Advances in Communication and Swallowing 27 (2024) 29–40
DOI:10.3233/ACS-220014
IOS Press

Delivering Script Therapy for people with aphasia in EVA Park: Two single case treatment studies

Jane Marshall[a,*], Niamh Devane[a,1], Jude Berraondo[b], Richard Talbot[a,1], Panagiota Temponera[a], Katie Clegg[a] and Stephanie Wilson[c,1]

[a]*Division of Language and Communication Science, City, University of London, London, UK*
[b]*Linguistic Resolutions, Pinner, UK*
[c]*Centre for Human-Computer Interaction Design, City, University of London, London, UK*

Received 20 August 2022
Accepted 19 January 2023

Abstract.
BACKGROUND: There are few applications of virtual reality (VR) in aphasia rehabilitation. EVA Park is an online VR platform developed with and for people with aphasia. Our research is testing its potential to host aphasia therapies.
OBJECTIVE: Two case studies evaluated if delivery of Script Therapy in EVA Park is feasible and acceptable to participants, whether it improved production of trained scripts and promoted generalisation to untrained scripts, narrative speech and functional communication.
METHODS: Two participants with aphasia received 20 hours of Script Therapy in EVA Park. Feasibility was assessed through session attendance, completion of practice and ratings of treatment fidelity. Acceptability was explored via post therapy interviews. The impact of therapy on script production, narrative production and functional communication was assessed through measures administered twice before therapy, immediately post therapy and at 5 weeks follow up.
RESULTS: Participants attended at least 85% of sessions. Compliance with practice was good for one, but not the other. Fidelity ratings indicated that over 80% of core treatment components were fully present in recorded sessions. Participants expressed positive views about the intervention. Therapy significantly improved the production of words in trained scripts, with maintenance for one participant. Neither participant improved in the production of untrained scripts or personal narratives. One improved on the assessment of functional communication, but the margin of change was small.
CONCLUSIONS: The study adds to the evidence that EVA Park can host a range of interventions and that this platform is acceptable to its intended user group.

Keywords: Aphasia, tele-rehabilitation, virtual reality, Script Therapy

1. Introduction

Tele-rehabilitation involves the use of internet technologies to deliver intervention remotely. It has been used successfully in aphasia therapy (Weidner & Lowman, 2020), with equivalent outcomes to face to face delivery (Cacciante et al., 2021). The majority of aphasia tele-rehabilitation studies employed synchronous videoconferencing (e.g., Øra et al., 2020; Pitt, Theodoros, Hill, & Russell, 2018; Woolf et al., 2016). Virtual Reality (VR) has been less explored. This involves a three-dimensional, computer simulation of a setting with which the user interacts. Online VR offers the efficiency benefits of remote delivery, but with added rehabilitation potential. For example, VR is known to promote a sense of presence, in which the user feels highly engaged with

[1]ORCID ID: 0000-0001-8448-1478 (Niamh Devane); 0000-0001-5007-0785 (Richard Talbot); 0000-0001-6445-654X (Stephanie Wilson).

*Corresponding author: Jane Marshall, Division of Language and Communication Science, City, University of London, London, UK. E-mail: j.marshall@city.ac.uk.. ORCID: 0000-0002-6589-221X

the simulated environment (Brown & Cairns, 2004; Cummings & Bailenson, 2016). This may add depth to the therapeutic experience, so promote learning and generalisation of skills. Virtual environments can be colourful and amusing, so might inject fun into rehabilitation.

VR has been employed to support people with a range of communication impairments (Bryant, Bruner & Hemsley, 2019; Cao et al., 2021; Repetto, Paolillo, Tuena, Bellinsona & Riva, 2020). The few applications in aphasia include the Virtual Reality Rehabilitation System (Maresca et al., 2019), VR delivery of Intensive Language Action Therapy (Grechuta et al., 2016; 2017) and conversational therapy (Giachero et al., 2020). Cherney and colleagues have developed programmes delivered by virtual therapists. These are head and shoulders animated figures, with realistic mouth movements, that lead users through speech and language exercises (Cherney & Van Vuuren, 2012).

EVA Park is the only multi-user, online VR world that was developed with and for people with aphasia (Wilson et al., 2015; Marshall et al., 2016). This virtual island contains multiple locations, such as houses and a town square. It is accessed from a regular computer, without a VR headset. Users are represented by avatars, which can be personalised for example with respect to clothing. Communication takes place in real time, mainly through speech, for which users employ headphones and a microphone. Messages can also be typed. Minimal language is needed to access EVA Park and users navigate their avatars either via a simplified keypad, or a limited number of keys on the computer keyboard.

