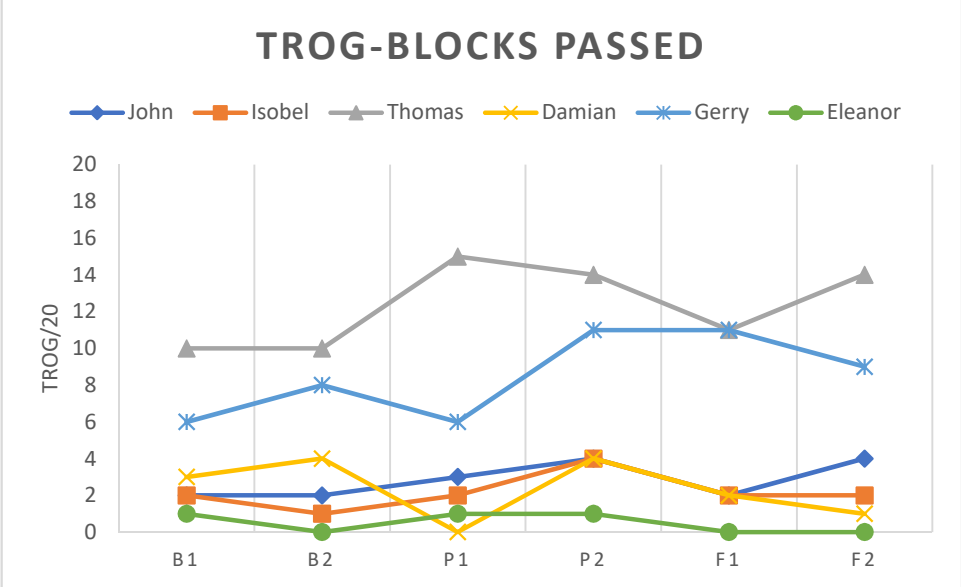


Figure 8.3. e-ACT Sentence Level Scores

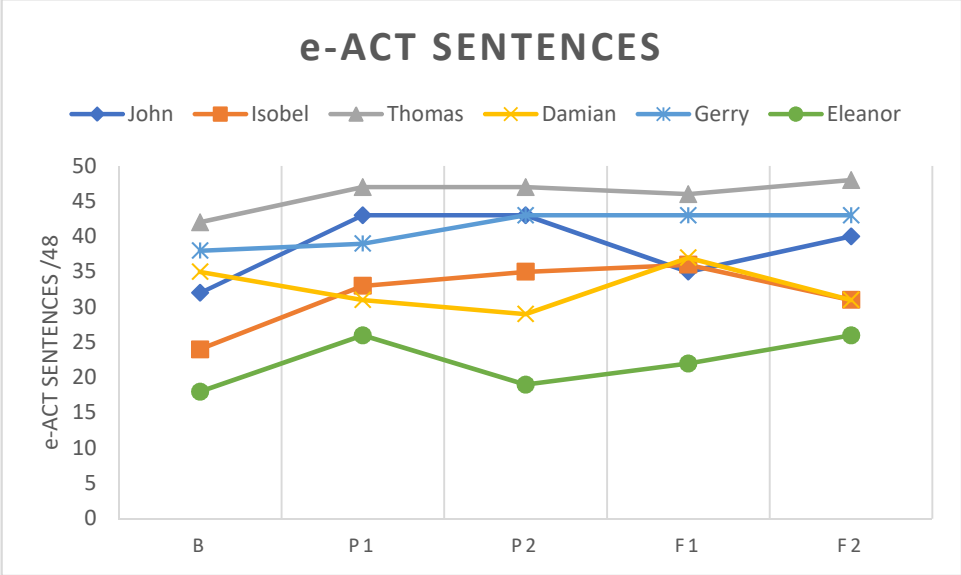


Figure 8.4. e-ACT Paragraph Level Scores

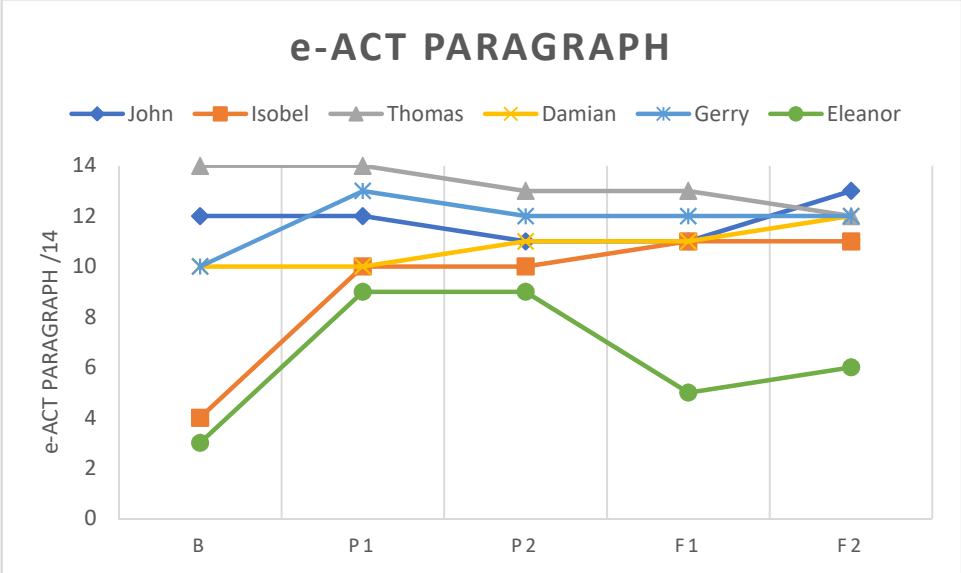
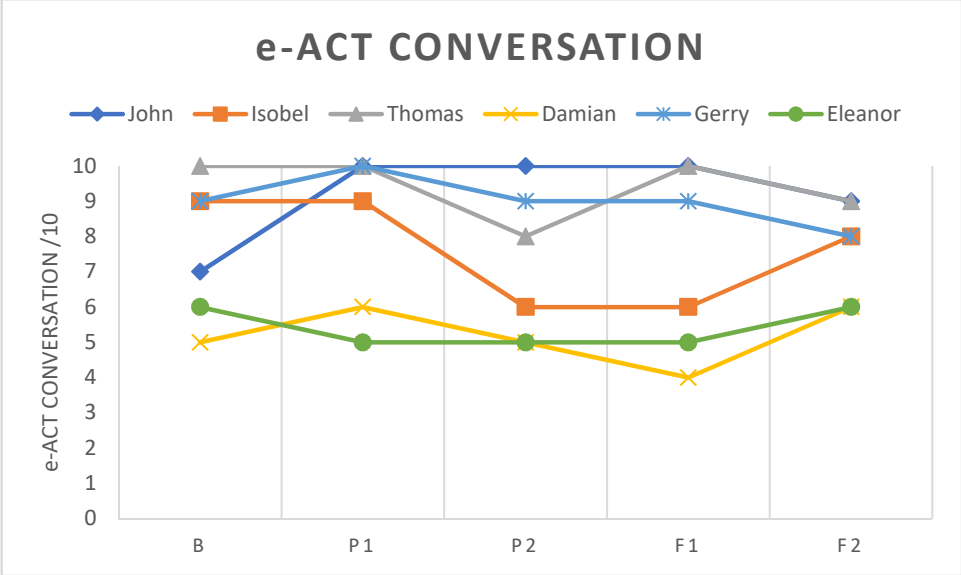


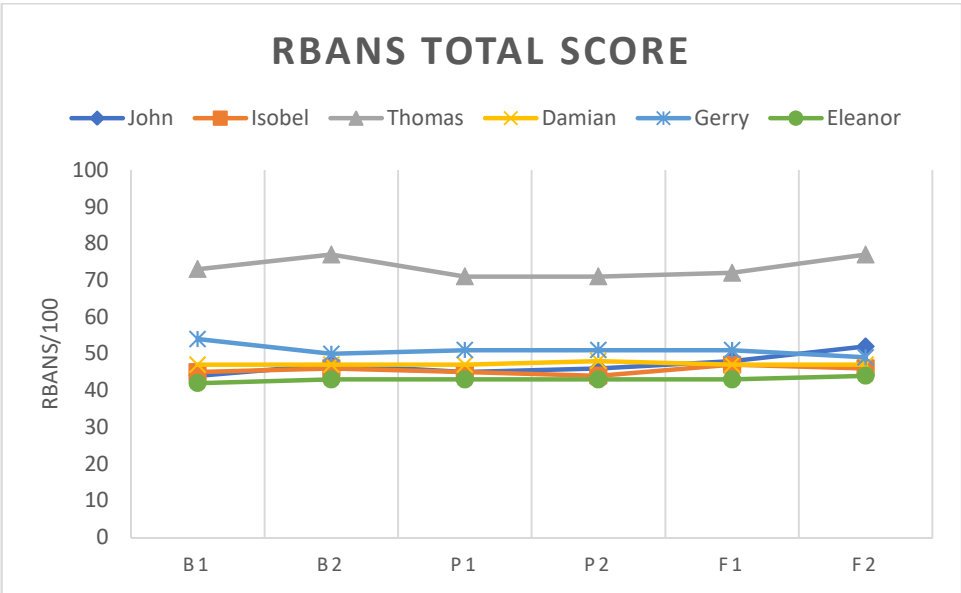
Figure 8.5. e-ACT Conversation Level Scores



8.3.2 Cognitive Skills

Cognitive skills were measured using the RBANS. See Figure 8.6 for an overview of the RBANS Total Scale score for each participant over the 5 outcome measurement time points. Friedman's test confirmed there was no change over the two phases in either Group 1($\chi2$=0.20, p=0.905) or Group 2 ($\chi2$=0.667, p=0.717).

Figure 8.6. RBANS Total Scores



8.3.3 Self-reported Quality of Life

The SAQOL-39 provides a health-related quality of life scale that is adapted for the needs of individuals with aphasia. Figure 8.7 provides an overview of the self-reported quality of life of each participant over the 5-time points of the research study as recorded on the SAQOL-39. There was no statistically significant difference between the repeated measures (baseline, Phase 1 and Phase 2) in Group 1 ($\chi 2=0.000$, $p=1.000$) or Group 2 ($\chi 2=0.000$, $p=1.000$) as assessed using Friedman's test. A similar finding is also noted in the outcomes of the self-reported quality of life scale that was developed for this study. Figure 8.8 provides an overview of the results for the 5-time points of the study. Again, there is no statistically significant effect of treatment in either Group 1 ($\chi 2=0.545$, $p=0.761$) or Group 2 ($\chi 2=0.000$, $p=1.000$) when comparing baseline measures with measures post Phase 1 and post Phase 2.

Figure 8.7. SAQOL-39 Total Scores

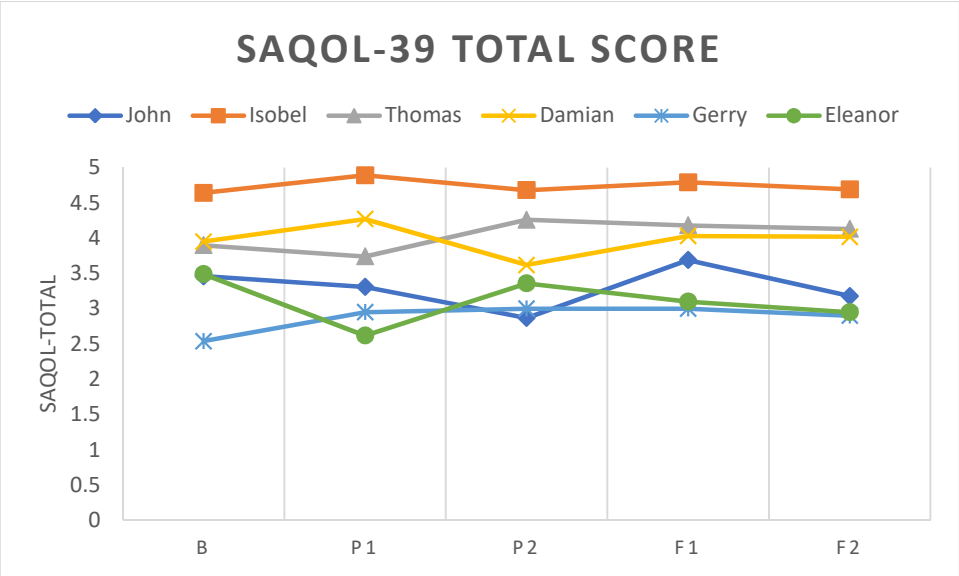
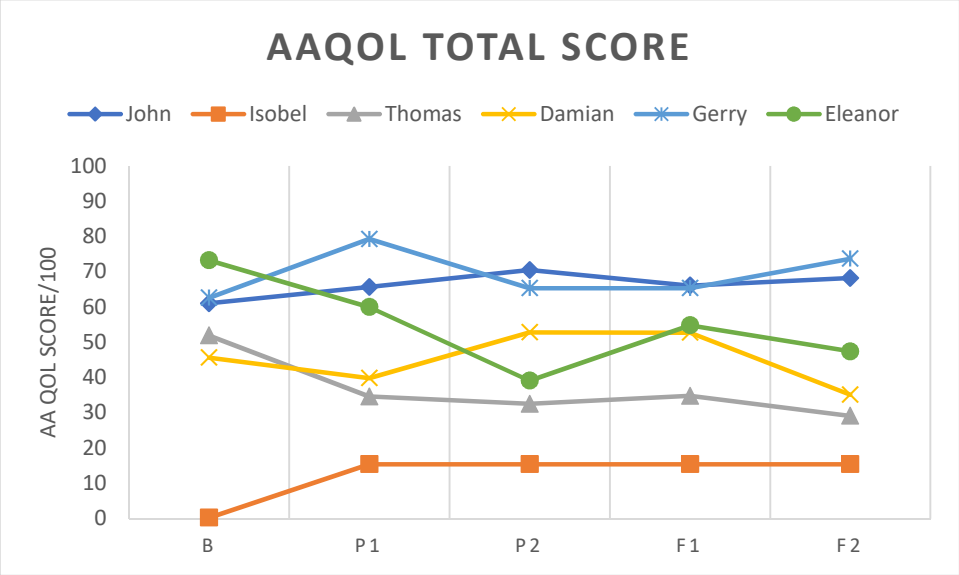


Figure 8.8. Aphasia-Accessible Quality of Life Total Scores



8.3.4 Control Tasks

The three PALPA repetition tasks, PALPA 7 word repetition (Figure 8.9), PALPA 8 non-word repetition (Figure 8.10) and PALPA 12 sentence repetition (Figure 8.11) were completed with each participant over the three repeated measurement sessions of the study. There was no statistically significant effect of treatment for Group 1 on PALPA 7 ($\chi2=1.000$, $p=0.607$), PALPA 8 ($\chi2=4.909$, $p=0.086$) or PALPA 12 (Group 1: $\chi2=3.000$, $p=0.223$). A similar finding is also noted in Group 2; PALPA 7 ($\chi2=3.818$, $p=0.148$), PALPA 8 ($\chi2=4.667$, $p=0.097$) and PALPA 12 ($\chi2=2.000$, $p=0.368$). Only two participants, both in Group 1 were able to complete the written naming task for PALPA 53, all other participants attempted the tasks but presented with single letters or copied the stimuli image and this was not appropriate for scoring. The two participants in Group 1 who completed PALPA 53 over at the repeated measure times over the crossover study did not present with a statistically significant change in performance ($\chi2=3.00$, $p=0.223$).

