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

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ABSTRACT

Purpose: Information and Communication Technologies (ICT) can provide an option for the delivery of intensive aphasia rehabilitation but the users' views (i.e. People with Aphasia) must be considered to ensure satisfaction, motivation and adherence with this mode of rehabilitation. The aim of this literature review is to provide a critical overview of studies where feedback was elicited from participants about their experiences with ICT-delivered aphasia rehabilitation.

Methods: A systematic search using six electronic databases was conducted in July 2015 and updated in May 2019. Studies of synchronous telerehabilitation and interventions targeting compensatory strategies were excluded from the review. Studies retrieved were screened for eligibility and information was extracted on the characteristics of each study, methods of data collection and study outcomes.

Results: Seventeen studies met the inclusion criteria including studies with quantitative, qualitative and mixed-methods research designs. The studies employed a variety of data collection methods, examining a number of ICT-delivered aphasia rehabilitation activities and the findings investigated aspects of feasibility, usability and acceptance of this mode of rehabilitation.

Conclusions: The findings indicate 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 is noted. There is currently no consensus measure of self-reported feedback in ICT-delivered aphasia rehabilitation.

Keywords: Aphasia, Rehabilitation, Information and Communication Technology, self-reported feedback.

INTRODUCTION

Stroke mortality rates have decreased worldwide over the past two decades, but the absolute numbers of people who have a stroke each year continue to grow and the subsequent burden of stroke is increasing [1]. The incidence of aphasia is estimated to be approximately 30% after first stroke [2]. Aphasia refers to an acquired loss or impairment of the language system. It can affect a person's ability to communicate effectively through spoken or written modalities. Aphasia can impact well-being and ability to engage in everyday social activities and people with post-stroke aphasia are less likely to return to work when compared with those without aphasia [3]. Individuals with aphasia can demonstrate positive outcomes following speech and language therapy and intensity is an important component of a successful intervention programme [4]. The use of computers in aphasia rehabilitation has been promoted as an efficient route for the delivery of intensive speech and language therapy [5]. The findings of a systematic review of computer therapy in aphasia rehabilitation suggest that computer therapy is effective when compared to no therapy and may be as effective as clinician-delivered therapy for specific conditions [6]. However, the authors conclude that the current quality of evidence is low due to the small number of studies available and highlight the need for further research.

Information and Communication Technologies (ICT) may provide an option for intensive rehabilitation for individuals with post-stroke aphasia [5] but consideration must be given to the feasibility and

acceptance of this mode of rehabilitation. Menger et al. [7] 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. personal computers (PCs), 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 [8], an assistive email interface [9] and two therapy tools [10]. Wilson et al. [10] 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 [11]. Eleven of the 23 included studies involved an intervention exclusively 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.

Nielsen [12], in his book on usability engineering, offers a model of system acceptability which identifies that both social and practical acceptability issues influence overall acceptance of a system [12,p.24]. ICT-delivered aphasia rehabilitation is an example of such a system. There are many factors that influence practical acceptability including: cost, compatibility of devices and operating systems, reliability, 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) [13]. These concepts are echoed by Mortley et al. [14] who proposed that a system used to deliver remote aphasia therapy should be "*accessible, usable, and acceptable to people with aphasia*" [14,p.207].

In addition to Nielsen's Model of System Acceptance [12] there are a number of models that explore acceptance and use of technology which have allowed researchers to gain insight into technology acceptance in a variety of fields. The Unified Theory of Acceptance and Use of Technology (UTAUT) is an example of a model that has been applied to the acceptance and usage of technologies in a number of settings including education and healthcare [15]. It has been used to examine factors that influence health professionals' acceptance of new technologies in stroke rehabilitation [16] and is emerging in research of patients' perceptions of telerehabilitation for chronic conditions [17], but has not been utilised in examining patients' perspectives of technology in aphasia rehabilitation research to date. The model provides a framework to understand the factors that may influence the acceptance and usage of technology. The key constructs within the model that determine behavioural intention to use technology include: performance expectancy, effort expectancy, social influence and facilitating conditions.