EVA Park's utility as a platform depends on its capacity to host a range of aphasia interventions. Two trials demonstrated feasibility for interventions targeting functional communication (Marshall et al., 2016) and group social support (Marshall et al., 2020). Case studies also investigated whether the platform could be used to deliver language therapies. Such single case data can explore feasibility and early stage modelling of a complex intervention (Craig et al., 2008) as well as outcomes for the individuals involved. We have already reported results from therapies that aimed to improve word retrieval (Marshall et al., 2018) and narrative (Carragher et al., 2020). Here we report on the use of EVA Park to deliver Script Therapy (Youmans, Holland, Munoz & Bourgeois, 2005).

Script Therapy aims to improve spoken discourse. Individual, word for word, scripts are developed, ideally based on the interests or functional needs of the person being treated (Cherney, Kaye, Lee & van Vuuren, 2015). Scripts are repeatedly practised in therapy, with the aim of achieving automatic production (Hubbard, Nelson & Richardson, 2020; Youmans et al., 2005). Generalisation tasks are often included, which aim to facilitate production of the script with different conversational partners or with varied content (Goldberg, Haley & Jacks, 2012; Youmans et al., 2005).

A recent review identified 22 studies of Script Therapy involving people with non-progressive aphasia (Hubbard et al., 2020). In almost all studies the production of words in trained scripts improved after therapy, with maintenance of gains. Many studies also reported an increase in speech rate (e.g., Ali, Rafi, Ghayas Khan & Mahfooz, 2018; Cherney, Halper, Holland & Cole, 2008; Goldberg et al., 2012; Lee, Kaye & Cherney, 2009; Youmans et al., 2005). Generalisation was variously measured. For example, some studies reported improvements in the production of untrained scripts (e.g., Bilda, 2011; Fridriksson et al., 2012) or in spontaneous speech and functional communication (Nobis-Bosch, Springer, Radermacher & Huber, 2011).

Script Therapy can be provided face to face by a therapist (e.g., Ali et al., 2018; Youmans et al., 2005) or through self-directed practice (e.g., Bilda 2011; Fridriksson et al., 2012; Grasso, Cruz, Benavidez, Pena & Henry, 2019). It has been delivered remotely using videoconferencing technology (Goldberg et al., 2012; Rhodes & Isaki, 2018) and via AphasiaScripts, a computer administration delivered by a virtual therapist (Cherney et al., 2008, 2015; Cherney, Braun, Lee, Kocherginsky & van Vuuren, 2019; Cherney & van Vuuren, 2022; Lee et al., 2009).

This study explored whether Script Therapy delivery was feasible in EVA Park and acceptable to those receiving the intervention. Although VR practice of Script Therapy has been explored through AphasiaScripts, the opportunities offered in EVA Park are different. Here therapy is hosted in a virtual world that allows synchronous, real-time interactions. Therapeutic practice can be conducted in relevant settings in EVA Park and followed up with situated open conversation. For example, talk about gardening can take place in the EVA Park greenhouse. It was hypothesised that these opportunities might stimulate learning and the generalisation of skills to untrained scripts, spontaneous speech and functional communication.

Table 1
Participant details

Pseudonym (gender)	Age at Recruitment	Stroke Information	Time Post Stroke (Months)	Pre-stroke Occupation	Aphasia (clinical judgement)	Repetition Scores
Keats (M)	49	Left hemisphere; Right hemiplegia	63	Business owner	Moderate/Severe Non fluent	CAT 12:23/34 (71.9%) Combined score (CAT 12,13 & 16): 24/50 (48%)
Austen (F)	54	Left Hemisphere; Right Hemiplegia	36	Administrator	Moderate/Severe; non fluent	CAT 12:34/34 (100%) Combined score (CAT 12, 13 & 16) 43/50 (86%)

The study addressed the following research questions (RQs):

RQ1 Is the delivery of Script Therapy feasible in EVA Park, as indicated by compliance and fidelity data?
RQ2 Is the delivery of Script Therapy in EVA Park acceptable to participants as indicated by interview data?
RQ3 Does Script Therapy delivered in EVA Park improve the production of trained scripts, in terms of the % of script related words and speech rate? Are gains maintained at follow up assessment?
RQ4 Does Script Therapy delivered in EVA Park improve the production of untrained scripts?
RQ5 Does Script Therapy delivered in EVA Park produce improvements in spontaneous, narrative speech and on a measure of functional communication?