Figure 8.9. PALPA 7 Word Repetition Total Scores

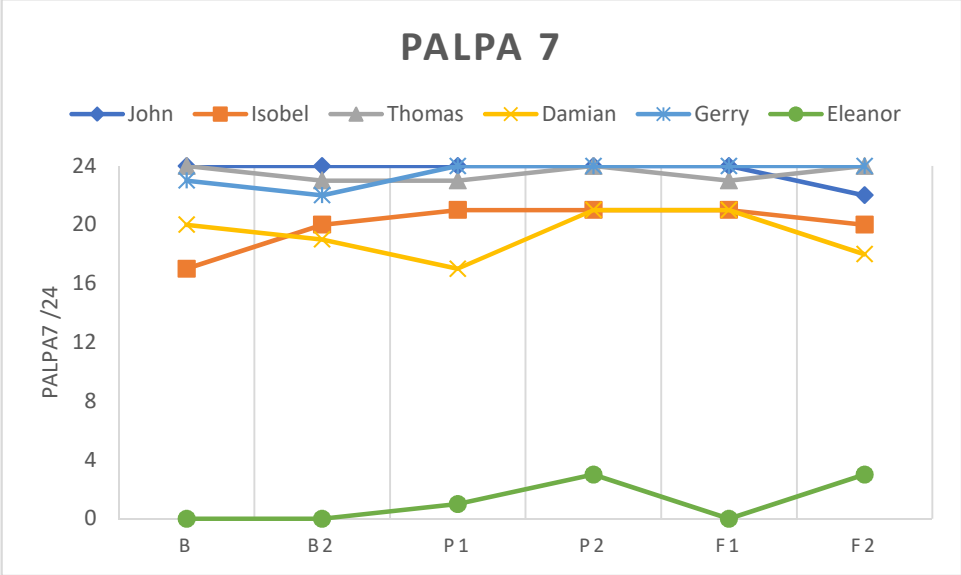


Figure 8.10. PALPA 8 Non-Word Repetition Total Scores

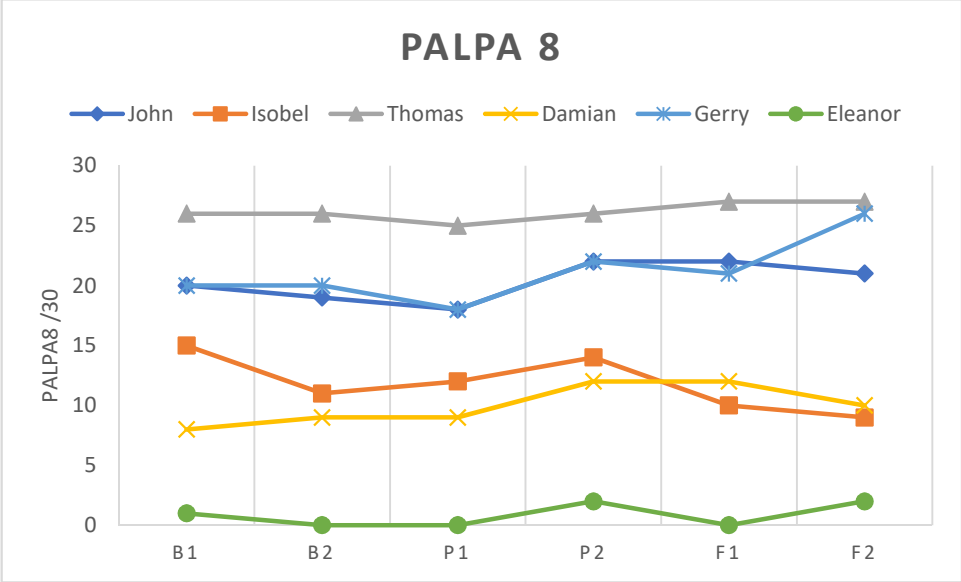
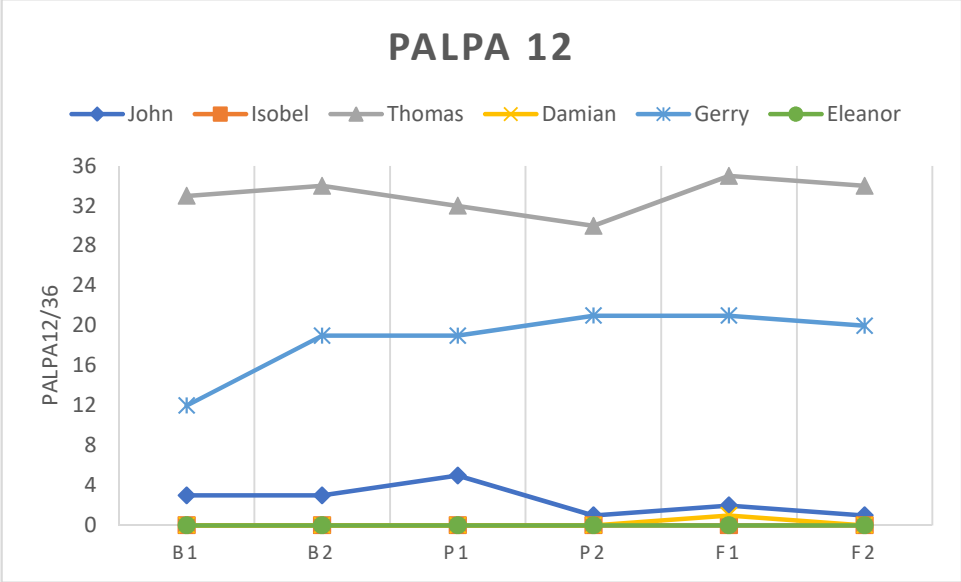


Figure 8.11. PALPA 12 Sentence Repetition Total Scores



8.3.5 Usage Data

It was not possible to calculate usage data in terms of participant time spent on the intervention programme due to a bug in the remote monitoring software of this programme. It was possible to retrieve information on the number of levels completed and the number of items that were attempted and answered accurately within a level. The data for the control programme was also gathered in a similar manner in addition to the time stamp. In order to try to compare the data between the programmes the number of levels completed and number of levels attempted are presented in Table 8.5. There were 20 task items in each of the 16 levels of the control programme. The number of items in the individual levels of the intervention programme varied slightly and ranged from 20 – 22 items. Group 1 attempted more levels than Group 2 (Z= 2.48, p=0.013) and completed more levels than Group 2 (Z=2.32, p=0.020) throughout the two phases of the crossover study.

There was no statistically significant difference between the number of levels attempted on the intervention programme and the control programme (Z= 1.04083,

p=0.30) or the number of levels completed in both programmes (Z=-1.20, p=0.23). There was a very strong and statistically significant relationship between the number of levels attempted during the intervention phase and the proportion of change achieved as measured with the e-ACT sentence level tasks following the intervention (r=0.912, p=0.011). There was a strong inverse relationship between the number of levels attempted and the proportion of change in the TROG following the intervention but this was not statistically significant (r=-0.600, p=0.208). One participant (Isobel) presented with a large number of levels attempted and completed within the intervention programme and the reason for this described in the case series (8.4.2).

Table 8.5. Usage Data

	John	**Isobel**	**Thomas**	**Damian**	**Gerry**	**Eleanor**
Phase 1	*Intervention*	*Intervention*	*Intervention*	*Control*	*Control*	*Control*
Levels attempted	78	135	67	25	17	22
Levels completed	70	95	64	15	7	4
Phase 2	*Control*	*Control*	*Control*	*Intervention*	*Intervention*	*Intervention*
Levels attempted	112	41	95	27	66	54
Levels completed	89	16	79	22	24	31

8.4 Case Series

This section provides an overview of each of the individual participants. This serves to explore the individual responses to the therapy programme and provide a greater understanding of individual experiences when engaging in ICT-delivered therapy. Each participant has been provided with a pseudo name. Each case is presented with summary background information on the participant as well as

their baseline measures on all assessments of language, cognition, quality of life and control measures. This is followed by an overview of their perceived ease of use and independence using the programme as well as their acceptance and usage of the programme. Finally, the outcome measures over the crossover study are presented. Table 8.3 and Table 8.4 provide an overview of the measures across the 5 time points of the study. Statistical analysis of language (TROG and e-ACT) and control tasks (PALPA7, PALPA 8, PALPA 12, PALPA53) were carried out using McNemar tests to compare item level accuracy between different time periods between 1) Baseline and post Phase 1, 2) Baseline and post Phase 2 and 3) post Phase 1 and post Phase 2. The aphasia outcomes as recorded on the WAB AQ are discussed in relation to the clinical significance which is measured as a change of 5 points or more on the WAB AQ (Katz and Wertz, 1997). Table 8.6 provides an overview of the summary information on usability and acceptance gathered during the structured observations, feedback questionnaire and semi-structured interviews.

Table 8.6. Summary Information on Usability and Acceptance

	John		Isobel		Thomas		Damian		Gerry		Eleanor	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
Ease of use questionnaire – median [#]	3	3	1	1	2	1	1	1	1	3	4.5	4
Observation session– level of independence	Near independent	Independent	Near independent	Near independent	Near Independent	Independent	Some assistance	Near independent	Some assistance	Near independent	A lot of assistance	Some Assistance
Perceived workload /NASA TLX [##]	45	50.83	8.33	8.33	49.17	47.50	33.3	33.3	91.67	81.67	89.17	72.50
Usage – Total attempted	78	112	135	41	67	95	25	27	17	66	22	54
Usage – Total completed	70	89	95	16	64	79	15	22	7	24	4	31
Recommend programme	Didn't know	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Couldn't make recommendation	Couldn't make recommendation
Preference for mode of intervention	No preference	ICT-delivered	ICT	No preference	ICT-delivered	ICT-delivered	Combination of face-to-face and ICT-delivered	Combination of face-to-face and ICT-delivered	Face-to-face	Combined face-to-face and ICT-delivered	Face-to-Face	Face-to-Face

[#]Ease of Use Ratings Range 0-5 (0 = No Problems/Very Easy, 3 = Neutral Ratings, 5 = Lots of Problems/Very Hard)
[##] Rating 1 – 100 (1 = Very Low Level of Cognitive Workload, 50 = Medium Level of Cognitive Workload, 100 = Very High Level of Cognitive Workload)

8.4.1 John

Summary background information

When recruited to the study, John was 32 years old and he lived with his parents and brother in a rural area. He worked as an accountant prior to experiencing a left cerebral haemorrhage almost 8 years prior to recruitment to the study and had not returned to work. He previously attended speech and language therapy in both inpatient rehabilitation and community services as well as part of a student speech and language therapy placement clinic. He had also attended support services for adults with acquired brain injury but was not attending any support or rehabilitation service at the time of recruitment to the study. John was independently mobile and used public transport.

John presented with moderate Broca's aphasia characterised by reduced fluency, impaired auditory comprehension for complex information e.g. sequential commands, impaired repetition for longer utterances and word finding difficulties. Occasionally, when John experienced word finding difficulties, he attempted to write the word or the initial letter of the word. This would rarely result in an accurate spoken production of the name but often provided the conversation partner with the written word, or initial letter, to facilitate naming and conversation. At single word level, John's comprehension of nouns was better than verbs. However, results indicated some level of impairment of noun comprehension with confusions noted on close semantic distractors e.g., pram → baby. Errors on verb comprehension tasks were typically noun related errors e.g. cycling → bicycle. At sentence level, John required a large number of repetitions to complete sentence comprehension activities and errors indicated reduced knowledge of the meaning of grammatical

constructions as well as processing difficulties. John reported that he has difficulty attending to and remembering information. He used his phone to photograph relevant information for future retrieval, for reminders and as a daily diary. John's hearing was within normal limits in both ears.

The RBANS Total Scale Index score indicated general cognitive impairment with extremely low immediate memory, language, attention and delayed memory skills and low visual spatial/constructional skills.

The SAQOL-39 provided an insight into John's perceived health-related quality of life and when comparing John to an overall sample of people with chronic aphasia 40 – 45% of this population would report a higher overall health-related quality of life. He was close to the average in terms of psychosocial functioning and energy levels; and the physical aspects of health-related quality of life were better than 65 – 70% of this population. His perception of the impact of stroke and aphasia on his communication was worse than 70% of the population with chronic stroke. John frequently reported fatigue as an issue since his stroke.

John used an iPhone for phone calls and text messages and also had an iPad which he used for entertainment, searching information, online banking, and social media and emailing. His digital technology use did not change much after his stroke except that he did not email as much as before. He did report a change in the usage of other technologies e.g. washing machine, microwave, ticket machine etc. This reflected a change in his personal circumstances as he was no longer living independently. He also had a travel pass so he did not need to use ticket machines for transport. He reported reduced confidence when using technology since his stroke, especially when using his phone for calls and text messages, emailing, engaging in social media, searching for online information and online banking.

All outcome measurement sessions, observations and interviews were completed in a local acquired brain injury support services building.

Programme acceptance and usage

The intervention programme was allocated to John during Phase 1. When completing this programme, John reported a medium level of workload as measured by the NASA TLX score of 45/100. He also provided a neutral rating with respect to the ease of use of the programme; indicating it was neither very easy nor very hard to use. John was observed to use the programme almost independently during the mid-phase observation session. He required assistance to find a specific activity level, as this was not set up on his menu when he logged in. John completed 70 levels, having attempted 78 levels throughout the 6-week phase. He indicated he had no preference for either face to face or ICT-delivered therapy and reported that he didn't know if he would recommend the programme to other individuals with aphasia.

John completed the control programme during Phase 2. He reported a slightly higher NASA TLX score for this programme but continued to indicate a medium level of workload (NASA TLX = 50.83/100). John provided neutral ratings with respect to ease of use of the programme. During the mid-phase observation, he was observed to use the programme independently. He completed 89 levels, having attempted 112. He reported that he would recommend the programme to other people with aphasia and indicated that he preferred ICT-delivered aphasia rehabilitation. This was also reaffirmed in the exit interview.

Outcome measures post intervention and control programmes

McNemar's test indicated statistically significant improvement on the e-ACT sentence level test comparing the item accuracy after the intervention in Phase 1 with

the baseline measure ($\chi 2$ =6.75, p=0.006). This represents a medium effect of treatment (φ=0.37). A small effect size was also noted on the TROG (φ =0.21) with ($\chi 2$=3.682, p=0.052) just outside the level set for statistical significance difference. No other statistically significant changes in outcome measures were noted. A minimal change in WAB AQ scores which increased by 0.3 after the intervention phase does not represent a clinically significant change in this assessment.

8.4.2 Isobel

Summary background information

Isobel was a 51-year-old woman who lived alone in an urban area at the time of recruitment to the study. Her mother lived close by and she had very supportive siblings. She experienced a left MCA infract with secondary haemorrhage seven years prior to recruitment to the study. She previously worked as an office administrator and had not returned to employment since her stroke. She attended a local support service for individuals with acquired brain injury and enjoyed frequent sun holidays with her mother and sister. She previously attended speech and language therapy including community-based services and a student speech and language therapy placement clinic. She was independently mobile with a slow gait pattern.

Isobel presented with severe aphasia with characteristics of Broca's aphasia. She presents with limited verbal output, generally producing only single words which are often effortful and hesitant. Her auditory verbal comprehension was impaired with difficulty following complex sentence structures and her repetition and naming abilities were significantly impaired. Isobel used gesture and mainly single words in conversation, and when possible, she used her phone to indicate

information that may be stored within it e.g. address, holiday destination etc. Isobel presented with impaired auditory verbal comprehension at single word level for both nouns and verbs. During a spoken word to picture matching task to investigate verb comprehension she presented with significant errors (22/40) and tended to choose noun related items e.g. raking → rake, followed by distractor verbs e.g. stamping → glueing. She also presented with significant errors on noun comprehension tasks (28/40) and tended to choose mainly close and some distant semantic distractors as well as some errors that were semantic and visual in nature e.g. thumb → finger. Isobel required a large number of repetitions of test items during the TROG. The number of lexical errors and pattern of blocks failed suggests that her difficulties cannot readily be attributed to grammatical problems alone and may indicate that she had difficulty remembering words and processing information. Isobel did not attempt PALPA 53 - written picture naming at baseline. Instead she indicated an inability to write following her stroke and repeated this at each time point. Isobel's hearing was within normal limits in both ears.

The RBANS Total Scale Index score indicated general cognitive impairment with extremely low immediate memory, language, and attention skills. She presented with slightly higher delayed memory skills and visual spatial/constructional skills, but both these remain in the extremely low classification.

Isobel perceived her health-related quality of life to be extremely high overall. Her SAQOL-39 score and the component psychosocial functioning, communication and energy level domains indicate that Isobel perceived her health-related quality of life to be better than over 95% of a sample of people with chronic

aphasia. The physical aspects of her health-related quality of life were rated slightly lower but still perceived to be better than 85% of that population.

Isobel owned a non-smartphone but rarely used it and only for calls with close family members. She owned an iPad which she used for entertainment, online banking and gaming. She reported some changes in her technology usage after her stroke. She no longer uses emails or self-service facilities e.g. self-service supermarket check-out. However, she did not feel her confidence when using technology had been impacted by her stroke.

All outcome measurement sessions, observations and interviews were completed in a local acquired brain injury support services building.

Programme acceptance and usage

The intervention programme was allocated to Isobel during Phase 1. When completing this programme Isobel reported a low level of workload with a NASA TLX score of 8.33. She also reported neutral to positive ratings with respect to ease of use of the programme. Isobel was observed to use the programme with near independence, requiring assistance only to switch on the device as it belonged to the researcher (she had forgotten to bring her own device to the session). During the phase, she completed 95 levels having attempted 135 levels overall. It must be noted that this included over 20 repeated attempts of level 12. On inspection, during the structured observation session, it was noted that this level did not register as completed and was not automatically removed from the task list. This automatic removal was a feature with all other levels but a programme bug meant this presented as incomplete, despite working on the level and completing all tasks within it. Isobel reported that she would recommend the programme to a person

with aphasia and indicated a preference for ICT-delivered aphasia rehabilitation during Phase 1.

In Phase 2, Isobel completed the control programme and again reported a low level of workload with a NASA TLX score of 8.33. She reported that all aspects of the programme were easy to use and that she worked independently on the programme. The structured observation session indicated that she required some minor assistance to log in to the programme and was working almost independently on the programme. She required some assistance to log in but again the researcher's device was used during the observations and this may have impacted on her independence. She completed 16 levels in the control programme and attempted 41 levels overall. She reported that she would recommend the programme to others and indicated no preference for face-to-face or ICT-delivered aphasia rehabilitation in Phase1. She indicated a preference for face-to-face therapy during the exit interview.