Performance expectancy is the "*degree to which an individual believes that using the system will help him or her to attain gains in job performance*" [18,p.447]. This is the strongest predictor of intention to use and within aphasia rehabilitation is likely to represent the perceived usefulness of the therapy programme for language gains in rehabilitation. The effort expectancy construct is the "*degree of ease associated with the use of the system*" [18,p.450]. Within aphasia rehabilitation, this construct will

likely reflect the impact of the programmes' usability in terms of ease of use, learnability and memorability. Social influences are defined as "*the degree to which an individual perceives that important others believe he or she should use the new system*" [18,p.451]. It is possible that clinicians, family members and significant others may indeed represent social influencers within aphasia rehabilitation. Facilitating conditions "*the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system*" [18,p.453] is likely to reflect the context of the aphasia rehabilitation activity including the access to resources and support systems for the person with aphasia. These four constructs are also considered to be moderated by four factors: gender, age, voluntariness i.e. if the decision to implement the technology is under the person's own control or not, and previous experience of technology. The UTAUT has been promoted as a useful framework for considering patient perceptions of willingness to use new technologies in health care as it provides a convenient structure to organise factors that may influence acceptance and intention to use new technologies [17].

Patient satisfaction has become an important part of quality healthcare, 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 [19]. Tomkins et al. [19] 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 [19].

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.

Methods

Structure of the review question

A literature review was carried out [20]. This employed restricted systematic review principles as outlined by Pluddemann et al. [21] 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 [22]. 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, personal 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.

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 [6]. 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 [6] were also included for screening. This search strategy was updated in May 2019 and was subject to the same procedure outlined here.

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 [23] 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.

Results

Study Selection

Database searching identified 4197 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 2910 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.

Search Results

Seventeen studies were included in the review: 6 qualitative, 1 quantitative and 10 mixed-methods studies. See figure 1 for an overview of search strategy findings. Studies were screened using the Mixed Methods Appraisal Tool [23]. 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 described in Supplementary table S1. 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.

[Insert Figure 1 here]

Study Designs

Table 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 [24]. The remaining study designs were case series [25, 26, 27], case studies [28, 29, 30], feasibility studies [31, 32, 33, 34], a usability study [35] and qualitative research design [36, 37, 38, 39, 40]. Eight of the studies reported therapeutic outcomes in conjunction with participant reported outcomes [25, 26, 27, 28, 29, 30, 31, 33]. The remaining nine studies reported the therapeutic outcomes elsewhere [24, 32, 34, 35, 36, 37, 38, 39, 40]. Although not within the scope of this paper, it was interesting to note that the views of carers were also gathered in combination with people with aphasia in five of the studies [24, 28, 32, 36, 37]. One usability study also explored the perspectives of speech and language therapists [35].

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 [24, 25, 37] and feasibility [30, 31, 32, 34] of the mode of therapy and/or programme, exploration of programme utility [26, 28], barriers and facilitators for programme and device use [38], support and learning requirements for programme use [25, 29], usability [34, 35], ease of use [31], satisfaction with the programme [27, 32, 33, 35, 36], user experience [39] and exploration of participants' views, perceptions and experiences in relation to the target programme [24, 30, 32, 37, 40].

Rehabilitation Programme Activities and ICT devices

The rehabilitation activities provided by these software programmes varied between studies and targeted: sentence production [28], improved written production using speech to text software [29], reading comprehension [25], script training [26, 36], gesture therapy [31], lexical retrieval [24, 27, 30,

37], increasing talk time [38], improved function and everyday communication [39] and individualised therapy [32, 33, 34, 35, 40].

Nine studies investigated the use of specialist therapeutic software applications/programmes on a laptop/computer [24, 26, 28, 32, 36, 37] or on a tablet computer [33, 34, 35]. 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 [27]. Bruce et al. [29] 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 [25]. Marshall et al. [31] 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 [30, 39, 40]. 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 objects that provide spoken naming cues. Two of the studies are linked to a quasi-randomised study evaluating the benefits of aphasia intervention delivered in a virtual world [41]. The third study investigated the feasibility of delivering two different treatment approaches for word retrieval in a virtual world [30]. Finally, Brandenburg et al. [38] examined the use of an iPhone application developed by the research team and commercially available hardware to increase talk time.

Data Collection Methods

The methods of data collection for self-reported participant feedback included interviews [24, 25, 26, 28, 30, 31, 35, 36, 37, 38, 39, 40], written narrative [29] and questionnaires (using visual analogue scales) [24, 27, 32, 33, 34]. In addition to self-reported participant data, observations [25, 28, 31, 35, 39], field notes [28, 35, 38] and usage data [24, 31, 33, 34, 39] were gathered to provide further insight into usage and acceptance.