2. Method

Ethical clearance was given by the Research Ethics Committee of the School of Health Sciences, City, University of London (LCS/PR/Staff/16-17/04). Participants gave written consent, using materials designed to be accessible to people with aphasia (Rose, Worrall, Hickson & Hoffmann, 2012). Recruitment and data collection took place between August 2016 and January 2017 (participant 1: Keats) and between December 2018 and May 2019 (participant 2: Austen).

2.1. Participants

Keats and Austen (Pseudonyms) were recruited. They met the following selection criteria: aphasia following a stroke that occurred at least 4 months prior to the study; fluent pre-stroke users of English (both were monolingual); not receiving speech and language therapy elsewhere during the study; no severe impairments of hearing or vision and no additional diagnosis affecting cognition. As the facilitation techniques for Script Therapy involve repetition, they were required to score above 50% on the single word repetition subtest of the Comprehensive Aphasia Test (CAT 12; Swinburn, Porter & Howard, 2004). Repetition of complex words (CAT 13) and sentences (CAT 16) was also screened. They needed to demonstrate poor connected speech (screened via the CAT picture description task and clinical judgement) and be motivated to improve this aspect of their aphasia.

Participant details are provided in Table 1 and connected speech samples are in Table 2. Both participants met the selection criteria with respect to single word repetition. However, Keats showed poor repetition of complex words and sentences (CAT subtests 13 & 16).

Table 2
Spoken picture description samples (CAT; Swinburn et al., 2004)

Keats	Austen
The er sleep on the (.) erm sleep the (1.5) uh book (.) (unintelligible) there [point to the book and gestures falling] (1) cat got the (.) fish (1.5) er (unintelligible) walking the er (1) cup of tea and the no (unintelligible) er with the (2.5) er open the (1) tea got the (1) so that one [points to child]	Asleep (.) and books and a cat and a boy (.) grandad

2.2. Design

The study employed a single case repeated measures design, in which data from each participant were analysed separately. Assessments were administered at four time points (T1 – T4) each separated by a period of five weeks. Therapy was administered between T2 and T3. Thus, each participant was assessed twice before therapy, providing a double baseline, once immediately after therapy and once five weeks later (follow up). Assessments were administered face to face (i.e. not in EVA Park) by a non-treating therapist in the case of Keats and by a non-treating student of speech and language therapy in the case of Austen. Assessments were filmed and scoring of the assessments was conducted blind to time point. This was accomplished by presenting the films in random and blinded order to the scorer (who was not the assessor).

2.3. Measures

RQ1 Feasibility of delivering Script Therapy in EVA Park was assessed through compliance and fidelity data. The percentage of treatment sessions attended and completion of generalisation practice was recorded (via self-report). Eleven treatment sessions (27.5% of the total) were filmed, 7 with Keats and 4 with Austen. These films were subject to fidelity checking, conducted by two students (authors PT and KC), who were not otherwise involved in the project. A checklist of core treatment components was devised, based on the therapy protocol (see Supplementary Materials 1). Each student rated the 11 recorded sessions of therapy against the list, indicating whether a component was fully present, partially present, absent or not applicable. The latter rating was given if a component was not relevant to an observed session. For example, rehearsal of previously practised scripts was not relevant in early sessions. The ratings provided a fidelity score for treatment delivery (the percentage of rated components that were fully present). Inter-rater reliability of the checklist was assessed, using Cohen's Kappa statistic.

RQ2 To explore acceptability, each participant was interviewed by their non-treating assessor at T3. Questions covered views about EVA Park, navigational aspects, being represented by an avatar, receiving therapy in EVA Park, relationship with the treating therapist, and any perceived benefits from therapy. Eleven questions also elicited rating responses. Interviews were recorded and transcribed. Data were analysed thematically (Braun & Clark, 2006).

RQ3 & 4 Five personalised scripts were developed with each participant prior to T1 (see below). An elicitation question for each was also agreed, for example: 'Can you tell me what you would say to introduce yourself at the stroke group?' At each assessment point, participants were asked to produce the five scripts, in random order, in response to the elicitation questions. No further cues were given, beyond invitations to continue.