Outcome measures post intervention and control programmes

A statistically significant improvement was noted on the e-ACT paragraph level test when comparing baseline and post-Phase 1 (intervention phase) measures ($\chi 2$= 4.16, p=0.031). This represents a small effect size (φ=0.23). There was a small treatment effect noted on the e-ACT sentence level tasks (φ=0.25) but this is not statistically significant. There are no other statistically significant changes in outcome measures following Phase 1. Following Phase 1, the WAB AQ was 5.9 points lower than the baseline measure which indicates a clinically significant negative change in WAB AQ score. This remained unchanged following Phase 2 but improvements of 3 and 5.7 points were noted when comparing Phase 2 with the

follow up at 4 and 16 weeks. There was a statistically significant change in both the TROG ($\chi 2=10.316$, $p=0.001$) and the e-ACT sentence level test ($\chi 2=5.50$, $p=0.17$) when comparing outcomes after Phase 2 (control phase) with the baseline measure. This represents medium effects of ($\varphi=0.36$) and ($\varphi=0.34$) respectively. This was accompanied by a statistically significant improvement on the TROG when comparing the outcome post-Phase 1 and the outcome after the control phase in Phase 2 ($\chi 2=14.087$, p=0.0001).

8.4.3 Thomas

Summary background information

Thomas was a 59-year-old widow who lived in his own home with his son in a rural area. While undergoing a coronary bypass graft, Thomas experienced an ischaemic infarct in the left frontal lobe. This occurred over 4 years prior to recruitment to the research. Prior to his stroke he worked in construction and had expressed an interest in returning to employment but was not working for the duration of the research. Thomas was independently mobile and drove his own car.

Thomas presented with mild anomic aphasia, characterised by some word finding difficulties and very mild repetition difficulties. His auditory comprehension of nouns and verbs at single word level was intact. His performance on the TROG indicated processing difficulties as his errors were sporadic and he required a number of repetitions which suggest mild abnormality with respect to the need for repetition. On hearing screening, he did not meet the threshold of 40db at 4000Hz in his left ear but presented with adequate hearing within the defined threshold in his right ear. An average of the four relevant speech frequencies indicates hearing within appropriate limits in both ears for study inclusion.

The RBANS Total Scale Index score indicated a borderline cognitive impairment with extremely low immediate memory, borderline language and attention scores, low average delayed memory skills and average visual spatial/constructional skills.

When comparing Thomas' SAQOL-39 total score to the overall sample of people with chronic aphasia, 20-25% of the population would report a better overall health-related quality of life. This is also reflected in his scores on the physical domain, which is better than 75-80% of the population; and the psychosocial domain, which is better than 80-85% of the population. His energy domain is below the average, with 40-45% of the population worse than him and his perception of the impact of stroke and aphasia on his communication was above the average, better than 55-60% of the population.

Thomas owned an iPad and a non-smartphone which he used for calls and text messages. He used his iPad to store reminders for events, Skype calls, entertainment, online shopping/browsing and searching for online information. He regularly used *www.rip.ie*, an obituary website, to keep up to date with local funeral arrangements. He reported that his usage of technology had not changed much since his stroke but his confidence has decreased for activities such as using the television and remote control, using the ATM, speaking on the phone and text messages.

The baseline measures and all eye-tracking measures were completed in a local acquired brain injury support services building. All other outcome sessions, observations and interviews were completed in Thomas' own home.

Programme acceptance and usage

The intervention programme was allocated to Thomas during Phase 1. When completing this programme Thomas reported a medium level of workload, indicated

by a score of 49.17 on the NASA TLX. He reported neutral to positive ratings with respect to ease of use of the programme and he reported that he used the programme independently at home. Thomas was observed to use the programme almost independently during the structured observation session only requiring the assistance of the therapy support manual to navigate to a specific task level. During Phase 1, he completed 64 levels and attempted 67 levels overall. Thomas reported that he would recommend the programme to other people with aphasia and indicated a preference for ICT-delivered aphasia rehabilitation.

Thomas worked on the control programme during Phase 2 and again reported it provided a medium level of workload (NASA TLX=47.5). He also positively rated the ease of use of the programme with all questions marked at the highest level of no problem/easy to use. During the structured observation session, he was noted to work independently on the tasks with no need for assistance. He attempted 95 levels of the control task and completed 79 of these. He again reported that he would recommend the programme and indicated his preference for ICT-delivered aphasia rehabilitation.

Outcome measures post intervention and control programmes

A small treatment effect (φ=0.22) was noted on e-ACT sentence level tasks and there was improvement in the number of blocks passed in the TROG after Phase 1 (intervention phase) but these did not reflect a statistically significant change. No other statistically significant changes in outcome measures were noted. A small improvement of 1.2 points on the WAB AQ after Phase 1 was also accompanied by a smaller improvement of 0.2 points following Phase 2. These do not represent a clinically significant change in this assessment.

8.4.4 Damian

Summary background information

Damian was a 40-year-old man who lived with his father and sister, having lived away from home prior to his stroke. He experienced a left temporal parietal haemorrhage while at work, almost three years prior to the recruitment to the study. He worked as an engineer and had not returned to this role but had recently set up a new business venture with support from his family. Damian was independently mobile and drove his own car.

Damian presented with moderate aphasia, with characteristics of Wernicke's aphasia. His speech was fluent, and he occasionally produced irrelevant information and presented with word finding difficulties. His auditory verbal comprehension was impaired and he had difficulty following complex commands. His repetition and naming abilities were impaired and errors were often phonological in nature e.g. toothbrush → toothdush. He presented with some difficulties during auditory comprehension tasks for nouns (31/40) and verbs (34/40) at single word level, choosing close semantic and semantic-visual distractor items e.g. dart → spear and distractor verbs e.g. skating → skiing. His performance on the TROG indicated poor attention and memory and he required multiple repetitions for task items. His errors included lexical errors as well as random errors and a systematic error pattern for reversible passives. Damian attempted PALPA 53 – written word naming at baseline but abandoned the assessment after four items which were answered with only single letters and two episodes of perseveration on letters. Damian's hearing was within normal limits in both ears.

The RBANS Total Scale Index score indicated general cognitive impairment with extremely low immediate memory, language, attention and delayed memory skills and borderline visual spatial/constructional skills.

When considering Damien's SAQOL-39 total score he reported his health-related quality of life was better than 75-80% of a sample of people with chronic aphasia. He was better than 65-70% of the population in terms of the physical aspects of his quality of life, better than 80% of the population in his psychosocial functioning and well-being and better than 70% in terms of his energy level. His perception of the impact of stroke and aphasia on his communication was better than 80-85% of the population with chronic aphasia.

Damian owned a smartphone, iPad, laptop and Mac computer. He used his smartphone for calls and text messages as well as a daily schedule and reminder. All appointments were entered into the calendar application on his iPhone. He used both speech-to-text and text-to-speech accessibility features to assist him with reading and writing on his phone. He previously worked as an engineer which required him to use digital technologies e.g. email. He reported a small number of changes in his usage of technology after his stroke: he no longer used self service facilities, audiobooks or digital/cable entertainment. He also reported less frequent use of skype, email and online shopping. A significant change in his confidence rating with respect to using technology since his stroke was noted. Prior to his stroke, he had rated his confidence when using ticket machines, ATMs, engaging in phone calls and text messages and emailing as very high. This was reduced to an average rating for email and a low rating for mobile phone use for calls, and ATM use after his stroke.

Damian completed all baseline measures and while waiting for the programme to become available for the research he was offered an opportunity to

attend local speech and language therapy services. He was advised to contact the research team when this block of therapy was completed. All repeated outcome measures (WAB, TROG, RBANS, SAQOL-39, AAQoL, PALPA 7, PALPA 8, PALPA 12 & PALPA 53) were completed prior to commencing Phase 1. There was a four-month time interval between initial baseline measures and the repeated measures prior to Phase 1. The baseline measures were initially stable with TROG ($\chi2=2.083$, $p=0.146$), PALPA 7 ($\chi2=0.444$, $p=0.508$) PALPA 8 ($\chi2=0.083$, $p=0.774$) while PALPA 12 could not be calculated as a baseline was not established. There was a statistically significant difference in TROG scores after the break ($\chi2=8.643$, $p=0.002$) when compared to the initial baseline measure. This may suggest some change in baseline stability. However, this is not reflected in other repeated measures.

All outcome measurement sessions, observations and interviews were completed in a room within the University buildings.

Programme acceptance and usage

The control programme was allocated to Damian during Phase 1. When completing this programme, he reported a low level of workload as noted by the NASA TLX score of 33.3 and he indicated positive ease of use ratings for most aspects of the programme. He rated the ease of use involved in navigating the programme negatively. He was noted to require some assistance during the structured observation in order to navigate the task levels to find the appropriate task and to exit the programme during the structured observation session. He completed 15 levels, having attempted 25 levels overall. He reported that he would recommend the programme. When asked about his preference for mode of intervention he indicated he would like a combination of face-to-face and ICT-delivered therapy.

During Phase 2, he carried out activities on the intervention programme. Attempts to upload the app to his iPad were unsuccessful and this required him to use his Mac PC, which was located in his bedroom at home, for all tasks during this phase. He reported a low level of workload, again scoring 33.3 on the NASA TLX. He rated most aspects of the programme as easy to use but rated navigating tasks and hearing the sound stimuli as negative with respect to ease of use. During the structured observation session, he was observed to work almost independently on the programme only requiring assistance to switch on the device. This was likely due to the fact that the researcher provided her laptop for the observation activity. He completed 22 levels and attempted 27 levels during the 6-week phase. Again in this phase, he reported that he would recommend the programme and indicated a preference for a combination of face-to-face and ICT-delivered therapy.

Outcome measures post intervention and control programmes

An increase in the numbers of blocks passed on the TROG was observed when comparing the outcomes after Phase 1 with the outcomes following Phase 2 (intervention phase) but this did not reflect a statistically significant change. There was no effect of treatment on item level analysis of either the TROG or any e-ACT test and no other statistically significant changes in outcome measures were noted. A small improvement of 2.6 points was noted on the WAB AQ after Phase 2 but this change does not reflect a clinically significant change and falls within the standard error for this assessment. No statistically significant changes in any other outcome measurements of language, cognition, quality of life or control tasks, were noted.

8.4.5 Gerry

Summary background information

At the time of recruitment to the study, Gerry was a 67-year-old man who lived in an urban area with his wife and his adult children lived close by. He worked as a mechanic prior to his left frontal and temporal lobe infarct which happened seven and half years prior to recruitment. He did not return to employment after his stroke.

At baseline, Gerry presented with moderate, transcortical-motor aphasia, characterised by anomia and halting, telegraphic speech with impaired auditory verbal comprehension of complex sequential commands. At single word level, his comprehension of nouns was better than verbs; the latter was characterised by equal numbers of noun-related (eating → food) and distractor verb-related (mopping → wiping) errors. On sentence level auditory comprehension tasks, Gerry required a large number of repetitions to complete activities and presented with primarily sporadic errors on the TROG indicating processing difficulties. Gerry attempted PALPA 53 – written word naming but reported he could not write following his stroke and instead copied the drawing of the visual stimuli. This was abandoned after two attempts and repeated guidance to write the word instead of drawing the picture. Gerry presented with hearing outside the threshold of 40db at 4000Hz in both ears. However, when considering the average of the four relevant speech frequencies, his hearing was within the appropriate limits and was therefore considered adequate for inclusion in the study.

The RBANS Total Scale Index score indicated general cognitive impairment with extremely low immediate and delayed memory, visuospatial/construction, and attention skills and borderline language skills. This test was repeated during

baseline, five weeks after first tested and the total score continued to indicate extremely low abilities but visuospatial/constructional score improved to reflect low average skills. Overall there was stability in this measure (Z=-1.826, p=0.068) at baseline.

When comparing Gerry's SAQOL-39 to the overall sample of people with chronic aphasia, 80-85% of the population report a better overall health-related quality of life than Gerry. He rated himself to be close to the average in terms of the physical impact of his health-related quality of life and he was worse than 80-85% of the population in his energy level. His perception of the impact of stroke and aphasia on his communication, and psychosocial functioning and well-being was worse than 90-95% of the population.

Gerry had post-stroke epilepsy that is generally managed with medication and he experiences recurrent diverticulitis. During the study, he experienced a period of ill health and required medical review and hospitalisation. This occurred towards the end of Phase 2 and impacted on the timing of his outcome measurements. He was unable to attend these sessions but did attend the follow-up sessions 4 weeks later. The eye-tracking assessments were completed in a computer lab within the university. All other initial baseline and outcome measurement sessions, observations and interviews were completed in Gerry's own home. Gerry's wife attended all sessions with him in the University and a family member or his wife was always present at home for these sessions as he is never left alone due to his epilepsy.

Gerry's baseline measures indicate a degree of instability. As noted above there was a small but not statistically significant improvement in cognitive status as measured on the two RBANS completed during the baseline period. His repeated

TROG scores indicate a statistically significant difference in receptive grammar skills between these two baseline measures ($\chi 2=9.375$, $p=0.002$) and his outcomes on the sentence repetition task (PALPA 12) indicate some variation but this is not statistically significant ($\chi 2=3.273$, $p=0.065$). The remaining repeated baseline measures (PALPA 7 and PALPA 8) do not indicate any variability in baseline scores.

Gerry used an iPad, laptop and desktop computer and he had not used a phone for calls or text messages since his stroke. He used speech-to-text to search for information on Google and after his stroke, he began to use digital technologies for Skype calls and entertainment; activities he did not partake in before his stroke. He did not use digital technologies for online shopping but was observed to browse shopping websites and his family would complete the purchase for him. Although he did not report any significant changes in the frequency of usage of technologies since his stroke, he did report reduced confidence when engaging in activities such as using the television and remote control, as well as using the microwave and DVD player. Gerry enjoyed art, a hobby he took up since his stroke, and his house had many of his own paintings hanging on the wall.

Programme acceptance and usage

The control programme was allocated to Gerry during Phase 1. When completing this programme Gerry reported a high level of workload (NASA TLX=91.67) and positive ratings with respect to ease of use of the programme. Gerry reported he used the programme independently and was observed to require some assistance to switch on the iPad, log in and exit the programme. Gerry completed seven levels, having attempted 17 levels overall. He recommended the

programme for others but also indicated that he preferred face-to-face therapy rather than ICT-delivered intervention.

Gerry worked on the intervention programme during Phase 2 and reported a high level of workload (NASA TLX=81.67); slightly lower than his rating of the control programme in Phase 1. He also provided less favourable ratings for ease of use of the programme indicating neutral ratings. During the structured observation session, he was noted to work almost independently, only requiring some assistance to delete and reinstall the app during the session. This was required due to a programme bug which resulted in the sound stimuli not playing and the only workaround required the programme to be deleted and reinstalled. Gerry attempted 66 levels and completed 24 levels throughout the phase. However, it must be noted that he became unwell in week 5 and was admitted to hospital. He was not well enough to complete the post-Phase 2 outcome sessions until 4 weeks after the end of the phase. Therefore, his 4-week follow up session was considered his post-Phase 2 outcome measures for the purpose of statistical analysis. During Phase 2, Gerry reported that he would recommend the programme to others with aphasia and he indicated a preference for combining face-to-face therapy and ICT-delivered therapy.

Outcome measures post intervention and control programmes

Gerry attended three of the four outcome measurement sessions. Due to illness following Phase 2, he could not attend this session and his next outcome was obtained four weeks later at Follow-up 1 session. The data gathered at Follow-up 1 is used as his post Phase 2 data. McNemar's test indicates a statistically significant improvement on the TROG comparing the outcomes four weeks after the intervention in Phase 2 with outcomes following Phase 1 ($\chi 2$ =12.893, p=0.001) and against the baseline measurement ($\chi 2$ =18.893, p=0.001). This represents a medium

effect of treatment (φ=0.40) following the intervention in Phase 2. There was no treatment effect measured on the e-ACT sentence level tasks. When comparing the PALPA 12 outcomes after Phase 2 with the baseline measures there is a statistically significant improvement (χ2=4.267, p=0.035). There is no statistically significant difference between Phase 1 and Phase 2 on this measure. A large improvement of 13.1 points was noted on the WAB AQ after Phase 1. This reflects a clinically significant difference as it falls outside the standard error for the assessment. Phase 1 was the control programme phase, and such change would not be expected following the programme. The WAB AQ fell by 4.4 points after Phase 2. There were no clinical or statistically significant changes in any other outcome measurement.

8.4.6 Eleanor

Summary background information

Eleanor was a 67-year-old woman who, at the time of recruitment to the study, lived part-time with her brother in a rural area and part-time with her sister in an urban area. This arrangement allowed her to attend support services for people with acquired brain injury. She experienced a stroke four and a half years prior to the recruitment to the study. Before her stroke, she worked as an office administrator. She had not returned to employment since her stroke. She had strong family support from her brother and sister and was unmarried.