[Insert Table 1]

Summary of Participants

Data was gathered from 151 people with aphasia and participant details are summarised in table 1. Two of the studies [39, 40] report on participants from one intervention study [41]. 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) [34] and up to 29 years post-stroke [24]. Participants were between 21 and 92 years old and represented a wide range of aphasia types and severity.

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 [25, 27, 30, 32, 36]. Two studies reported this information elsewhere [39, 40], two studies briefly described participants as owners of either a laptop or PC but with little other information on participants' ICT skills [28, 29] and one study reported that no participant used a PC before the study [26]. Three studies investigated the participants' pre-stroke computer skills [31, 34, 37]. Within two of these studies, the recruited participants were at least 2 years post-stroke onset [24, 37], the third study examined the feasibility of mobile tablet-based rehabilitation in the acute care setting [34] 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 [33, 35, 38]. 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 [24], and two studies examined if participants had previous experience of computer-based aphasia rehabilitation [35, 37]. There was wide variation among participants' rating of ICT experience and skills, see table 1.

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 2. Positive and negative factors relating to ICT-delivered aphasia rehabilitation were reported by a number of studies and table 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.

[Insert Table 2 here]

Perceived Gains

Improvement in language skills

A number of studies explored the perceived benefits of ICT-delivered aphasia rehabilitation [24, 25, 26, 30, 32, 35, 36, 37, 40]. Four of these studies also report the therapeutic outcomes in addition to participants' feedback [25, 26, 30, 32]. Therapeutic outcomes are not reported in two of these studies

[35, 36] or are reported elsewhere [24, 37, 40]. 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 [26, 37] and at least half or more of the participants reported perceived improvements in three studies (18 of 20 participants in Galliers et al. [39]; 20 of 23 participants in Cherney et al. [36] and 7 of 14 participants in Palmer et al. [24]). 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 [26]. 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 [32]. 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 [42]. 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 [30]. 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 [43] following training [25]. 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 [44].

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 [24, 25, 26, 27, 28, 29, 31, 33, 34, 35, 36, 37, 38, 39]. Increased confidence was reported by 41 of the 70 participants in 6 studies [24, 25, 26, 36, 37, 40] and many of the participants in two studies [35, 39] 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 [25], 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 [36, 40]. Participants valued the independence and autonomy that computer-delivered therapy offered [24, 27, 37] 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 [24, 29]. 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 [35].

Usability

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 [26, 27, 30, 31, 32, 33, 35, 36, 39]. Three of these studies used questionnaires with Likert scale responses [27, 32, 33] 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 [26, 30, 31, 35, 36, 39] and one participant's report of their perceived progress made in therapy is explicitly identified as a source of satisfaction [26]. Other studies do not explicitly report on the source of satisfaction but participants have also reported perceived benefits [35, 36] and mastery of the programme among the majority (6/8) of the participants [31]. 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 [39], and some reported they felt the purpose of the tasks within the programme was unclear [35]. 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 [31].

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 [24, 25, 26, 29, 39]. 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 [39]. 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 3 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 [24]. The virtual therapist, which acted as the agent of therapy, caused both frustration and enthusiasm at different times in a script training programme [26]. The participant in a case study exploring if voice recognition software could result in improved written output, experienced frustration when attempting to correct mistakes [29]; 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. [39] 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.

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 [26, 28, 29, 34, 35] but there was variability in the

use of accessibility features that were introduced to participants in one study [25]. The initial introduction and training of the ICT-delivered aphasia rehabilitation programmes were referenced in a number of studies [24, 25, 27, 28, 29, 31, 33, 35, 37, 38, 39]. 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 [27, 35, 38]. 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 [38]. 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 [34]. Usability and ease of use of specialised therapeutic software were reported in nine studies [27, 30, 31, 33, 34, 35, 36, 38, 40] and this was also investigated in the study of e-reader usage for reading comprehension [25]. Participants with aphasia were generally positive about the efficiency and usability of the programmes [25, 27, 30, 33, 34, 35, 36, 38, 40] and this was supported by carers' reports in two studies [31, 36] and observation data [25, 31]. Mixed views were reported in some studies with respect to aspects of ease of use [34, 35, 38, 40]. 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 [34]. In the study by Amaya et al. [40] 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. [30] 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 [30]. Hill and Breslin [35] 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. [38] 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 [38].