Two scores were extracted from the scripts at each assessment point. One was the percentage of script related words. This was the number of words produced from each script expressed as a percentage of the total word count. All words were counted, i.e., content and function words. Only verbatim realisations were scored (e.g., not synonyms). Phonetic/phonological errors were accepted, providing these were recognisable attempts at the target. The other score was the speech rate. The time taken to produce each script was recorded, extracting any time taken by the tester. The total number of words produced in that period was recorded and expressed as a word per minute (wpm) score. In line with previous research (e.g., Youmans et al., 2005) any real word contributed to the wpm score, not just script words. Scripts were trained in a random order until a criterion was reached (see intervention section). Keats was accordingly trained on two scripts and Austen on four. Scores were therefore available on both trained scripts (RQ3) and untrained scripts (RQ4).

RQ5 A sample of connected speech was taken at each assessment point in the form of a personal narrative. Each participant was asked to recount a story that was personally meaningful, using consistent, scripted prompts. No time limit was imposed. If production was limited the participants were encouraged to continue or add more information. Samples were recorded and transcribed and 3 measures were extracted, using criteria from the Quantitative Production Analysis (Rochon, Saffran, Berndt & Schwartz, 2000). These were: Number of words; Number of utterances; Number of well-formed sentences.

Communication Activities of Daily Living (CADL-2, Holland, Frattali & Fromm, 1999) was administered at each assessment point to investigate any changes in functional communication.

2.4. Script development

Following recommendations in the literature (Holland, Halper & Cherney, 2010) personally relevant scripts were developed with each participant. Participants were invited to think about different communication scenarios in their lives and evaluate them for importance and difficulty. From this discussion five scenarios were prioritised for each participant, which formed the basis for their scripts. For example, one of Austen's scripts focussed on her FaceTime conversations with her grandsons; while Keats developed a script for talking with stroke survivors which was important for his hospital volunteering role. The wording of each script was drafted by the treating therapist, with the participants giving direction and feedback on each phrase. Austen's scripts were also reviewed by her husband, who confirmed that the wording reflected what she might have said pre-stroke. Script development took place face to face, not in EVA Park, over one session.

2.5. Intervention

Prior to the intervention, EVA Park was set up on each participants' home computer. They also developed their avatar, making choices about all aspects of appearance. Each participant was given about 30 minutes training in how to use EVA Park. Set up, avatar creation and training was supported face to face by the treating therapist or the student/therapist assessor.

Participants were offered 20, one hour intervention sessions over 5 weeks (4 sessions per week). Sessions were delivered 1:1 by authors JB and ND. All sessions were delivered in EVA Park, with the participant and therapist represented as an avatar. Participants worked at home and the treating therapist worked either from their home (JB) or from the University (ND).

Scripts were randomly assigned a number between 1 and 5, which determined the order in which they were trained. The training protocol was developed from published accounts of Script Therapy (Youmans et al., 2005; Goldberg et al., 2012). Each script was worked on one phrase at a time. First the therapist modelled each phrase for repetition. This was followed by choral reading in which the therapist and participant read the phrase aloud together. Then the participant produced the phrase without the therapist. Problem words, that were not achieved, were cued via repetition, first phoneme cues or syllabic segmentation. Once achieved they were repeated 5 times before the whole phrase was practised again. EVA Park contains a note card facility, which allows written material to be available on the screen. This was used to provide the written text of scripts while they were being practised. The therapist also used an Instant Messaging facility in EVA Park, to type problem words as they were being rehearsed.

Each phrase in a script had to be achieved independently at least 10 times, before progressing to the next phrase. Mastery of a script was defined as 10/20 independent productions of the whole script. Once this was achieved, the next script was introduced. Previously mastered script(s) were revisited at the end of each session, to promote maintenance of learning. Keats received training on two scripts, reaching criterion on one. It took 12 sessions for him to reach criterion. Austen received training on 4 scripts, reaching criterion on three. The number of sessions taken by Austen to reach criterion on each script ranged between 4 and 6.

2.6. Generalisation practice

Scripts were practiced in varying locations in EVA Park. Both participants were required to practice their scripts with different conversation partners. Keats received one session a week in EVA Park with a student of speech and language therapy (this was included in the 20 hours of intervention) with whom he rehearsed his scripts. Austen was encouraged to practise her scripts outside EVA Park with her husband. She received a text message of her current script and was asked to practise this for 15 minutes per day.

Participants also had the option to rehearse their script with 'Ruby Robot'. Ruby Robot was an automated avatar in EVA Park. When encountered she offered an opportunity to practice, with a prerecorded invitation: 'Hello, I'm Ruby Robot. Do you want to practice your script with me?' No further facilitation or feedback was provided, e.g., Ruby Robot did not employ speech recognition and did not contribute to any dialogue. Participants were made aware of Ruby Robot, and her limitations. She appeared with a label, which identified her as a robot.