Eleanor presented with very severe, Broca's type aphasia. Her auditory comprehension was impaired with difficulties following auditory word comprehension tasks and sequential commands on the WAB-R. Her expressive output was characterised by short meaningless utterances reflective of jargon

aphasia. During a spoken word to picture matching task to investigate verb comprehension Eleanor presented with significant errors (24/40) and tended to choose distractor verb items e.g. raking → hoeing, followed by noun related items e.g. peeling → apple. She also presented with significant errors on noun comprehension tasks (27/40) and tended to choose mainly distant (shoe → trousers) and some close (pram → baby) foils. The results of the TROG suggest an auditory processing difficulty, however, it must be noted that she presented with a number of lexical errors which in adults may indicate poor attention or memory. Eleanor indicated that she could not write following her stroke when asked to complete PALPA 53 – written word naming. She presented with hearing outside the threshold of 40db at 4000Hz in both ears and at 40dB at 2000Hz in her right ear. However, when considering the average of the four relevant speech frequencies, her hearing was within the appropriate limits and was therefore adequate for inclusion in the study.

The RBANS Total Scale Index score indicated general cognitive impairment with extremely low immediate and delayed memory, language, attention and slightly higher visual spatial/constructional skills but these also remain in the extremely low classification.

A summary of Eleanor's SAQOL-39 test indicated that 55-60% of a sample of people with chronic aphasia report poorer health-related quality of life. She was close to the average in terms of the physical aspects of her health-related quality of life. Her psychosocial functioning was better than 60-65% of the population and her energy levels were worse than 65-70% of the population. Her perception of the impact of stroke and aphasia on her communication was better than 80-85% of the population of people with chronic aphasia.

Eleanor owned an iPad; she did not own a mobile phone. She reported a significant change in technology usage since her stroke. Prior to her stroke, she used ATMs, ticket machines, self-service facilities, audiobooks, camera as well as email; these were no longer being used. She also reported changes in the frequency and confidence of use of everyday technologies such as navigating the television and speaking on the phone.

All eye-tracking data collection sessions were completed in a room within the University. All other outcome measurement sessions, observations and interviews were completed in her sister's home.

Programme acceptance and usage

The control programme was allocated to Eleanor during Phase 1. When completing this programme Eleanor reported a high level of workload (NASA TLX=89.17) and negative ratings with respect to ease of use of the programme. Eleanor was observed to require a lot of assistance when using the programme. She could switch the iPad on but needed assistance to log in, navigate to the level, repeat the stimulus question if unclear and exit the level and the programme. She was receiving help from her siblings to work on the programme at home. During the phase she completed 4 levels, having attempted 22 levels overall. Eleanor reported that she would not recommend the programme, indicating that she did not feel she was in a position to do this. She indicated a preference for face-to-face therapy.

During Phase 2, Eleanor worked on the intervention programme. She reported a slightly lower level of workload (NASA TLX=74.5) when compared to her Phase 1 rating. Overall, this continued to represent a high level of workload. She was observed to work with less assistance but still required help to switch on the iPad, login, find the level and exit the programme. She was able to independently

repeat the stimulus information. She indicated that she was working on her own without support from her siblings. She completed 31 levels, after attempting 54 levels overall during the phase. Again, she indicated that she did not feel she could recommend the programme and she indicated a preference for face to face therapy.

Outcome measures post intervention and control programmes

Improvements were noted on the e-ACT sentence level test after Phase 1 which was the control programme so these changes were not anticipated. The McNemar's test indicates a statistically significant change ($\chi 2 = 5.146$, $p=0.016$) when comparing the baseline measurement with Phase 1 outcomes. This represents a medium effect of treatment ($\varphi=0.33$). There was no statistically significant difference between Phase 1 and Phase 2 outcomes, and the scores suggest a decline occurred. No other statistically significant changes in outcome measures were noted. Interestingly, her quality of life as reported by the SAQOL-39 indicated a perceived deterioration in health-related quality of life, after Phase 1. This was in contrast with the quality of life measure developed for the study which indicated improvements (0 indicates no impact on communication-related quality of life). However, the SAQOL-39 completed after Phase 2 reflected a return to her baseline scores, and the quality of life measure developed for the study indicated further improvements in perceived communication-related quality of life. There is no clinically significant change in WAB AQ scores when comparing baseline scores with outcomes following Phase 1 (improvement of 1.2 points noted) and comparing scores following Phase 1 with scores following Phase 2 (fell by 2.1 points).

8.5 Perspectives of ICT-delivered Aphasia Rehabilitation

This section reports on the experiences of the participants engaging in ICT-delivered aphasia rehabilitation in this feasibility study. Interviews were carried out mid Phase 1, mid Phase 2 and 4 weeks after Phase 2 to explore the participants' views of ICT-delivered aphasia rehabilitation. The interviews also covered aspects of the participants' use of digital technologies in everyday life. Individual preferences, reports of independence when working and recommendations for others are noted within the case series information. The following section provides an overview of the themes that were identified following qualitative content analysis of the transcripts over the 3-time points.

Three themes were identified in the transcripts: Engaging in ICT-delivered aphasia rehabilitation, Programme Features and The Role of ICT in Everyday Life. Table 8.7 provides an overview of the themes, subthemes and related codes. Each theme will be discussed below.

8.5.1 Engaging in ICT-delivered Aphasia Rehabilitation.

Two key subthemes were identified within this theme; Facilitatory Milieu and Personal Preferences. The participants identified a number of factors that promoted the facilitatory milieu for the use of this mode of intervention in rehabilitation. They also identified a number of factors that acted as barriers. One key supporting factor within the facilitatory milieu, identified by all participants, was the ability to work independently. This ability to work independently allowed the participants to have autonomy over the therapy they engaged in. Thomas highlighted this as a positive aspect of the mode of intervention: *"So you have your-, your own control over it".*

Table 8.7. Overview of Themes from Interviews with Participants with Aphasia

Theme	Subtheme	Codes
Engaging in ICT-delivered aphasia rehabilitation	Facilitatory milieu	Challenge with self-managed therapy
		Coercion by others
		Convenience of ICT for therapy
		Face-to-face is easier
		Intensity of the research protocol
		iPad better than paper
		Opportunity to have therapy
		Support from others
		Time issues
		Working independently
		Cost
	Personal preferences	No preference for mode of rehab
		Prefer combination of face-to-face and ICT therapy
		Prefer face-to-face therapy
		Prefer ICT therapy
		Altruism
		Boredom
		Fatigue
		Frustration
		Perceived improvements and success
		Sadness
		Worry and or anxiety
Programme features	Attitudes to the programme	Indifferent to the programme
		Not in a position to recommend the programme
		Positive attitude about the programme
	Function and usability of the programme	Internet issues impact programme function
		Requesting other tasks for therapy as well
		Able to repeat tasks on the programme
		Compatibility
		Control v intervention
		Easy to use
		Levels of difficulty or challenge of tasks and number of tasks
		Motivating feedback
		Personalisation and culturally relevant
		Programme bugs
		Programme images or features causing problems
		Unsure of progress or function of programme
	Experience and Learning	Previously used the programme
		Problem solving how to answer target
The role of ICT in everyday life	ICT functions	Deciding not to use or carry ICT
		ICT facilitating compensatory strategy
		ICT for banking, online shopping or browsing
		ICT for communication, cognitive function and info
		ICT for entertainment
		ICT only used for aphasia therapy
		ICT used for work or business activities
		Most frequently used ICT device
		Portable ICT
		Positive impact of ICT
		Prefers iPad to PC
		Something to do
	Impact of stroke on ICT use	(Un)changing patterns of computer use and knowledge
		Advertisement distractions on internet
		No change or impact due to ICT in life
		Impact of aphasia e.g. spelling, WFD
		Impact of cognitive change e.g. memory, processing
		No reported cognitive issues

Not all participants worked independently at all times. Eleanor identified that she received support from family; this was particularly noted in the first phase and was less prominent in the second phase. Two other participants, John and Gerry, noted how families were important when issues arose with the programme. John experienced difficulties with the items not downloading in the programmes and when asked about what did he indicated he got support at home: *"(Uses hand to make a gesture of making a phone call) Rang my mum, yes".*

Families were either able to problem-solve these issues or contact the researcher. The support provided by families and others around the person with aphasia was highlighted by four of the participant and in particular families were noted to provide support throughout the rehabilitation process. In addition, the researcher herself was recognised by two participants as valuable support for providing guidance on the direction within therapy and identifying the tasks that were needed to be carried out. Damian considered it important that the researcher provided this level of guidance: *"but this way now is, you know, someone to tell me what I'm doing and you know you move one and see where you are you know*".

Damian also identified the need to have someone to monitor progress and guide therapy when self-administered: *"the biggest problem I suppose is, you can-, you can buy, but you-, you got no one to help you with it".*

In addition, Thomas spoke about a rehabilitation assistant that was allocated to him as part of his provision from a local voluntary agency supporting people with acquired brain injuries. He described her as "*worth a fortune*". In contrast to this support role, there was also a spectrum of support that moves towards coercion. This was indicated by two participants who spoke about their experience of family

members encouraging them to carry out the research tasks. John identified that the programme gave him something to do and he imitated his mother's voice; the interviewer probed further to establish if his mother was encouraging him to do the work and he agreed. When asked if he would do the programme without his mother's encouragement, he replied "*No chance"*.

Time was recognised by some to be both a facilitator and a barrier to ICT-delivered aphasia rehabilitation. All six participants were asked about the time commitment for the study. John reported that the recommended intensity of five hours per week was too much. Others identified that they had difficulty finding the time to complete the tasks. Damian highlighted that he was spending time on other activities and this meant less time for the programme: *"it was that hard, it was that point it was make the time to do that, I was doing so much stuff the other, my own stuff now that I, I, I wasn't making the time coz I was doing other stuff".*

John also indicated that running the research over Christmas time was an inconvenience and when asked about suggestions for improvements he responded "*January"*, indicating that he would have preferred to start the programme then. Others did not report that either time spent on the programme, nor the timing of the research, were significant issues for them and they found they could work around their schedule with little effort. John highlighted the cost of the software as an issue in relation to recommending the programme to others. This was not highlighted by others in the study, although Damian had reported he bought the intervention programme sometime prior to the study.

Using the ICT device to provide therapy allowed participants to receive speech and language therapy that they were not readily accessing prior to the study.

Damian highlighted this when asked about recommending the programme: *"ah, well, without them you have nothing".*

The use of an iPad to provide home-based therapy was also noted by John as important for him instead of using paper. He indicated that this had been an experience from prior SLT and he indicated a preference for the use of digital technology rather than paper-based activities. ICT-delivered therapy was considered convenient, both from the perspective of deciding when to carry out the tasks and also as it meant that tasks were completed under the person's own control at a time of their choosing. John indicated this when asked why he preferred ICT-delivered therapy instead of face-to-face by responding "*Fast. Done.*" This also reflected the convenience of not needing to travel for therapy as noted by Thomas.

The second subtheme explored personal responses from participants in relation to ICT-delivered therapy. As would be expected, there is variation among the participants' responses and preferences. This is noted across individuals and also within individuals over the duration of the crossover study, as can be seen in the case series data. John, who originally indicated no preference for a particular mode of intervention in Phase 1 (the intervention phase), indicated a preference for ICT in Phase 2 and during the exit interview. However, Isobel indicated a preference for ICT in Phase 1 and then went on to indicated no preference for mode of intervention in Phase 2 (the control phase) and a preference for face to face therapy during the exit interviews. In addition to the preferences for mode of intervention, participants also discussed their responses to ICT-delivered aphasia rehabilitation. All participants reported they perceived improvements or felt success after using the programmes. This was reflected in comments by participants using the control programme as well as the intervention programme. These improvements were

generally not described in detail but rather in general terms. Isobel reported "*change"* as a reason why she liked the programme during the exit interview. She also indicated her satisfaction with this change using a visual cue, indicating the change was positive. She indicated during Phase 1 (the intervention phase) that she would recommend the programme to others and when asked why she stated: *"Better. Better".* Following up on this, she was asked if the programme was making her better and she responded *"oh yeah".* During the intervention phase, Gerry reported he was *"Oh, a lot better altogether"* when asked about using the iPad but did not comment specifically on the programmes.

However, there were also reports of negative impacts such as experiencing frustration and annoyance with some of the tasks. This was often related to the images in the stimuli that made the tasks more difficult. For example, the use of sketched men in a pattern recognition task in the control programme was a source of annoyance for both Gerry and Thomas.

Three participants reported feeling bored while engaging in programme activities. Gerry reported that he gets bored after about 30 minutes working on the programme and also experiences fatigue; fatigue was reported by four participants. Gerry reported he would go to bed in the afternoon and tended to do the work on the programme in the mornings. Both John and Eleanor also experienced fatigue and noted that they would feel tired after working on the programme. Damian also reported fatigue as an issue but indicated that he often stayed up late working on his own business activities and this had a knock-on effect on his levels of tiredness the next day.

8.5.2 Programme Features

Three subthemes were identified in this theme; Attitudes to the Programme, Function and Usability of the Programme and Experience and Learning.

Participants revealed their attitudes to the programmes during the interviews. Attitudes were primarily positive and all except Eleanor indicated they would recommend the programme to others with aphasia during at least one or both phases. The reasons for recommending varied. Gerry highlighted that he would recommend the control programme because: *"it's visual, visual, visual, you forget about that name"*.

Thomas reported he enjoyed using both programmes in the exit interviews and Isobel also confirmed that she enjoyed the programmes. However, Eleanor indicated she was not in a position to recommend the programme in Phase 1 (control programme) when asked about it responding: *"I couldn't, I think because I wouldn't know there and myself"*.

Some participants indicated indifference to the programmes. When asked about the intervention programme during the exit interview John responded "*Mediocre*" and indicated that he found it acceptable while also gesturing it was neither a thumbs up nor thumbs down from him.

The function and usability of both programmes were impacted by a number of negative issues. Both John and Gerry discussed issues they experienced with images and sounds not downloading. John believed this may have been due to his broadband signal as he lived in a rural location and this was an issue with other Interact-based activities. Damian also had an issue with the compatibility of the programme and his devices. He used an iPhone, iPad and Mac computer. Although it was possible to download the intervention app onto other participants' iPads, it

would not work on his iPad. It was necessary to access the programme through the webpage on his Mac computer. He indicated this was a problem: *"Yes, it would be great to be able to use that (pointing to the visual cue of the iPad). Yes, there's a problem with that"*.

Damian also questioned the homogeneity of the tasks in the intervention programme and asked if more variety might be better for him: *"I mean with the ones I'm doing should, sh, there, about this, ehm, a bit like the same (gestures hand in a circle to indicate repeating action) almost should I do other ones or is it better doing the same ones and getting yourself better"*.

Isobel also indicated that she wanted to work on expressive output. She stated "*speech*" when asked about her preference for the mode of therapy and this was initially misunderstood in the interview to indicate the lack of face-to-face speech and language therapy services. However, later in the interview, she pointed at the keyword "*speech*" when considering future therapy and the researcher asked if she wished to improve her speech and she indicated "*yeah, yeah*". Five of the participants talked about the level of difficulty within the programmes. During the exit interviews, Thomas reported that at times tasks were too easy for him and for other tasks the levels appeared out of order in terms of difficulty: *"You see, they were good. Now, uhm, there was eh level eight, but I struggled big time with four and five. I think, No, Jesus!"*

At the exit interview, Damian reported that he didn't know if the control programme activities were helping him and indicated that the intervention programme tasks, "*they were hard*". As noted earlier, the images in the control programme were highlighted as challenging by both Gerry and Thomas. In particular, a set of images in the pattern recognition tasks illustrating sketched men

in different positions caused difficulties and Thomas identified them as "*Bastards*" in a whispered voice. However, he also indicated that he liked the challenge of the tasks. Five participants appreciated the feedback that each programme provided on their success. Thomas highlighted that he wanted to achieve 100% and repeated the tasks until he could accomplish this. Some comments regarding the reasons for liking the programmes reflected the perceived ease-of-use of the programmes. When Damian was asked about using the control programme in Phase 1, he noted: *"it's not simple but it's, it's easier to use it, that's probably that's the way, probably that's the way to say it"*.

This is also reflected in Gerry's response to the question of what he liked about the intervention programme during the second phase: *"The simplicity of it"*.

A final subtheme relates to the experience and learning gained when using the programmes. Both Damian and John had previously used the intervention programme before the study and Damian reported on the improvements in the programme since he last used it. Two participants talked about the strategies they developed in order to answer questions in the programmes. Thomas described the technique he used to complete some of the tasks in the control programme. This involved using a pen on the screen, lining it up with the stimulus images for pattern recognition tasks which were constructed with lines and different angles. He did this in order to help him to problem-solve the direction and angle of the line so as to accurately complete the tasks. Gerry also discussed how he accurately completed the intervention programme tasks by initially excluding the non-related or distantly related foils and then trying to decipher which of the two remaining images fit the initial phrase of the sentence that he continues to repeat aloud when looking at the remaining two images on the screen.