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 [31, 33, 35, 37]. 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 [33]. As noted earlier, one participant in a study of gesture therapy indicated a discrepancy between her priority for rehabilitation and the programme target [31] 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 [35]. 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*" [30,p.1060].

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 [24]. 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. [34] one participant also reported having difficulty holding the iPad.

Engagement with the mode of rehabilitation

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 [24, 35, 37]. Hill and Breslin [35] 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 [35]. 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 [24]. 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 [37]. 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 [24, 37]. The concern regarding the monitoring of self-managed aphasia rehabilitation also emerges in two other studies [35, 38]. 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 [38]. Interestingly, the findings of the study by Marshall et al. [31] 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.

Recommend for others

Participants were asked in six of the studies if they would recommend the programme or consider it appropriate for others [25, 30, 32, 36, 37, 40]. The results are not reported in two of these studies [25, 37]. 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 [36] and all 22 participants would recommend the multi-user virtual world to other people with aphasia [30, 40]. 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 [32]. One study asked participants to consider what they would be willing to pay for the software programme [33]. This is not investigated in any of the other studies however Palmer et al. [24] 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 [24].

Time

The time commitment while engaging in ICT-delivered rehabilitation was perceived by participants in three studies to be a disadvantage or a challenge [24, 37, 40] with the time spent on ICT-activities meaning less time available for other activities [37, 40]. This was considered especially relevant for individuals post-stroke if sitting too long without stretching, particularly for those with hemiplegia [37]. 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 [38]. The time demand was also reported as a factor in participant attrition within that study [38]. In addition, time was reported as an important aspect for training a voice recognition software system [29] and troubleshooting issues e.g. unable to log into the application [38]. 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 [34].

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 [34]. In a separate study, one participant did not wish to wear a headset to the shops and would not use the device in public [38].

Age as a factor of acceptance and usage

Two studies referenced age as a potential factor in the acceptance and usage of technology [35, 38]. 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 [38]. 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 [35]. 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 [24, 31, 33] 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.

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 [28, 37, 38] and also from the research team [31, 35, 38, 39, 40]. When this support was missing it was identified as a barrier for acceptance and usage [29, 34].

Usage data

Five studies reported on usage data within the research [24, 31, 33, 34, 39]. Three of these studies provided the participants with specific targets for time spent working on the programme [24, 34, 39]. 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 [34]. In another study, participants were asked to complete at least 3 sessions per week over the 5 months of the study [24]. 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 [39]. 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% [24] and 83% [34] 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 [39]. One study recommended that participants spend "as often as possible for as long as possible" over the period of the study [33]. The final study did not report this information, however, the authors reported they were interested in dosage in the study introduction [31]. 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 [33]. However, in the second study, there was no significant correlation between usage and gesture gains [31]. The authors of this study identify that this is not surprising due to the small sample size of the study [31]. Three of the studies provide

individual usage data and the gender of participants [24, 31, 33]. 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.

[insert Table 3 here]

Discussion

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 healthcare and as participants with aphasia may have different requirements and expectations that influence satisfaction with ICT-delivered aphasia rehabilitation [19] 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 [45] and patient experiences [46] 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 [46] as well as challenges including the impact of hemiplegia [46] the

appropriateness of the level of difficulty of prescribed tasks [45, 46] and issues with respect to participants requiring additional support and finding the time to complete the prescribed activities [45, 46].

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 [12] and the UTAUT [18]. These were previously highlighted by Mortley *et al.* as important components for a system delivering remote aphasia therapy [14]. 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 [18]. 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 [31]. 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 [19]. 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 [24], holding an iPad [34], accessing touchscreen devices [35] and pairing Bluetooth devices [38]. These challenges must be considered and addressed so as to increase digital inclusion for people with aphasia [7] and feedback from participants with aphasia can assist researchers in the design [31, 39] and refinement process for future research of ICT-delivered aphasia rehabilitation [35, 38].