Script training was supplemented with at least 10 minutes of open conversation per session. This focused on topics that were both related and unrelated to the scripts. Appropriate settings in EVA Park were employed for the practice. For example, a conversation about cooking took place in the EVA Park house kitchen.

See Supplementary Materials 2 for a description of the intervention based on the Template for Intervention Description and Replication (TIDieR; Hoffmann et al., 2014).

3. Results

3.1. RQ1: Feasibility

Both participants completed all stages of data collection. Keats attended all scheduled therapy sessions. Austen missed three, one due to ill health and two because of internet connectivity problems. Keats attended all practice sessions with the student of speech and language therapy and also carried out independent practice, in which he listened to recordings of his script (produced by the therapist) while driving his car. Austen in contrast, indicated that she rarely practised outside the therapy sessions, despite being invited to do so with her husband. Both reported that they made no use of Ruby Robot.

132 treatment components were assessed for fidelity (12 components over 11 sessions). Of these, 14 were rated as not applicable; 81.4% of the remaining components were rated as fully present, and a further 14.4% were rated as partially present. Fidelity scores for individual sessions ranged from 72.7% to 91.6% (percentage of components that were fully present). All sessions were independently rated by two assessors. Percentage agreement between the two raters was 81.8%. The Kappa value was .63 ($p < 0.001$). According to the benchmarks set by Landis and Koch (1977) this equates to 'substantial agreement'.

3.2. RQ2: Acceptability

Four main themes emerged from the interview data and associated ratings (see Table 3). The first theme related to the overall response to EVA Park. Here the ratings and views of both participants were extremely positive:

'*It's amazing. It's really happy*' *(Keats)*
'*Experience is amazing*' *(Austen)*

Both participants indicated that they would recommend EVA Park to other stroke survivors with aphasia. Austen enjoyed using EVA Park even when she was on her own. This was not true for Keats who gave a low rating for lone use. His main criticism was the lack of company:

Keats: Nothing. I can be . . . You can go . . . computer, nothing. Nobody there.

The second theme related to the experience of receiving therapy in EVA Park. Again this was highly rated, with associated positive comments. Keats singled out his therapy sessions as the most enjoyable aspect of the experience:

Keats: One hour when the computer, er, lady, lady. . .
INT: So you liked the therapy sessions more than anything?
Keats: Yes.

Austen flagged her therapist for praise, describing her as '*brilliant*'

Keats indicated that he would value more features in EVA Park to support independent practice of his scripts, such as audio recordings. He described having to record himself using his phone. He also found the therapy sessions tiring:

'*It's . . . one hour. She's talking. She's.. bloody . . . knackered [points to self]. My . . . I was . . . I was sleeping. After*' *(Keats)*

The third theme related to usage and technical features. Navigational aspects, such as moving the avatar, and using the mouse caused no difficulties. There were no negative responses to being represented by an avatar. Both participants identified some technical problems, Keats with sound during early sessions and Austen with internet connectivity.

The final theme related to perceived impacts of the intervention. Both participants detected changes in their communication, e.g.:

'*Speech flows better*' *(Austen)*
'*It's . . . it's talking. It's . . . it's . . . it's really happy*' *(Keats)*

Keats also gave an example of being able to use one of his scripts at his stroke group.

3.3. RQ3 & 4: Improvement in trained and untrained scripts

Table 4 reports the percentage of script related words achieved on each script at each time point. Taking Keats first, the table suggests that the production of words in treated scripts increased at T3 (immediately post therapy), but this gain was not maintained at T4. This was tested statistically by using McNemar chi square to compare the number of correct words achieved across the treated scripts at paired time points. The analysis revealed no significant difference over the baseline period (T1 vs

Table 3
Ratings (1 = did not like; 5 = like) for participants' experience of EVA Park

Rated area	Keats	Austen
Overall enjoyment of EVA Park	5	5
Use of EVA Park on your own	2	5
Interactive features of EVA Park (e.g. making the donkey bray)	5	3
Being in EVA Park with the therapist	5	5
Therapy in EVA Park	5	5
Moving your avatar	5	5
Using the keypad	5	3
Using the mouse	5	5
Overall rating for your avatar	5	5
Using avatar gestures	4	No rating provided
Being in control of your avatar	5	5

Table 4
% of script related words and speech rate at each time point on treated (shaded cells) and untreated scripts