8.5.3 The Role of ICT in Everyday Life

The final theme includes two subthemes; ICT functions and the Impact of Stroke on ICT use. There were many positive reports regarding the impact of ICT on the participants' everyday lives. The most common activity provided by ICT was entertainment. All except Isobel reported using their device for some form of entertainment e.g. YouTube, Netflix etc. However, Eleanor only began to use the iPad for entertainment in the second phase when she opened YouTube and swiped through music that she was listening to, by scrolling down the suggestion list on the left side of the screen. In the first phase, she indicated that she was not using the iPad for any other activities other than the research programme. Four of the participants also indicated that their Internet-enabled iPads allowed them to search for information online, and both Isobel and Damian reported they used online banking. Thomas used his iPad to keep up to date with local and international news and indicated he very much valued the device. He highlighted websites and applications that he would use including an obituary website, TV player apps and shopping sites. He also described how he used the iPad to record upcoming meetings and events. These were recorded in the notes app rather than the diary but it was a system that he found very useful.

Damian used both speech-to-text and then text-to-speech to send and receive text messages on his iPhone. This was noted as particularly useful for him because he was trying to set up a business but his reading and writing skills had been significantly impacted by his stroke. This provided him with some independence, but he reported he can also ask his family for help when needed. He reported that he used his Mac computer at home to carry out a number of computer-based activities related to his new business venture. Gerry also used speech-to-text on both his iPad

and a desktop computer with dictation software in order to input content for online searches. ICT devices were noted to provide a variety of functions for different individuals but John also reported that using the iPad and therapy programmes provided him with an activity to occupy his time. During the first phase and final exit interview, John was asked about what was good about the programme and what did he like about it. He indicated indifference to it and when probed further he added it was an activity that he could spend time on: *"Something to do (makes a gesture of throwing hand up like a shrug)"* and when questioned further he suggested he could watch Game of Thrones instead.

John indicated that the portable nature of the iPad was a positive feature of it but also reported that he would not bring it with him to some venues as it was awkward to carry his backpack in crowds. He also indicated that he preferred the iPad to a laptop/desktop computer.

Three participants spoke about the impact of aphasia on their ability to use their ICT device for therapy or general use. Thomas noted that he mixed-up words during the intervention programme and this made it difficult for him to remember the sentence and complete the activities. Damian expressed concern about his accuracy when completing speech-to-text activities to write messages: *"The problem is though, am I actually saying what I'm saying? Sometimes I send the answer it's like, did I say the right thing I was saying to her? You know".*

Gerry also indicated that he can no longer write following his stroke so he uses speech-to-text for online searches. Five participants reported having difficulty concentrating on the programmes and in some cases, they had difficulty remembering the information. However, Isobel did not feel this was a problem for her. Damian highlighted that advertisements on websites were something he had to

ignore and he used a different browser with advertisement blocking software to avoid them. Both Damian and Gerry talked about their computer use at work before their stroke. Both used ICT devices for a variety of purposes since their stroke but in a manner that was noted to be different to their ICT-use while they worked. Thomas also reported that he didn't use computers much before his stroke and he finds his iPad is invaluable to him. If something happened to it he would need to replace it the next day "*So eh, oh I couldn't be without it [referring to his iPad]*".

8.6 Summary of Results

This research attempted to explore and answer the following research questions:

1) Is ICT-delivered aphasia rehabilitation an effective mode of rehabilitation targeting change in auditory comprehension impairments?
2) Is ICT-delivered aphasia rehabilitation perceived to provide beneficial outcomes, as perceived by people with aphasia?
3) What are participants' perceptions regarding the usability of the ICT device and software programmes?
4) What are participants' experiences of engaging in this mode of rehabilitation?

A mixed methods matrix in Table 8.8 provides an overview of these questions and related subheadings for each participant in the case series. The information probed within the matrix reflects the framework for research topics presented in Figure 7.5 (Chapter Seven). This matrix serves to combine the information gathered using the different methods applied in this study. The findings will be discussed in the next section.

Table 8.8. Mixed Methods Matrix Summary of Results

	Gains		Usability		Engagement			
Participant	Change measured on language tests (NS = not significant)	Intervention perceived as beneficial	Easy to use / level of cognitive workload	Factors that influence satisfaction	ICT as an acceptable mode of therapy	Factors that support ICT	Barriers & challenge	Role of ICT in aphasia rehabilitation
John	Medium treatment effected on e-ACT sentence and small effect on TROG (NS)	Yes	Somewhat Neutral rating of ease of use Medium workload Near independent	Convenience of mode Occupies time Increasing levels of complexity	Yes Would recommend programme Prefers ICT High usage	Under own control Family Support	Internet Stimuli not downloading Intensity	Initially indicated no preference by exit interview preferred ICT-delivered therapy
Isobel	Small treatment effect on e-ACT sentence and medium effect on TROG (NS) (P2)	Yes	Yes Positive rating of ease of use Low workload Near independent	Not specified other than perceived change and improvement	Yes Would recommend programme Prefers ICT High usage	Not specified	Reported no negative issues	Initially preferred ICT-delivered therapy but by exit interview preferred face-to-face therapy
Thomas	Small effect on e-ACT sentence (NS)	Yes	Yes Positive rating of ease of use Medium workload Near independent	Convenience The challenge of the increasing levels Motivational feedback	Yes Would recommend programme Prefers ICT High usage	Under own control	Reported no negative issues	Preferred ICT-delivered therapy
Damian	Small change on WAB AQ (NS)	Yes	Yes Positive rating of ease of use Low - Medium workload Near independent	Motivational feedback Able to repeat stimuli	Yes Would recommend programme Prefers combination of ICT and face-to-face Low usage	Remote monitoring by researcher	Unable to use his iPad for the programme Finding time in his schedule to carry out tasks	Preferred a combination of face-to-face and ICT-delivered therapy
Gerry	Medium treatment effect on TROG	Not reported in relation to intervention Reported improved iPad use	Somewhat Neutral rating of ease of use High workload Near independent	The simplicity of the programme The problem solving of the programme Immediate feedback on answers	Yes Would recommend programme Prefers combination of ICT and face-to-face Low usage	Family	Stimuli not downloading Needed to delete and reinstall app repeatedly	Preference for combined ICT-delivered & face-to-face therapy during intervention phase but preferred face-to-face at exit interview
Eleanor	No change	Yes	No Negative rating of ease of use Medium – High workload Some assistance	Not specified	No Unable to recommend programme Prefers face-to-face Low usage	Family Remote monitoring by researcher	Stimuli not downloading Needed to delete and reinstall app repeatedly	Consistently preferred face-to-face therapy

8.7 Discussion

This study provides new insights into the feasibility and acceptance of ICT-delivered rehabilitation targeting auditory comprehension impairments at sentence level. Three key research questions were posed in relation to the gains following intervention (both actual and perceived), the usability of the programme and the engagement with ICT-delivered aphasia rehabilitation targeting auditory comprehension at sentence level. These will be discussed individually.

8.7.1 Gains

Four participants were noted to make gains on spoken sentence comprehension tests following intervention (John, Isobel, Thomas and Gerry). When examining the item level accuracy scores on the e-ACT sentence level test, two participants demonstrated a small, though not statistically significant, treatment effect (Isobel and Thomas) and one demonstrated a statically significant, medium treatment effect (John) after the intervention. One participant (Gerry) demonstrated a statistically significant, medium effect of treatment as measured on item level accuracy scores on the TROG and one presented with a small effect, that was not statistically significant (John).

One participant, Isobel, presented with a small treatment effect, that was not statistically significant on both e-ACT sentences and TROG following Phase 1 (intervention phase). However she demonstrated further improvements following Phase 2 (control phase). She presented with a general cognitive impairment on the RBANS and extremely low classification on all component subtests. It may be that the control programme provided non-language, cognitive stimulation that facilitated

change in language processing skills. Alternatively, it may be a practice effect due to the repeated measures of these assessments.

There was a very strong relationship between the number of levels attempted in the intervention programme and the proportion of change as recorded by the e-ACT sentence tasks. The participants in Group 1 attempted more levels in both programmes when compared to GROUP 2 and presented with a large, though not statistically significant, treatment effect as measured on the e-ACT sentence level test and the TROG. The participants in Group 2 demonstrated a small treatment effect on the e-ACT sentences and a medium treatment effect on the TROG. However, two of the three participants in Group 2 did not present with a stable baseline on the TROG. This may have impacted on the outcomes. The sentence stimuli in the e-ACT test are also treated within the intervention programme and improvements post intervention on the e-ACT sentence level test may represent specific gains on treated items.

Group 2 were noted to present with a large treatment effect on the WAB AQ after Phase 1. This is an unusual finding as the group was allocated the control programme during this phase. However, one participant, Gerry, experienced a 13.1 point increase in WAB AQ. This has likely contributed to the large effect. Gerry's baseline measures indicated a degree of instability as noted in the case series (8.4.5).

There were no other gains in language, cognition or quality of life measures following intervention for the groups. Despite some individual improvements noted within item level analysis on the sentence processing tests our findings suggest that the current format of this ICT-delivered aphasia rehabilitation targeting auditory comprehension at sentence level may not provide favourable outcomes in terms of either clinically or statistically significant differences on aphasia outcome measures

post intervention at a group level. Further research on the therapy approach of the programme, adherence to the timing of intervention and a study with a larger sample size are indicated. It may be possible that the therapy approach used in the intervention programme is not conducive to treatment effects outside of the therapy tasks. The therapy tasks required the participants to match a target picture with a spoken sentence. This reflects a general approach to auditory comprehension therapy. Within this general approach, the therapy tasks are not informed by the levels of deficit within a language processing model, instead, therapy involves working through different types of sentence structures with increasing difficulty (Morris and Franklin, 2012). The assessments which demonstrated statistically significant change on item level analysis were outcome measures of spoken sentence comprehension. These tests involved matching a target picture with a spoken sentence, similar in format to the therapy approach in the intervention programme. It may be that the improvements noted on these outcome assessments are related to the therapy activity itself and this did not facilitate carry over to other language assessments. The programme in the study of ICT-delivered phonological training by Woodhead, et al. (2017) yielded a small treatment effect on comprehension scores of the CAT. It may be that the variety of therapy activities within their training programme facilitated this effect. Woodhead, et al. (2017) employed a software programme with six independently adaptive tasks during a 5-week treatment block where participants were asked to spend 10 hours per week on the programme. Their findings indicate a small but statistically significant effect after treatment. As noted, the outcomes in our study are not as promising; despite some individual improvements in sentence level auditory comprehension, there is no statistically significant improvement post-intervention at a group level.

The use of an eye-tracking paradigm during language assessment was intended to provide insight into the visual strategy used by the participant when completing the tasks (Bojko, 2013). There was no difference between the mean fixation duration measures among the group of typical adults and the group of participants with aphasia. Fixation duration is a measure of how long the eye stays still in a position and can provide information on the level of information-processing difficulty (Bojko, 2013; Holmqvist, et al., 2011). There was a statistically significant difference between the mean fixation count on all AOIs between the typical adults and the adults with aphasia recruited to this study. Fixation count is an indicator of search efficiency; larger fixation counts may represent less efficient search strategies (Holmqvist, et al., 2011). There was no statistically significant difference on fixation count on target AOIs between the two groups. However, there was a statistically significant difference in fixation count on non-target AOIs, with a higher mean fixation count among the participants with aphasia indicating a less efficient search strategy for non-target AOIs. There was no statistically significant change in fixation count in the group of participants with aphasia over the following two assessment periods of the crossover study. However, it must be noted that fixation count is a measure of the number of fixations in an AOI and where the test is not time controlled, as in this assessment, it may not provide a suitable comparison between or within groups as those who spend longer on tasks are likely to present with a larger number of fixations. Analysis of non-target AOIs based on error type has not been carried out.

Overall, there was a perception that the ICT-delivered programmes within this study provided beneficial outcomes, with five of the participants commenting on this and one commenting on the improvements gained from using his iPad. One

participant questioned the function of the control programme and suggested that he didn't see how this was helping him. None of the other participants reported this and this programme was received well overall. The perceived benefits contrast with the limited treatment effects that were gained following the intervention. However, this may not be surprising as reports of perceived benefits of therapy do not always accompany improved therapeutic outcomes on standardised assessments (Caute, et al., 2016).

8.7.2 Usability of the Programmes

Three participants in our study considered the programmes to be easy to use and two reported less favourable but acceptable ease of use scores. One participant indicated negative ratings with respect to ease of use and the cognitive workload involved in using the programmes. Overall, the tasks within the programmes as well as the functions required to access these had favourable usability ratings; being described as simple while providing an appropriate cognitive challenge. In other studies that explore efficiency and usability of therapeutic software programmes, participants with aphasia were generally positive about these features (Amaya, et al., 2018; Brandenburg, et al., 2017; Caute, et al., 2016; Cherney, et al., 2011; Hill and Breslin, 2016; Mallet, et al., 2016; Marshall, et al., 2018; Routhier, et al., 2016). However, frustration can occur with a particular programme feature or process (Bruce, et al., 2003; Caute, et al., 2016; Cherney, et al., 2008; Galliers, et al., 2017; Palmer, et al., 2013) and this was evident in our study; two participants highlighted their annoyance and frustration with a particular set of images in the control programme. It is interesting to note that the two participants in our study who rated ease-of-use negatively and provided the highest rating of cognitive workload were also the two oldest participants; both were 67 years of age. A strong relationship

between age and the perceived ease of use of an iPhone and app to increase talk time was identified by Brandenburg, et al. (2017) who noted that as the age of the participant increased the ease-of-use scores were rated as harder to use. However, Marshall, et al. (2016) reported that age was not found to influence the amount of time spent using their programme but noted that prior computer use was linked to greater amounts of time spent in the programme. Alternatively, individuals' perception of their age may be a barrier to Internet use and they may lack confidence in their own ability for Internet and technology use (Menger, et al., 2019). Prior experience of ICT may provide additional confidence and those with limited experience may be more likely to question their ability to engage in ICT-delivered aphasia rehabilitation (Hill and Breslin, 2016) . The two particpants in our study had prior experience of computer use, however one particpant (Isobel) reported statistically signficiant change when comparing use, frequency of use and confidence with digital tehcnologies before and after her stroke.

The convenience and autonomy of self-administered rehabilitation carried out in one's own home was identified as a factor that influenced satisfaction with this mode of rehabilitation. The independence and autonomy that computer-delivered therapy offers has been noted to be valued by people with aphasia (Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003). The provision of motivating feedback on task accuracy and overall performance during sessions were highlight as positive aspects of both the programmes in our study. The increasing complexity in tasks, as the levels increased within the programmes, was identified as beneficial to the programmes. This was also reflected in the description of problem-solving techniques that participants were using to complete the therapy tasks. However, it must be noted that the order of the complexity of the levels within one set of tasks in

the control programme caused confusion for some participants. This was because some of the earlier levels were considered more challenging than later levels. Targeting the level of complexity of tasks to suit all participants can be challenging within a computer-based rehabilitation programme. Hill and Breslin (2016) reported mixed views from participants with aphasia with respect to the grading of tasks with some reporting tasks as too difficult and others considering them too simple.

8.7.3 Engagement with the Mode of Rehabilitation

Five of the participants in this study considered ICT-delivered aphasia rehabilitation to be an acceptable form of rehabilitation and stated they would recommend the programme to other people with aphasia. The sixth participant described that she was not in a position to recommend the programme and also indicated a preference for face-to-face therapy. When asked about recommending ICT-delivered aphasia rehabilitation there is generally a strong positive response from people with aphasia to recommend the programmes or devices they are using (Amaya, et al., 2018; Cherney, et al., 2011; Marshall, et al., 2018; Wenke, et al., 2014). It is important to note that in our study, individuals withdrew during, or at the end of, Phase 1. Although the timing of the study and written content of the control programme were cited as reasons, it may also be possible that these participants did not consider this form of intervention to be acceptable. Taking into account the attrition rate, with half of those recruited to the study withdrawing either during the baseline measurement phase or Phase 1, it is prudent to consider that ICT-delivered aphasia rehabilitation may not be acceptable to all. Alternatively, it may have been the intensity of the research protocol that is reflected in this attrition rate. A minimum of five baseline measurement sessions, of approximately one-hour

duration each, were required. Spending time on ICT-delivered therapy will result in less time available for other activities (Amaya, et al., 2018; Wade, et al., 2003) and the time demand of taking part in research has been identified in other studies as a factor in participant attrition (Brandenburg, et al., 2017; Woodhead, et al., 2017). The participants in our study were asked to spend a minimum of 5 hours per week working on the programme. Unfortunately, due to a bug in the timestamp of the intervention programme, it was not possible to measure the time spent. However, taking into account the number of levels attempted throughout each phase, it is likely that participants did not spend this amount of time. What is clear is that some participants in our study identified challenges with finding time to complete the programme tasks. This appears to reflect a choice being made in terms of prioritising other activities over ICT-delivered aphasia rehabilitation. In terms of the feasibility of our study protocol, the recruitment of participants to the study was challenging at times. Potential participants were referred to the study from local health services and voluntary agencies. This meant that direct contact between the person with aphasia and the research team did not occur until the person was identified by a gatekeeper, either an SLT or a professional working within a voluntary agency that provides support to adults with acquired brain injuries. This recruitment pathway was dependent on the gatekeepers identifying participants for the referral to the study. It is interesting to note that the oldest participant was 67 years of age. It may be possible that older adults with post-stroke aphasia were not referred due to overgeneralised beliefs, or "*myths*", regarding age and digital technology use (Wandke, Sengpiel, & Sonksen, 2012). Age will be discussed later in the discussion. However, it must be noted that the recruitment rate was similar to

that of other studies exploring ICT-delivered interventions in aphasia rehabilitation (Palmer, et al., 2012).