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 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 [26], however, two participants in another study felt their limited experience impacted on their ability to use the programme [35]. Amaya et al. [40] 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. [41] 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. [41] 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 [35]. However, ICT-delivered aphasia rehabilitation can be feasible for individuals with all levels of experience from beginner to skilled [24, 26, 31, 33]. It is clear that the provision and availability of support from family and/or clinicians [24, 28, 31, 38] is a key factor reported among some participants and where experience is limited this may be an important mediator for ICT use and acceptance [37].

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 [24, 38] and family members of the person with aphasia [24, 28, 31, 37, 38] are identified as positive influencers in many of the studies as well as the impact of training [24, 25, 27, 28, 29, 31, 33, 34, 35, 37, 38, 39] and support manuals [25, 27, 35, 38]. This contrasts with participants' reluctance to use ICT devices in public in two studies due to embarrassment [34] and feeling uncomfortable when asked about the device [38]. Brandenburg et al. [38] 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 [18]. 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 [35, 38]. Indeed the level of support provided is an important factor in patient satisfaction with their healthcare [19]. Kelly et al. [47] 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 [41] 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. [38]. 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 [37, 38]. 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 [34]. The construct of time for both the participant with aphasia and also the clinician [16] reflects an important facilitating condition for usage and acceptance of ICT-delivered aphasia rehabilitation [18].

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 [36]; 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 [34] and phrasing the question statement in a positive manner "the programme has good readability" [33]. 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 [39]. 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 [39].

Future research

Wade et al. [37] 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.

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.

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 [25, 30, 31, 39, 40]. 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.

Limitations of the current review

Unfortunately, due to resource constraints, the first author 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 paper. 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.

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 research study 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.

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Table 1. Study and Participant Characteristics

	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 [28]	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 [40]	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 [38]	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 [29]	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 [25]	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 [26]	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 [36]	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 [33]	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

Galliers et al. 2017 [39]	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 [35]	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 [34]	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-*	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.

			in-1, Category Therapy, Conversation Therapy) Lingraphica Small Talk Oral Motor, Speech Sounds on Cue, Jay Bacal apps							21/30 had previous experience using an iPad
Marshall et al. 2013 [31]	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 [30]	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 [24]	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
Routhier et al. 2016 [27]	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 [37]	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 [32]	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

Table 2: Information investigated within the 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 [28]						x				x						x			
Amaya et al. [40]	x	x			x								x			x		x	
Brandenburg et al. [38]					x					x	x				x	x		x	x
Bruce et al. [29]		x		x		x				x						x		x	
Caute et al. [25]	x	x		x	x		x						x						
Cherney et al. [26]	x	x	x	x		x													
Cherney et al. [36]	x	x	x		x								x					x	
Choi et al. [33]			x		x			x		x							x		
Galliers et al. [39]		x	x	x						x						x	x		
Hill and Breslin [35]	x	x	x		x	x		x		x	x			x	x	x		x	
Mallet et al. [34]					x	x						x				x	x	x	x
Marshall et al. [31]			x		x			x		x						x	x		
Marshall et al. [30]	x		x		x			x					x						
Palmer et al. [24]	x	x							x	x				x			x	x	
Routhier et al. [27]			x		x					x	x							x	
Wade et al. [37]	x	x						x		x			x	x		x			

Wenke et al. [32]	x	x	x									x						

Table 3. Factors reported to influence participant experience and outcomes when engaging in ICT-delivered aphasia rehabilitation

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 [28]						+									+		
Amaya et al. [40]	+ *	+ *			+ -							+			+	-	
Brandenburg et al. [38]					+ -					+				-	+	-	-
Bruce et al. [29]		+		-		+									+ -	+ -	
Caute et al. [25]	+ *	+		-	+		+ -					#					
Cherney et al. [26]	+	+	+	-		+											
Cherney et al. [36]	+ *	+	+		+							+ *				+ -	
Choi et al. [33]			+		+			+									
Galliers et al. [39]		+	+	-											+		
Hill and Breslin [35]	+	+	+		+ -	+		+ -					+	-	+	-	
Mallet et al. [34]						+					-				+ -	-	-
Marshall et al. [31]			+ *		+ ~			+							+		
Marshall et al. [30]	+		+		+			+ -				+					
Palmer et al. [24]	+ *	+							-				+ -			-	
Routhier et al. [27]			+		+											-	
Wade et al. [37]	+	+						+ -				#	+ *		+		
Wenke et al. [32]	+	+	+									+ *					
	*+ 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*																

Figure 1. Search Strategy Results