	Script 1		Script 2		Script 3		Script 4		Script 5	
	% Script Related Words	Rate: Words per Minute	% Script Related Words	Rate: Words per Minute	% Script Related Words	Rate: Words per Minute	% Script Related Words	Rate: Words per Minute	% Script Related Words	Rate: Words per Minute
Keats										
T1	16.07	57.27	5.21	39.31	25.81	56.00	12.90	67.50	8.80	66.00
T2	5.38	46.42	5.21	60.59	10.34	63.39	3.23	58.89	11.11	75.16
T3	78.57	84.88	32.29	56.32	0.00	60.00	9.68	79.00	15.56	95.29
T4	10.71	45.71	3.13	64.32	6.42	41.71	9.68	63.18	11.11	58.04
Austen										
T1	19.05	38.18	0.00	60.00	23.08	28.23	4.16	120.00	0.00	39.99
T2	23.81	41.05	5.26	73.33	3.85	16.36	0.00	22.75	3.12	45.00
T3	100	65.45	89.47	42.35	92.31	56.13	50.00	35.59	6.25	22.50
T4	80.95	71.25	73.68	45.00	96.15	64.99	4.16	27.27	3.12	34.28

T2 McNemar chi square $p = 0.15$), but a significant increase following therapy (T2 vs T3, McNemar chi square, $p < 0.001$). This increase was not maintained at T4 (T2 vs T 4, McNemar chi square, $p = 0.45$). A similar analysis was carried out on the pooled data from the untreated scripts. Here none of the findings was significant (T1 vs T2, McNemar, $p = 0.45$; T2 vs T3 McNemar chi square $p = 0.34$; T2 vs T4, McNemar chi square $p = 1$). Thus, Keats demonstrated a significant improvement in the production of script related words. However, this improvement was confined to treated scripts and was not maintained at the follow up assessment.

Turning to Austen, across the pooled treated script data there was no change in the number of correct words over the baseline period (T1 vs T2 McNemar Chi Square $p = 0.344$). Scores rose significantly at T3 (T2 vs T3 McNemar Chi Square, $p < 0.001$) and this change was maintained at T4 (T2 vs T4 McNemar Chi Square $p < 0.001$). The realisation of words in the one untreated script did not change significantly over time (T2 vs T3, McNemar chi square $p > 0.5$; T2 vs T4 McNemar chi square $p > 0.5$). Thus, Austen demonstrated a significant and well-maintained improvement in the production of script related words, but this was confined to treated scripts.

Speech rate data are also reported in Table 4. These were explored descriptively. Keats' rate increased on one treated script at T3 (Script 1) but not on the other (Script 2). His speaking rate on the untreated scripts was similarly variable. Two were produced more fluently immediately after therapy (Scripts 4 and 5), but one was not (Script 3). His speaking rates at T4 showed little change from the baseline values. Austen's speech rate increased at T3 and T4 on two treated scripts (Scripts 2 and 4). However, this was not the case for the other two treated scripts (Scripts 1 and 3), or for the untreated script (Script 5). Thus, Script

Table 5
Number of words, utterances and well formed sentences produced in the personal narratives at each time point

	Number of Words	Number of Utterances	Number of Well-Formed Sentences
Keats			
T1	169	29	6
T2	170	32	4
T3	205	31	4
T4	175	30	7
Austen			
T1	21	4	0
T2	82	2	0
T3	53	5	1
T4	103	4	0

Table 6
Raw scores on the CADL-2 at each time point

	T1	T2	T3	T4
Keats	81	86	85	90
Austen	71	70	77	77

Therapy did not consistently impact on the speaking rate of either participant.

3.4. RQ5: Improvements in narrative speech and functional communication

Table 5 reports the three analysed values from the personal narratives. These data offer little evidence of therapy induced change, for either participant.

Table 6 reports results from CADL-2 (Holland et al, 1999). A therapy effect cannot be argued for Keats. Austen's raw score increased by 7 points at T3, following a stable baseline, and that gain was maintained at T4.

4. Discussion

The first research question asked whether delivery of Script Therapy in EVA Park was feasible. Results were positive. In terms of compliance, one participant attended 100% of scheduled sessions and the other 85%. These figures exceed typical attendance rates for NHS outpatient appointments, which between 2009 and 2019 ranged from 78.2% to 81% (NHS Digital, 2019). The main reason for non-attendance in this study was failed internet connectivity. Such problems have been recorded in other studies of remote intervention (e.g., see Øra, Kirmess, Brady, Sørli, & Becker, 2020).