Family members played an important supportive role facilitating ICT-delivered aphasia rehabilitation for three participants in our study. This role was essential for trouble-shooting programme bugs with two participants. Family support has been identified as an important support structure for ICT-delivered aphasia rehabilitation (Albright and Purves, 2008; Brandenburg, et al., 2017; Wade, et al., 2003) and this reflects an important facilitating condition for use and acceptance of technology (Chen and Bode, 2011; Venkatesh, et al., 2003). The support of the SLT researcher was also valued and one participant highlighted the SLT role in the remote monitoring and planning of therapy, emphasizing the challenge he would face without such support. The supportive role of the research team has been acknowledged in other studies exploring participant feedback of ICT-delivered aphasia rehabilitation (Albright and Purves, 2008; Brandenburg, et al., 2017; Marshall, et al., 2013; Wade, et al., 2003).

Feedback from participants in our study was primarily positive, however, a number of issues emerged that impacted on their experience. Occasionally in the control programme the images would not download but instead, the icon of the picture files would appear on the screen. This meant that participants could not complete the tasks accurately but could move on to the next level by repeatedly clicking on any icon. However, doing this meant that incorrect answers could be logged as it was not possible to know where the target item was positioned. There were also difficulties with downloading the files for the rehabilitation tasks in the intervention programme. In some instances, the sound file would not download. This meant that the participant could not hear the stimuli. It is only possible to

choose an answer after the sentence has played and, in these cases, it was not possible to progress in the level. It was only possible to exit the level. When returning back into the level this problem sometimes reoccurred again. In this case, the only option was to exit and then delete the downloaded file with the stimuli for that level. This required a new set of instructions and actions and was not always successful. This meant that on a number of occasions, for the final two participants, it was necessary to uninstall and then reinstall the app in order to work around this problem. This trouble-shooting required time and support from the SLT researcher. This support necessitated face-to-face contact with the person with aphasia, as highlighted in other studies of ICT-delivered aphasia rehabilitation (Brandenburg, et al., 2017). Alternatively, support with troubleshooting was provided to a family member over the phone.

Most participants saw a role for ICT-delivered aphasia rehabilitation in service provision. In some cases, this was favoured as the optimal way to engage in rehabilitation. ICT-delivered therapy was noted as convenient, quick and under the person's own control. The ability to provide more intensive and higher levels of repeated practice has been noted as an advantage of ICT-delivered rehabilitation (Hill and Breslin, 2016). However, face-to-face therapy was clearly valued when either combined with ICT-delivered therapy or as the sole mode of rehabilitation. The mix of views on the mode of rehabilitation and the value of social contact afforded by face-to-face therapy sessions reflect the findings by Palmer, et al. (2013). The combination of both face-to-face and computer-based therapy has been echoed as a desirable option for service provision (Palmer, et al., 2013; Wade, et al., 2003).

8.7.4 Limitations

The PhD researcher was involved in all stages of the research data collection and implementation for this feasibility study. This provided a single contact for participants in the event of programme issues but may have also influenced their feedback on the programmes. This is because the researcher provided the training and support as well as the outcome measurement and qualitative data collection throughout the research study. With respect to outcome measurement, all assessment sessions were audio- and video-recorded and analysed by a speech and language therapist who was blind to the phase and allocation of participants. The e-ACT battery and TROG were administered on a computer with eye-tracker, which tracked participants' responses. During the qualitative data collection sessions, the researcher reiterated that all feedback both positive and negative was welcome and important in order to provide a comprehensive overview of the experience. A sample of three interview transcripts was coded by a researcher with experience of qualitative data analysis who was not involved in the research project. After this sample coding, the two researchers discussed the codes, their meaning and definitions, and any disagreements were resolved through discussion.

There are a number of limitations with respect to the eye-tracking test design and analysis. The tests used in this research were refined from an initial test battery developed as part of a study examining auditory comprehension among typical adults carried out in 2016. In these tests, participants are presented with a set of images and an auditory sentence stimulus that matches only one image. There is a delay between the presentation of the images and the subsequent onset of the initial word of the sentence stimulus. This delay prevents meaningful analysis of initial fixation data as the participants have time to scan the images before the sentence is

heard. The software that accompanies the eye tracker provides qualitative visual analysis of gaze patterns but the data must be exported and analysed in a separate programme in order to determine the order and sequence of fixations. It is possible to see the time spent on each individual task item but there is no mechanism for exporting the time stamp data to facilitate meaningful analysis of time and variations in time spent on individual test items and the test as a whole. Finally, after the commencement of the study, it became clear that measures of pupil diameter and pupil dilation can be used to explore cognitive processing load. These could be applied in conjunction with the NASA TLX measure.

The use of effect size calculation must be accompanied with the caveat that the sample size is very small in our study. Fritz, et al. (2012) advocate the use of calculating the effect size based on the *Z* value from non-parametric statistical tests such as the Mann-Whitney and Wilcoxon tests but no reference is made to a minimum sample size. The effect size estimates obtained when dividing the *Z* value by the square root of the total sample is noted to remain independent of sample size despite the presence of the sample size in the formula. This is because the *Z* value is sensitive to sample size and dividing by a function of sample size removes the effect of sample size from the resultant effect size estimate (Fritz, et al., 2012).

Three of the participants presented with unstable baselines as measured on the TROG. The test administration instructions of the TROG indicate re-administration should not be carried out within 9 months of initial testing (Bishop, 2003). The re-administration within 5 weeks may have impacted on the baseline stability for three participants. However, this assessment has been used in other studies as both a control measure (Waldron, Whitworth, & Howard, 2011) and an outcome measure (Salis, 2012) before and following treatment of 11 and 13 weeks,

respectively. It must be noted that one of these participants (Gerry) also presented with a clinically significant change on the WAB AQ after Phase 1. He was allocated the control programme during this phase. He presents with post-stroke epilepsy and perhaps this is a reason for the variation in these scores. A second participant (Damian) attended speech and language therapy after the initial set of baselines were completed and when he returned there was a statistically significant difference in his TROG scores but no other indications of change after his block of therapy.

Finally, the participants in this study were not advised which programme they were allocated in either of the phases of research in order to ensure that they were blind to the intervention. For this reason, the nature of the programme was not highlighted in the interviews and the analysis of the data was completed with all data sets rather than separating the control and intervention phase data sets. This was necessary as the final exit interview discussed the programmes in general and the nature of the intervention programme was not discussed. Only one participant highlighted the control programme and questioned its benefits. Therefore, the findings in this study refer to both programmes including in this ICT-delivered aphasia rehabilitation research and not just the intervention programme.

8.7.5 Future work

It is possible to further refine the parameters of the eye-tracking data. This would allow the data to be filtered with respect to the timing of sentence onset and sentence type. In doing so it would be possible to identify if patterns exist in scan paths depending on sentence type. It would also facilitate analysis of non-target fixations based on error type e.g. grammatical, phonological, lexical or irrelevant items. It is also possible to export the eye-tracking data to establish the pupil size and the order of fixations by using additional programming languages. These

activities do not provide additional supporting information with respect to answering the current PhD research questions. For this reason, they have not yet been carried out and are planned for future work (see Chapter 10).

8.8 Conclusion

Four of the six participants who completed the study presented with small and medium treatment effects on analysis of item level accuracy on outcome measures related to auditory sentence processing. Two of these effects were statistically significant. These outcome measures reflect the therapeutic approach which involves matching a picture to a spoken sentence stimulus. There were no clinically or statistically significant outcomes in other measures of language, cognition or well-being following the intervention. The findings of this study suggest that the intervention programme implementing a general approach to auditory comprehension therapy does not result in a clinical or statistically significant treatment effect at group level when administered in its current format. However, due to the small sample size of the study, conclusions with respect to programme efficacy are not yet possible. Self-administered aphasia rehabilitation may be an acceptable mode of intervention but consideration must be given to supports required, remote monitoring of progress, adherence and individual preferences for therapy. The feasibility of self-administered ICT-delivered aphasia rehabilitation for auditory comprehension deficits is not yet clearly answered and further research is indicated.

8.9 Chapter Summary

This chapter provided information on the feasibility study, which was completed as part of Research Strand Three. This mixed methods case series

employed a crossover research design in order to determine the feasibility of an ICT-delivered aphasia rehabilitation programme targeting auditory comprehension impairment. The outcomes of the two groups (intervention/control and control/intervention) were presented to examine within-group differences after each phase. This was followed by a case series examining outcomes as well as the usage and acceptance of ICT-delivered aphasia rehabilitation targeting auditory language impairments at sentence level. All the findings were summarised within a mixed methods matrix to provide answers to the research questions posed in this study. The findings suggest that a general approach to auditory comprehension therapy does not result in a clinical or statistically significant treatment effect at group level when administered in its current format. ICT-delivered aphasia rehabilitation may be acceptable to people with aphasia but face-to-face therapy sessions are also valued and individual preferences should be considered when planning rehabilitation.

Chapter Nine

Chapter Nine – Discussion of Research Findings

9.1 Introduction to Chapter

This chapter provides a summary of the findings of the research presented in the three research strands within this thesis (9.2). It outlines the application of these findings (9.3) and discusses the strengths and limitations of the research (9.4). The chapter considers the role of the researcher within the research process (9.5) and provides a critical analysis of the contribution of the findings (9.7). Finally, the clinical implications for the Irish health context are outlined (9.8) and a concluding statement is provided (9.9).

9.2 Summary of Main Findings

This research set out to explore the perspectives of ICT-delivered aphasia rehabilitation among two groups of stakeholders: the person with aphasia (PwA) and speech and language therapists (SLTs). In order to achieve these aims it was necessary to employ a mixed methods approach within the research process. Three literature reviews informed the three empirical studies that encompassed the three research strands.

The first integrative literature review (Research Strand One, Chapter Two) sought to identify the current, available research exploring the views of SLTs with respect to acceptance and usage of ICT-delivered aphasia rehabilitation. In doing so it aimed to identify the barriers, facilitators and issues emerging with respect to this mode of aphasia rehabilitation. Ten studies met the inclusion criteria for this review and these included both quantitative and qualitative research designs. However, the description of the research methods employed was limited in some of the studies. Reflecting the findings of this review against the Unified Theory of Acceptance and

Use of Technology (UTAUT) indicated that facilitating conditions are frequently cited as significant factors that impact on SLTs' decisions to introduce ICT in aphasia rehabilitation. These include factors such as training, time constraints, support systems and relationships and system flexibility. In addition, a number of personal features related to the individual with aphasia e.g. cognition, visual and auditory skills and ICT skills were also reported as factors. These reflect the construct of effort expectancy. The review identified that ICT-delivered aphasia rehabilitation may be acceptable to SLTs as a mode of rehabilitation. It also highlighted that little research has been carried out on this phenomenon and that further research was indicated.

The views of SLTs, with respect to ICT-delivered aphasia rehabilitation, were explored in a qualitative study employing thematic analysis (Research Strand One, Chapter Three). The integrative review of SLTs' perspectives of ICT-delivered aphasia rehabilitation (Chapter Two) highlighted the limited attention being paid to this topic in peer-reviewed research. SLTs (n=15) were recruited from a range of clinical settings in the Republic of Ireland and invited to participate in one of four focus groups. Four key themes were identified within the focus group discussions: 1) Infrastructure, Resources and Support, 2) SLT Beliefs, Biases and Influencers, 3) Function & Fit for Purpose?, and 4) ICT and Living Successfully with Aphasia. The SLTs discussed a wide variety of factors that influence their decisions to introduce ICT in aphasia rehabilitation including the abilities and skills of the PwA, the confidence and knowledge of the SLTs, the availability of support and ICT access in the rehabilitation environment and ICT programme features. There is a positive perception of the potential benefits of using ICT devices in rehabilitation and in functional everyday communication. However, this is also accompanied by the

perception that there are many barriers currently preventing easy implementation of this mode of rehabilitation.

The second literature review was carried out using restricted systematic review methods (Research Strand Two, Chapter Four). This literature review aimed to investigate the usability, feasibility and acceptance of ICT-delivered aphasia rehabilitation from the perspective of the ICT-user with aphasia. All research designs that recorded self-reported feedback from people with aphasia engaging in ICT-delivered aphasia rehabilitation were included in the review. Studies of synchronous telerehabilitation and therapy targeted at a compensatory level e.g. alternative and augmentative communication systems were excluded. Seventeen studies met the inclusion criteria including studies with quantitative, qualitative and mixed-methods research designs. The results were categorised under three headings: perceived gains, usability and engagement with the mode of rehabilitation. The findings indicate that ICT-delivered aphasia rehabilitation is considered an acceptable mode of rehabilitation by people with aphasia who reported generally positive feedback, though variation among personal perspectives and experience was noted. This review highlighted that there was no consensus measure of self-reported feedback in ICT-delivered aphasia rehabilitation and limited consideration of human-computer interaction theories within the research designs and summaries of findings.

The literature review completed as part of Research Strand Two (Chapter Four) highlighted the need for a comprehensive data gathering approach when exploring participants' perspectives of ICT-delivered aphasia rehabilitation and noted that no consensus measure is currently being used. This prompted the co-design research process that resulted in the development of an ICT Feedback

Questionnaire (Research Strand Two, Chapter Five). Using public patient involvement (PPI) in health research, a co-design process was employed throughout 6 workshops. Six people with aphasia, with a range of aphasia severities, collaborated with the PhD researcher in the co-design process. The final product, an online user feedback questionnaire, was developed. This ICT feedback questionnaire provides an outcome measure that investigates: cognitive workload, satisfaction, programme functionality and ease of use, as well as the level of assistance required when engaging in ICT-delivered aphasia rehabilitation. The questionnaire was combined with structured observations, interviews, and usage data as part of the feasibility study investigating ICT-delivered aphasia rehabilitation targeting auditory comprehension impairments at sentence level (Research Strand Three, Chapters Seven and Eight). This combination of data collection methods provides insight into the participants' perspectives of engaging with this mode of rehabilitation.

The final literature review (Research Strand Three, Chapter Six) was also carried out using restricted systematic review methods. The aim of this review was to synthesise the available evidence investigating the efficacy of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment. Two studies met the inclusion criteria for the review. A single randomised control trial provided good quality evidence to support a small effect on spoken comprehension using a self-administered programme of phonological training when compared to no training (Woodhead, et al., 2017). A case-controlled research design provided weak evidence to suggest that some participants may experience improvements in auditory comprehension at sentence level after ICT-delivered aphasia rehabilitation in a clinical setting (Zakariás, et al., 2016). However, it must be noted that the quality of

the study methods was poor. The findings highlighted the paucity of evidence for ICT-delivered aphasia rehabilitation targeting auditory comprehension. This is in contrast to available evidence supporting ICT-delivered anomia rehabilitation and other expressive language impairments.

The final empirical study sought to investigate the feasibility of an ICT-delivered aphasia rehabilitation programme targeting auditory comprehension at sentence level (Research Strand Three, Chapters Seven and Eight). A case series experimental two-phase crossover treatment design was employed which compared a self-administered aphasia software rehabilitation programme, targeting auditory language comprehension at sentence level, with a self-administered control programme not targeting language. This multiple baseline design included random allocation to phase. Each 6-week phase was separated by a 4-week washout period and follow up measures were gathered at 4 and 16 weeks after the second phase. Both quantitative and qualitative data was gathered including language, cognitive and quality of life measures as well as observations, interviews and questionnaire data developed for the study. Eye-tracking methodology was also employed; this data provided a novel insight into the visual search strategy and engagement of participants when completing computer-based auditory comprehension assessments. Twelve people with aphasia were recruited to the study. Six participants with a median age of 54.5 (range=32-67 years), median time post-stroke of 6.17 years (range=3-8years) and WAB AQ mean of 54.2 (SD=26.0) completed both phases of the research and provided feedback on their experiences. There was variation noted with respect to participants' adherence to the programme recommendations, their ratings of the levels of support required, ease of use and cognitive workload and preference for mode of intervention. There was also variation in participant outcome

measures with two of the six participants presenting with statistically significant treatment effects on item analysis of sentence comprehension tests with test tasks presented in a similar format to the therapy tasks. There was no change in other outcomes measuring language and cognitive skills or self-reported quality of life and no statistically significant change in outcomes after either therapy or control programme phases at a group level. There was a generally positive attitude towards ICT-delivered aphasia rehabilitation among most participants but the role of face-to-face contact within therapy sessions remained highly valued. Self-administered aphasia rehabilitation may be an acceptable mode of intervention but consideration must be given to supports required, remote monitoring of progress, adherence and individual preferences for therapy. Due to the small sample size, conclusions with respect to programme efficacy are not possible. However, in its current format the ICT-delivered aphasia rehabilitation carried out in our study may not provide sufficient clinical effects outside of the treated task approach. The format, saliency and therapeutic approach of the programme should be further explored.