Compliance with generalisation practice was only achieved by Keats, largely because it was supported by a student of speech and language therapy. However, he also carried out independent practice using recordings of his script. Austen was invited to practise her scripts outside EVA Park with her husband, but rarely did so. Austen's husband often supported her access to EVA Park during therapy sessions. It is possible that further involvement in the generalisation practice was too demanding. Family supported homework showed poor compliance in a previous study (Rhodes & Isaki, 2018), suggesting that this is an insecure basis for script practice. It is also important that treatment does not have adverse side effects with respect to carer burden. Ruby Robot was not used for practice by either participant, possibly because of her un-responsive nature. Comments made by Keats during his interview suggested that modifications to EVA Park could promote self-initiated practice, such as the availability of audio recordings of scripts.

The fidelity data indicated that delivery of Script Therapy within EVA Park did not induce drift from the protocol. Excellent treatment fidelity has been demonstrated in previous administrations of Script Therapy (e.g., Grasso et al., 2019), possibly reflecting the highly prescribed nature of the intervention. In line with previous findings (Marshall et al., 2018) our data show that well established aphasia therapies can be delivered as intended within the environment of EVA Park.

The second research question asked whether delivery of Script Therapy in EVA Park would be acceptable to participants. The answer to this was 'yes'. In line with previous intervention studies involving this platform (Amaya et al., 2018; Marshall et al., 2018) participants rated the experience of receiving therapy in EVA Park highly and felt a strong connection with the treating therapist. Technical problems were flagged, but these did not undermine the overall experience for either Keats or Austen. Both participants in this study perceived changes to their speech as a result of the intervention. This is consistent with previous studies of Script Therapy, which documented self-reported changes in communication as elicited through interview (Cherney, Halper & Kaye, 2011) or questionnaire responses (Rhodes & Isaki, 2018).

The remaining research questions concerned the impact of therapy on participants' script production, spontaneous speech and functional communication. Previous studies of Script Therapy have consistently reported improved production of the words in trained

scripts (Hubbard et al., 2020), with most reporting maintenance of gains (e.g., Ali et al., 2018; Bilda 2011; Goldberg et al., 2012; Grasso et al., 2019; Youmans et al., 2005). In the current study production of trained scripts similarly improved, but maintenance at five weeks follow up was only achieved by Austen. It was also striking that Austen reached criterion on more scripts than Keats. In order to reduce burden, participants' language and cognition was not extensively tested pre-therapy. It is therefore difficult to hypothesise about why they responded differently to therapy. The speech samples (Table 2) and personal narrative data (Table 5) indicate that Keats had more extensive discourse production than Austen at baseline. In line with this, his scripts were longer than hers (see samples in Supplementary material). However, his CAT repetition scores were impaired, particularly with complex words and sentences (see Table 1). Given the role of repetition in Script Therapy, this factor may have been crucial.

A further limitation was the lack of change in speech rate. However, this has not been consistently demonstrated in previous studies of Script Therapy, particularly when aphasia was severe (Lee et al., 2009). Generalisation of gains to untreated scripts was achieved in some previous research (Bilda, 2011), but was not always shown or measured (e.g., Cherney et al., 2008; Grasso et al., 2019). In the current study, performance with untreated scripts remained unchanged for both participants.

There was no evidence of change in spontaneous speech for either Keats or Austen, as assessed by a personal narrative task. The measure of functional communication (CADL-2) was unaffected for Keats, but did improve following therapy for Austen. Her gain was also maintained at follow up. However, the change was modest and could not be assessed for clinical significance, making it difficult to draw strong conclusions.

It was hypothesised that situating Script Therapy within the simulated environment of EVA Park might promote generalisation of skills. In fact, there was little evidence of this. A previous intervention study using EVA Park did achieve significant change on a measure of functional communication, but included more one to one conversational practice and a weekly group conversation session (Marshall et al., 2016). It is possible that incorporating these additional components into EVA Park Script Therapy would enhance functional gains.

Future studies might explore whether treatment effects could be augmented through adjustments to the VR environment or other aspects of delivery. As suggested by Keats in his interview, enhancements to the platform might support independent practice. Such enhancements might include further interactive features, or arming Ruby Robot with speech recognition so that she can provide feedback. Creating greater synergy between script content and the contextual opportunities on offer within EVA Park might also be productive, so that language is practised in a range of appropriate settings. Keats's results also suggest that constraining the length of scripts may be important, although recent findings from Cherney and van Vuuren (2022) suggest that learning is promoted by adding to the linguistic complexity of target scripts. Thus, therapists may need to balance length, linguistic complexity and variety in the generation of scripts. The multiple settings of EVA Park, and opportunities for interactive communication afforded by the platform, offer a natural context for achieving this balance. As the therapist was represented by an avatar, participants lacked a visual articulatory model of their scripts. Although they did not comment on this negatively during the interviews, it may have affected outcomes, for example with respect to the time taken to reach criterion on trained scripts. Providing visual models during speech practice, for example through avatars with authentic mouth movements, might enhance gains. As argued above, the therapy protocol might also be augmented with further opportunities for one to one and group conversation practice.