9.3 Application of the Findings

The findings of this research are limited to the context of the Irish health service and the people with aphasia living in the Munster region of Ireland. By the nature of the research design and the small sample size of the feasibility study (Research Strand Three), it is not possible to generalise these findings. However, it must be noted that the feasibility study was conducted in a rigorous manner to ensure transparency and credibility of the findings. These findings may provide some insight into the potential issues for people with aphasia who wish to engage in ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment at sentence level. The variation among the participants' perspectives of engaging in

this mode of rehabilitation indicates that this may be a very personal choice for individuals and therefore, barriers and facilitators unique to each individual must be considered. One way of doing this is to use the UTAUT to frame potential issues what may influence acceptance and use of ICT in aphasia rehabilitation. This can be from both the clinicians' and the patients' perspectives. The factors within the UTAUT may vary depending on the stakeholder group e.g. people with aphasia or SLTs and they also may vary depending on each individual within that stakeholder group. Table 9.1 provides a convergence coding matrix to highlight the issues for the two groups under the UTAUT framework. These factors are discussed further with respect to variations and commonalities between the groups.

Table 9.1. Convergence Coding Matrix of Stakeholder Groups Reflecting the UTAUT

	Person with Aphasia (PwA)	Speech and Language Therapist (SLT)	Conclusion
Facilitating Conditions			
Support	Family SLT	IT Multidisciplinary Team Family SLT assistants Specialist SLT with IT skills	Support, from a variety of sources, identified as an important facilitating factor
Training	NR	For PwA For SLTs	Identified by SLTs only as an important facilitating factor for SLTs and PwA
Access/availability of ICT & software	NR	Access to devices and software Availability of suitable/targeted programmes Quality of programmes	Identified by SLTs only as a potential barrier
Cost	Noted by one participant NR	Cost Licences	May act as a barrier for both SLTs and PwA
Social Influence			
Family	Important role for some Bordering on coercion (2 PwA)	Important role Challenge of expectations	Family role is very important but must also be tempered with level of expectation
Effort Expectancy			
Time	Choices/priorities	Seen as a challenge with respect to upskilling and keeping up to date	Identified as a barrier by both groups, may actually reflect prioritisation of time and time choices

	Person with Aphasia (PwA)	Speech and Language Therapist (SLT)	Conclusion
Convenience	No need to travel		Identified by PwA only as a benefit of self-administered therapy
Independence and autonomy	Primarily positive perspective of independent practice in the feasibility study Generally self-administered with some support when needed	Saw a role for independent practice Questioned the feasibility of self-managed therapy	Independent practice seen as a benefit by both groups but SLTs questioned if self-managed therapy is feasible and in the same vein PwA also value the support provided by remote monitoring
Performance Expectation			
Targeted tasks	Some indicated a preference for a wider variety of tasks	Perception that suitable on-target, personalised therapy isn't easily found in existing programmes	A potential barrier to usage and acceptance of ICT-delivered aphasia rehabilitation
Feedback	Enjoyed motivating feedback and summary feedback	Positive about the potential for motivating feedback	A facilitator for ICT-delivered aphasia rehabilitation
Age	Small study Interesting to note that the two oldest participants reported the least favourable ease-of-use scores and highest workload	Bias noted with respect to age and impact of it on ICT usage and skills	Difficult to conclude on these findings but the perception of age may be a barrier rather than age itself
Gender	Not relevant due to sample size	Not reported	No conclusions
Prior Experience	All had some experience of ICT	Perception that prior experience is beneficial for both SLTs and PwA	Difficult to conclude but suggests that prior experience may be a facilitating factor

	Person with Aphasia (PwA)	Speech and Language Therapist (SLT)	Conclusion
Voluntary nature	Participants could decide when to carryout tasks and it appears that recommendations for intensive therapy may not be met when under voluntary control	Not relevant	Identified within the group of PwA only. When the decision to engage or not in ICT-delivered therapy is under one's own control some will and some will not
***Face-to-Face versus ICT-delivered therapy**	All, except one participant, saw a role for ICT-delivered therapy. Many in conjunction with face-to-face therapy and remotely monitored	ICT as an adjunct to face-to-face therapy	The role of face-to-face therapy is valued in conjunction with ICT-delivered therapy where appropriate

**Not included in UTAUT as it compares a technology-based and face-to-face modes of intervention but is relevant to the research aims of this research*

9.3.1 The Variation Between the two Stakeholder Groups

A number of different perspectives emerged within the two stakeholder groups. In Research Strand One (Chapter Three), the SLTs identified resources such as training, access to and availability of suitable ICT devices and programmes as barriers to the introduction of ICT-delivered aphasia rehabilitation. With respect to training, they identified the need for training for themselves and also for the PwA. The latter was perceived to require increased clinical time and the SLTs questioned their role in this process. Training has been identified as an important factor for SLTs engaging in ICT-delivered aphasia rehabilitation (Burke, et al., 2017) and when provided it is considered beneficial by SLTs (Hill and Breslin, 2016).

For the people with aphasia in Research Strand Three (Chapter Eight), the convenience of self-administered ICT-delivered therapy under one's own control is an important advantage of this mode of rehabilitation. The independence and autonomy that computer-delivered therapy offers has been valued by participants in studies of this mode of rehabilitation (Palmer, et al., 2013; Routhier, et al., 2016; Wade, et al., 2003) but as in our study this is valued under the assumption that the therapy is monitored by an SLT (Wade, et al., 2003). An alternative view of independent practice under one's own control is that people with aphasia then have the choice to engage or not engage with this mode of intervention. Although there was an issue with the time stamp preventing the gathering of usage data in our feasibility study, the differences in the number of levels attempted would suggest there was variation in the amount of usage and it is likely that some participants may not have spent the time that was asked of them. Variations in usage have been noted in studies of ICT-delivered aphasia rehabilitation (Galliers, et al., 2017; Mallet, et al., 2016; Palmer, et al., 2013) and in a study by (Marshall, et al., 2016) usage was not

affected by age or gender but interestingly it was affected by prior computer use. This may reflect existing ICT skills and associated confidence in one's own ability when using ICT or it may reflect a personal choice about spending time on these tasks.

9.3.2 The Commonality between the Two Stakeholder Groups

An important facilitating factor that emerged among both stakeholder groups is the provision of support to engage in ICT-delivered aphasia rehabilitation. The types of optimum support differed between the groups. In Research Strand One (Chapter Three), the SLTs identified the support for themselves as clinicians within the service in which they worked. This support was provided by other members of the multidisciplinary team as well as the potential for support from SLT assistants. The role of ICT support, dedicated to rehabilitation rather than systems-level ICT, was highlighted. They also envisaged an optimum service provision from a specialist SLT with skills in ICT use in clinical practice. The relationship with ICT support and the lack of technical support have been identified as important factors for ICT-delivered rehabilitation (Burke, et al., 2017; Chen and Bode, 2011). The SLTs also identified the role of the family in providing support as an important factor and this is reflected in the feedback from the participants with aphasia (Chapter Eight). The availability of support for the PwA engaging in ICT-delivered aphasia rehabilitation has been noted as a key facilitating factor (Burke, et al., 2017; Chen and Bode, 2011; Hill and Breslin, 2016). Family support has been rated as very important with a lack of family encouragement noted as a barrier to introducing ICT in rehabilitation (Benedon, 2018; Chen and Bode, 2011). However, it is also important to balance family expectation against potential gains expected in ICT-delivered aphasia rehabilitation.

Time was identified by both groups of stakeholders as an issue for the introduction and or engagement with ICT-delivered aphasia rehabilitation. In Research Strand Three (Chapter Eight), some of the participants with aphasia discussed challenges with finding time to work on the programme while others reported how they set aside the time that they considered was best for them to carry out the tasks. The SLTs in Research Strand One (Chapter Three), identified time constraints as an issue for their own upskilling and also as an issue for the implementation of ICT-delivered aphasia rehabilitation in clinical sessions. Time and the issue of time spent on rehabilitation as a choice of time away from other activities has been reported by people with aphasia in other studies of ICT-delivered aphasia rehabilitation (Amaya, et al., 2018; Wade, et al., 2003). Time has been identified as a potential barrier to ICT use for the SLTs, this included the time required to train, set up and oversee ICT-delivered aphasia rehabilitation (Burke, et al., 2017; Hill and Breslin, 2016; Sobel, et al., 2000). However, ICT-delivered aphasia rehabilitation was also viewed as efficient use of SLT time and the time spent with the initial set up was identified as a key investment once up and running (Burke, et al., 2017; Hill and Breslin, 2016; Sobel, et al., 2000). This latter benefit was not identified by the SLTs in Research Strand One (Chapter Three).

The availability of programmes to provide suitable, relevant therapy tasks was questioned by the SLTs in Research Strand One (Chapter Three). Programmes need to provide appropriate feedback for the person's age, background and culture (Swales, et al., 2016) as well as include therapy activities with a large bank of tasks with flexible levels of difficulty including sufficiently high level language tasks (Hill and Breslin, 2016; Schröder, et al., 2007; Swales, et al., 2016) and the ability to personalise tasks for the PwA (Burke, et al., 2017; Hill and Breslin, 2016). The

SLTs in Research Strand One (Chapter Three) perceived that many of the currently available programmes don't fit their patients' needs. Although the participants with aphasia in Research Strand Three (Chapter Eight) identified that the increasing levels and resultant increasing complexity of tasks were positive features of the programmes, some questioned the homogeneity of the programme tasks and asked if a greater variety of tasks would be more beneficial for them. The provision of motivating feedback and progress feedback is considered a key facilitator for ICT-delivered aphasia rehabilitation by both stakeholder groups (Burke, et al., 2017; Gunning, et al., 2017).

The SLTs in Research Strand One (Chapter Three) identified the potential for ICT as an adjunct to face-to-face therapy but strongly valued the face-to-face contact from traditional therapeutic sessions. Face-to-face contact was considered an important factor by SLTs before beginning ICT-delivered aphasia rehabilitation (Hill and Breslin, 2016). SLTs have identified the need for a larger variety of prompts and cueing within therapeutic software programmes to reflect what happens in face-to-face SLT sessions (Swales, et al., 2016). The participants with aphasia in Research Strand Three (Chapter Eight) also valued the support of the SLT. Although two preferred ICT-delivered aphasia rehabilitation, there was a clear appreciation of the role of face-to-face sessions in combination with ICT-delivered rehabilitation or on their own. The combination of both face-to-face and computer therapy has been highlighted as a desirable option for aphasia rehabilitation (Palmer, et al., 2013; Wade, et al., 2003).

Finally, the SLTs in Research Strand One (Chapter Three) identified their own ICT skills and indeed the ICT skills of the PwA as potential barriers when considering ICT-delivered aphasia rehabilitation. The people with aphasia in

Research Strand Three (Chapter Eight) all owned an Internet-enabled device. Their use and experiences of these devices varied, but it is possible to suggest that they may not be representative of the population of adults with aphasia in Ireland. Prior ICT experience has not been shown to be a barrier to ICT-delivered aphasia rehabilitation (Marshall, et al., 2013; Palmer, et al., 2013) but has been shown to influence the time spent using the programme (Marshall, et al., 2016).

9.3.3 The UTAUT Model as a Framework for Examining Acceptance and Usage

The findings as noted under the UTAUT model in Table 9.1 provide an overview of the constructs that were highlighted to impact on acceptance and usage of ICT-delivered aphasia rehabilitation within the two groups investigated in this research. Performance expectancy has been identified as the strongest predictor of intention to use technology. The SLTs identified the limited availability of suitable programmes that provide targeted therapy for individual needs as a substantial barrier to the implementation of ICT-delivered aphasia rehabilitation. This strongly reflects the performance expectancy construct with respect to obtaining gains from the programme in therapy. If the programme is not targeted to the individual's needs then it is considered unlikely to provide those gains. The group of adults with aphasia also identified aspects of the programme that reflect the performance expectancy construct. Some questioned the lack of variety of tasks and this may have been due to queries regarding the function and perceived benefit of the repetitive tasks. On the other hand, many reported that the provision of motivational feedback was a positive feature of the programme, allowing them to see their progress. However, there was a greater emphasis on aspects of ICT-delivered aphasia rehabilitation that reflect the effort expectancy construct for this group. The

ability to independently practice in the convenience of their own home was highlighted by some. Some identified the conflict of wanting to spend time working on the programme and then finding or prioritising the time to do this. Time was also an issue for the SLTs in terms of upskilling, keeping up to date with available programmes and resources and spending time within sessions introducing and setting up ICT-delivered rehabilitation. These all reflect the effort expectancy construct. The social influence construct was not echoed as strongly as the other constructs. Some of the participants with aphasia highlighted the influence of family in their participation within the research and the therapy activities. The importance of the family role was emphasised by the SLTs but this is likely to reflect a facilitating condition rather than a social influence. Indeed, it is this construct that appears to represent the largest number of facilitators and barriers identified by both groups. In particular, the support from others was identified as a key facilitating condition. For the PwA, this represents the support by family at home and the support and guidance provided by the SLT during the rehabilitation journey. For the SLT, this represents the professional support of their own colleagues, the members of the multidisciplinary team and the technical support from ICT departments to facilitate ICT-delivered aphasia rehabilitation. Certainly, for the SLTs, the facilitating conditions are perceived to be key enablers if present but currently appear to represent barriers. Limited access to resources, training and funding were all cited as challenges for the implementation of ICT-delivered aphasia rehabilitation.

9.4 Limitations and Strengths of the Research Design

9.4.1 Limitations

This research employed a mixed methods research design to explore stakeholders' perspectives of ICT-delivered aphasia rehabilitation. Two key groups of stakeholders were identified: the PwA and the SLTs who work with them. Attention to this topic is emerging within the research field but is primarily focused on the views of the PwA. As there is little available research on SLTs' views of ICT-delivered aphasia rehabilitation, a qualitative research approach with thematic analysis was considered the most appropriate research design to explore this topic. As with all qualitative research, the question of generalisation is problematic and the findings reflect the views of a particular set of SLTs. These clinicians were not working with the participants who were recruited to Research Strand Three. Therefore, combining these results may not reflect a cohesive study but rather provide insights from two associated but unrelated groups.

Building on the existing research and taking into account the limited attention with respect to ICT-delivered therapy for auditory comprehension impairment, Research Strand Three provides evidence on participants' perspectives of this mode of intervention. The participants in this study were 67 years of age or younger and were already using Internet-enabled ICT devices. Therefore, they may not be representative of the general population of people with aphasia in Ireland. However, as there is no available data to inform the incidence and prevalence of aphasia within an Irish context, it is not possible to identify the extent of this variation. The PhD researcher played a key role in the assessment and subsequent management of the ICT-delivered aphasia rehabilitation. It is, therefore, reasonable to assume that participants may be less likely to provide negative feedback. This has previously

been highlighted by Cherney et al. (2011). However, combining information from observations, questionnaires and semi-structured interview data collection methods provide a more comprehensive overview of participant experience. Finally, the small sample size in both studies limits the strength of the conclusions of each as well as the combined findings of the two studies. This is reflected in the conclusions.

9.4.2 Strengths

A key strength in this research is the implementation of a mixed methods design to establish the stakeholders' perspectives of ICT-delivered aphasia rehabilitation. This pragmatic approach to the research provides a broad overview of the research topic of interest. The limited available research exploring SLTs' views of ICT-delivered aphasia rehabilitation meant that a qualitative research design provided an in-depth exploration of the views and factors that SLTs consider when implementing ICT-delivered aphasia rehabilitation (Research Strand One). Within Research Strand Two the co-design of the ICT Feedback Questionnaire facilitated the development of a meaningful and relevant questionnaire that explores the usability, functionality and cognitive workload of the ICT-based programme in (Chapter Five). This questionnaire combined with structured observations and semi-structured interviews provided a comprehensive overview of the experience of engaging in ICT-delivered aphasia rehabilitation (Research Strand Three).

The feasibility study (Research Strand Three, Chapter Seven and Eight) investigated not only the efficacy of the intervention programme but also the participants' experiences of engaging in this form of intervention. The crossover study design provided a robust methodology to evaluate the intervention programme. The validity of the study design was greatly enhanced by the use of the computer-

generated list for random allocation to phase which was carried out by an individual not involved with the research. The participants were blind to the nature of the programme in each phase and the control programme was developed so as to mirror the intervention programme in terms of format and interface (described in Chapter Seven). Although the outcome assessor was not blind to the phase allocation, the assessments were video recorded and once all were completed, they were presented in random order and analysed by an experienced SLT who was blind to the phase of research.

9.5 The Role of the Researcher

Ethical approval for Research Strands Two and Three which both involved people with aphasia was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospital. It was important to ensure that information was accessible for people with aphasia. It was also important to ensure that participants had time and were supported when reading through the document and given the opportunity to ask questions. Information was written in an aphasia-accessible format (NIHR, 2014). The co-design study (Research Strand Two) differed to the feasibility study (Research Strand Three) in terms of participants' roles and the expectations for the process. Within the feasibility study, the intervention provided was similar to the clinical treatment that people will receive as part of speech and language therapy, albeit through the mode of software programmes and ICT devices. This meant it was similar in some way to the traditional face-to-face therapy sessions that people would be familiar with, but differed in the mode of delivery. It was supported by the PhD researcher, who was an experienced SLT, and this further re-enforced this familiar dynamic of the SLT providing support and guidance through the rehabilitation process. However, the co-design research was different in that it

involved people with aphasia as collaborative partners in the participatory research process. This changed the role of the SLT from one of professional support to that of facilitator and co-designer collaborating with co-designers with aphasia. This was a new challenge for the researcher. She had previously worked with adults with aphasia in her clinical and practice education roles. Although the latter role involved working collaboratively with adults with aphasia in the provision of a conversation partner scheme for student SLTs, this scheme was managed and overseen by the researcher adhering to the curriculum of the University programme. The co-design process was somewhat different as it was built on a shared, collaborative approach where all members of the group hold equal power and collectively the group determines the direction of the design. The researcher realised the need for a careful balance of roles and repeatedly journaled about this dilemma. This balance involved guiding the initial co-design development, so as to follow the research goal, while also relinquishing control in a manner that allowed the co-design process to grow and facilitate the questionnaire development. Constant reflexivity was needed to ensure this balance. This was in stark contrast with the subsequent research role in the feasibility study. Here, the researcher balanced the roles of outcome assessor, programme manager and data collector for feedback on the mode of intervention within the study. This involved a shift away from the participatory paradigm and a realisation that the pragmatic paradigm was guiding the research. Here, the methods chosen reflect the questions being asked throughout the research process. Pragmatic researchers can be flexible in their investigative techniques when attempting to answer a range of research questions that may arise (Onwuegbuzie and Leech, 2005). As a pragmatic researcher, it was possible to work back and forth between various frames of reference. In doing this the relationship of the researcher and the research

process, as being something either objective or subjective, was considered an artificial dichotomy (Morgan, 2007).

9.6 Challenges Experienced during the Research Process

A number of challenges emerged during the research process. The feasibility study in Research Strand Three employed a crossover design and two software programmes (a commercially available intervention programme and a control programme) were used. The original intervention programme was accessed through a webpage. During planning for the feasibility study, this programme was being developed as an app for iPad with a larger volume of therapy tasks. However, this process was significantly delayed and this impacted on the timeline for recruitment of participants to the study until the app was available. Similarly, the development of the control programme was also delayed. It was originally planned for development as part of a computer science student project in 2016 but the product was not usable at that time. Instead, a Computer Science student, in collaboration with the research team, developed the programme in 2017 as part of her final year project.

With hindsight, the allocation of funding to employ a researcher with programming and HCI skills could have provided valuable support to the team. This individual could have developed the control programme and provided additional support during the feasibility study. Similarly, it would have been beneficial to employ an SLT as a research assistant and blind assessor in the feasibility study.

9.7 Critical Analysis of the Overall Contribution of the Research

In spite of the limitations highlighted above, the three literature reviews and three empirical studies make an original contribution to knowledge development.

The first integrative review (Chapter Two) examined the perspectives of SLTs engaging in ICT-delivered aphasia rehabilitation. The comprehensiveness of the review was limited by the paucity of research on this topic and the quality of the available evidence. However, the findings indicate that ICT-delivered aphasia rehabilitation may be acceptable to SLTs as a mode of rehabilitation and identified a variety of factors that influence their decision to introduce it. The second literature review (Chapter Four) which employed restricted systematic review principles provided a comprehensive insight into the feedback from people with aphasia when engaging in ICT-delivered aphasia rehabilitation. The findings of the review were categorised into three areas: perceived gains, usability and engagement with the mode of rehabilitation. The review also highlighted the benefits of interdisciplinary research, combining researchers from speech and language therapy and Human-Computer Interaction backgrounds in order to provide a more holistic, comprehensive overview of the experience of engaging in ICT-delivered aphasia rehabilitation. The third literature review (Chapter Six) reported the limited attention paid to ICT-delivered aphasia rehabilitation for auditory comprehension impairments. This is in stark contrast to the growing research base for ICT-delivered therapies targeting expressive language impairments (Lavoie, et al., 2017; Zheng, et al., 2016).

The three literature reviews helped to guide the subsequent empirical research that sought to examine stakeholders' feedback on ICT-delivered aphasia rehabilitation. In order to investigate this from the perspective of adults with aphasia, it was necessary to collect data with a variety of methods including questionnaire, semi-structured interviews and observations. The co-design of the ICT Feedback Questionnaire (Chapter Five) was a health participatory research

activity that brought people with aphasia and the researcher together in the collaborative development of an ICT Feedback Questionnaire. To the author's knowledge, this is the first co-design measure available for use in planning or monitoring ICT-delivered aphasia rehabilitation. It provided a mechanism for gathering feedback from participants in the feasibility study (Chapter Seven and Eight) in conjunction with semi-structured interviews and structured observations. This mixed methods approach provides new insight into participants' perspectives of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment. This is the first study to examine participants' perspective on this particular therapy approach. The findings suggest that although this therapy approach does not yield a significant treatment effect, participants hold a positive view of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment but individual variation is noted. Finally, the qualitative study of SLTs' perspectives of ICT-delivered aphasia rehabilitation (Chapter Three) is the first in-depth analysis of therapists' views of this mode of rehabilitation in Ireland. The study highlighted that despite openness to using ICT-delivered aphasia rehabilitation in practice there are significant barriers for many SLTs who wish to implement this mode of intervention.

9.8 Implications for Research, Practice and Policy

9.8.1 Implications for Research

This research provides a rationale for collaborating with people with aphasia in Research Strand Two in the development of a questionnaire for use by people with aphasia in Research Strand Three. People with aphasia can, and should, be included in all stages of the aphasia research process and especially in the development and design of evaluation measures for use by people with aphasia. Future developments

should consider a co-design process with collaborative involvement of people with aphasia who bring their lived experiences of aphasia to the design process.

The intervention programme in Research Strand Three did not yield clinically significant outcomes, although individual variation and benefits were noted. The adherence to the requested level of usage, the challenges with programme bugs and the therapeutic approach itself may have influenced this outcome. The latter may have benefited from a broader range of therapeutic activities comparable to the programme in the study by Woodhead, et al (2017) which resulted in a small but statistically significant outcome for participants. Investigating the effect of combined therapy approaches may present a challenge when developing a research design but indeed a crossover study with single and combined approaches in alternating phases may provide a solution.

9.8.2 Implications for Practice

The co-design of the ICT Feedback Questionnaire provided a mechanism for gathering relevant and meaningful feedback as reported by people with aphasia who engaged in ICT-delivered aphasia rehabilitation. Although psychometric testing of the questionnaire is required, it has the potential to be used in planning and monitoring ICT-delivered aphasia rehabilitation following further testing. As perceived gains may not always reflect therapeutic outcomes it is important to monitor both of these aspects of ICT-delivered aphasia rehabilitation and the feedback questionnaire may provide a mechanism for this. Due to the small sample size and limited treatment effect of the intervention programme in Research Strand Three, it is not possible to currently recommend this programme as a self-administered ICT-delivered therapy. However, the use of ICT devices and programmes to provide independent home practice was valued by the participants in

this study and this should be considered as an option for individuals who are motivated and open to this. This is under the assumption that home practice is remotely monitored and takes place in conjunction with face-to-face sessions with SLTs. The role of face-to-face therapy sessions remains highly valued.

The SLTs in Research Strand One identified a role for a specialist SLT with skills in ICT for therapy. An SLT in a role such as this could act as a champion for promoting ICT in practice. McGrath, et al. (2017) found that when no expert or "champion" was available to educate occupational therapy staff on the availability and use of assisted living technologies, there was often a lack of uptake of more advanced technologies. There is currently no such clinical specialist role within the Irish Health Service. The development of such a role within teams may encourage the adoption and promotion of ICT within aphasia rehabilitation.

9.8.3 Implications for Policy

It is likely that the role of a champion within speech and language therapy requires not just a practice level change but a larger shift at a policy level. The SLTs in Research Strand One frequently reported issues with respect to limited resources acting as a barrier to ICT-delivered aphasia rehabilitation. Tablet computer and smartphone use in Ireland is growing (CSO, 2018) and this increase in ICT device usage among the general population is likely to be reflected in increased access among the post-stroke population. However, this does not appear to be mirrored in the SLTs' access to ICT devices and programmes. The Health Service Executive in Ireland has outlined their strategy for eHealth and it aims to reduce the long-term cost of health care by introducing and building on eHealth capabilities with the recognition that additional funding and resourcing are required to achieve this aim (Department of Health, 2013). In order for speech and language therapy departments

to optimise the use of ICT in therapy, it will be necessary to provide additional funding for equipment and training to facilitate this progress. In addition, it would be beneficial to determine the role of the champion within teams and the structures for ICT support to enable optimal acceptance and usage. Finally, training at pre-registration level for SLTs should include ICT-delivered therapy as a core competency.

9.9 Concluding Statement

The incidence of stroke is declining in many developed countries, however the total number of people living with disabilities following stroke continues to increase because of ageing populations. Aphasia can impact on an individual's well-being and ability to engage in everyday social activities, with the potential to lead to marginalisation and issues with respect to social inclusion. The proliferation of ICT in society, with the increased use of computer and smartphone technologies, can provide an option for self-administered aphasia rehabilitation. It is important to understand the experiences of those who undertake this mode of rehabilitation as this will facilitate planning within the rehabilitation process and potentially inform future programme development and refinement. People with aphasia can, and should, be involved in the development of evaluation measures for use by people with aphasia. Two of the six participants in our feasibility study demonstrated statistically significant treatment effects following intervention as measured on item analysis of tests of spoken sentence processing. These tests involved matching a target picture to the auditory sentence stimulus. However, our findings suggest that a programme underpinned by a general approach to auditory comprehension does not result in significant treatment effects outside of assessments that measure the treated therapy task approach. It is not possible to make thorough conclusions about the level of

acceptance of ICT-delivered aphasia rehabilitation due to the attrition rate in the feasibility study. However, it is possible to conclude that the majority who remained in the study expressed positive attitudes towards acceptance of this mode of intervention. The usage of this mode of intervention reflects a more variable pattern with Group 1 completing significantly more activities than the Group 2. It is likely that personal choices with respect to prioritising time for the programme, as well as the repetitive nature of the tasks over the duration of the study may have influenced the level of usage. Attention must be given to the level of support required, the remote monitoring of progress, and individual preferences and motivations when considering this mode of intervention. SLTs are open to and accept the potential for ICT in aphasia rehabilitation. This is reflected in the many benefits identified that enable the PwA to optimise their independence with the use of ICT devices and applications. However, the usage of this mode of rehabilitation is limited by a large number of barriers. These primarily represent facilitating conditions including professional support from IT departments, access to apps and ICT devices and professional training. In addition, the SLTs perceived that there is a limited variety of suitable programmes that provide targeted therapy for adults with aphasia. ICT-delivered aphasia rehabilitation has a role within the service delivery model but face-to-face contact remains a valued interaction within aphasia rehabilitation for both stakeholder groups. Attention must be given to the facilitating conditions required to support the PwA and the SLT to enable this mode of intervention as well as the evidence for the efficacy of therapeutic programmes.

Chapter Ten

Chapter Ten – Future Research Related to this Thesis

10.1 Introduction to Chapter

This final chapter presents plans for future research related to this thesis. Each research strand will be addressed separately and future research, that will build on the findings from this thesis, are outlined. Finally, the planned further analysis of the existing eye tracking data will be described.

10.2 Future Research Plans

Three key research strands were developed within this thesis: 1) SLTs' perspectives of ICT-delivered aphasia rehabilitation, 2) the co-design of a feedback questionnaire and 3) the feasibility of ICT-delivered aphasia rehabilitation targeting auditory comprehension impairment at sentence level.

10.2.1 Research Strand One

The findings of the Research Strand One provide an overview of barriers and facilitators as well as the factors that influence the decision making of a sample of SLTs when considering ICT-delivered aphasia rehabilitation. This study involved a small sample size and would benefit from a larger survey of SLTs' views in order to provide further evidence to support practice and policy change. In addition, the introduction of a champion role has been proposed as a potential implication for policy and practice in the acceptance and use of ICT in therapy. The introduction and implementation of such a role would benefit from an evaluation of the key barriers and facilitators as well as the potential benefits of this role.

10.2.2 Research Strand Two

The co-design process in Research Strand Two facilitated the development of the ICT Feedback Questionnaire. This was piloted in Research Strand Three. However psychometric testing has not yet been carried out. This questionnaire has the potential to provide feedback to clinicians to assist with planning and monitoring ICT-delivered aphasia rehabilitation. In order to achieve this future work must involve psychometric testing of this tool.

10.2.3 Research Strand Three

The attrition rate for the feasibility study was high at 50% and although some reasons for withdrawal have been accounted for it is interesting to consider this high level of attrition and if the stated reasons reflect the actual sentiment of participants. Future research would benefit from a consideration of reasons for withdrawal from this type of research. There are obvious, inherent challenges with respect to exploring participants' withdrawal from studies, but ultimately it may help further inform the acceptance and potential usage of ICT in aphasia rehabilitation.

Finally, a large amount of eye-tracking data was gathered during the feasibility study. It was not relevant to analyse all of this data in order to answer the research questions for this thesis. However, it is likely that further knowledge can be gained by analysing the accuracy and error patterns of the participants over the duration of the crossover study. As noted in 7.2.1 people with aphasia, in contrast to unimpaired adults, do not employ an online agent-first processing strategy. This is the tendency to initially fixate on the image in which the subject noun is the agent unless there are following morphological cues to suggest a passive sentence structure (Mack, Wei, Gutierrez, & Thompson, 2016; Meyer, et al., 2012; Schumacher, et al., 2015). In addition, people with aphasia have been noted to present with a

prolongation in the tendency to fixate on the left-most picture early in a sentence (Mack and Thompson, 2017).

It would be useful to determine if changes in the visual search strategies post-intervention reflect changes in fixation counts and duration on particular image foils depending on the sentence structure. In order to achieve this, it is necessary to complete a number of preparatory activities. All Areas of Internet (AOIs) must be defined relative to the target image for each sentence task. This would facilitate the development of a list of foil types for the non-target images in each sentence. These foils could be lexical, grammatical or non-related foils depending on the target sentence structure. This would allow for the measurement of change in fixation count and fixation duration based on the type of foils following intervention.

In addition to defining the AOIs with respect to the foil type, it is also necessary to cross reference the spoken stimuli in terms of sentence structure and content with the timing of the spoken phases. For example, in test item 14.1 of the e-ACT the sentence stimulus is "*The cat is looking at the woman"*. Here, the timings of 1) the agent in the initial noun phrase (*the cat),* 2) the action or verb (*looking*) and 3) the object in the prepositional noun phrase (*at the woman*) can be cross-referenced against the eye gaze data at each of those time-points. This would allow for the analysis of eye gaze against the timing of the spoken content to determine the trajectory of the eye gaze pattern based on the sentence information. In doing this, eye-gaze patterns based on the salient sentence structure information can be compared at different times. It would then be possible to determine if salient features of the sentence structure impacted on the participants' subsequent gaze path. This could facilitate a greater understanding of the information processing based on the timing and structure of the sentence information. It is not possible to use the

inbuilt Tobii Software for this type of analysis as it requires the development of a matrix of gaze paths. This matrix would record the gaze path at specific points in relation to the test sentence items. For example, in the sentence above it would establish if at the point the agent (*the cat*) is heard, does the participant divide their fixations between the three images with cats? Then, on hearing the action (*looking*) does the participant divide their fixations on the three images with looking? Finally, following the object (*the woman*), does the participant divide their fixations between the images with a woman. It would also be possible to establish the timing, and preceding gaze pattern, when the participant excludes items from the gaze pattern such as the non-target agent (*the dog*) and non-target actions (*not looking*).

It will be necessary to export the eye gaze data and use a programming language such a MATLAB to analyse this data. This detailed analysis can be completed on the data from the e-ACT sentence level tests and the TROG assessments.

The eye-tracking data gathered in this study provided information on fixation count and fixation duration on static items during auditory comprehension tasks presented on a computer screen with eye-tracking monitor. Future eye-tracking research would benefit from exploring the usability of the software programme as it is being used to deliver rehabilitation. This would provide useful information to programme developers and clinicians which can facilitate future refinement of the programme and potentially improve usability.

10.3 Chapter Summary

This chapter provided an overview of the planned future research in relation to the three research strands. A wider investigation of SLTs' perspectives on ICT-delivered aphasia rehabilitation using survey methods will provide a broader

understanding of the issues that are relevant to the implementation of this mode of rehabilitation. In addition, an evaluation of the potential of a champion role is also indicated. Psychometric testing of the ICT Feedback Questionnaire would provide a validated tool to assist SLTs and PwA in planning and monitoring ICT delivered aphasia rehabilitation. Finally, further in-depth analysis of the eye-gaze data, gathered as part of the feasibility study, would provide additional insights into information processing of spoken sentence and the impact of intervention on this.

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