Several limitations of this study need to be acknowledged. The time from data collection to publication has been extensive, mainly because of the Covid pandemic. However, Script Therapy is still a focus for research (Cherney & van Vuuren, 2022; Quique, Evans, Ortega-Llebaria, Zipse & Dickey, 2022) making our data current. Our assessors were not blinded to timepoint, although scorers were. As already suggested, further baseline testing could augment our understanding about candidacy for the treatment. Above all, these preliminary, single case results cannot be generalised to the wider population of people with aphasia.

Despite the limitations, the study adds to the evidence that Script Therapy can be provided remotely, in this case by an interactive VR technology. Alongside other papers (Carragher et al., 2020; Marshall et al., 2016, 2018, 2020) our findings show that EVA Park can be used to deliver a range of interventions and that it is enthusiastically received by its intended users. Events of the Covid pandemic have under-

scored the need for remote healthcare delivery. The EVA Park platform is a prototype, so further developments are required before the platform can be widely applied in clinical practice. Nevertheless, our findings show that remote VR might usefully augment mainstream aphasia therapy.

Acknowledgments

This study was funded by a research grant from The Tavistock Trust for Aphasia. EVA Park was developed with funding from the Stroke Association. We thank the students of Speech and Language Therapy who supported this work: Aneesa Malik and Bethannie Olding. We thank Nick Zwart for technical support for EVA Park. We thank our participants, Keats and Austen.

Conflict of interest

The authors have no conflict of interest to report

Supplementary material

The supplementary material is available in the electronic version of this article: https://dx.doi.org/10.3233/ACS-220014.

References

Ali, N., Rafi, M. S., Ghayas Khan, M. S., & Mahfooz, U. (2018). The effectiveness of script training to restore lost communication in a patient with Broca's aphasia. *Journal of the Pakistan Medical Association*, *68*(7), 1070-1075.

Amaya, A., Woolf, C., Devane, N., Galliers, J., Talbot, R., Wilson, S., & Marshall, J., (2018). Receiving aphasia intervention in a virtual environment: The participants' perspective. *Aphasiology*, *32*(5), 538-558. https://doi.org/10.1080/02687038.2018.1431831

Bilda, K., (2011). Video-based conversational script training for aphasia: A therapy study. *Aphasiology*, *25*(2), 191-201. https://doi.org/10.1080/02687031003798254

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Brown, E., & Cairns, P. (2004). A grounded investigation of game immersion. *CHI '04 Extended Abstracts on human factors in computing systems*. ACM, 1297-1300. https://doi.org/10.1145/985921.986048

Bryant, L., Bruner, M., & Hemsley, B. (2019) A review of virtual reality technologies in the field of communication disability: Implications for practice and research. *Disability and Rehabilitation: Assistive Technology*, *15*(4), 365-372. https://doi.org/10.1080/17483107.2018.1549276

Cacciante, L., Kiper, P., Garzon, M., Baldan, F., Federico, S., Turolla, A., & Agostini, M. (2021). Telerehabilitation for people with aphasia: A systematic review and meta-analysis. *Journal of Communication Disorders*, *92*, 106111-106111. https://doi.org/10.1016/j.jcomdis.2021.106111

Cao, Y., Huang, X., Zhang, B., Kranz, G. S., Zhang, D., Li, X., & Chang, J. (2021). Effects of virtual reality in post-stroke aphasia: A systematic review and meta-analysis. *Neurological Sciences*, *42*, 5249-5259. https://doi.org/10.1007/s10072-021-05202-5

Carragher, M., Steel, G., Talbot, R., Devane, N., Rose, M. L., & Marshall, J. (2021). Adapting therapy for a new world: Storytelling therapy in EVA park. *Aphasiology*, *35*(5), 704-729. https://doi.org/10.1080/02687038.2020.1812249

Cherney, L. R., Halper, A. S., Holland, A. L., & Cole, R. (2008). Computerized script training for aphasia: Preliminary results. *American Journal of Speech-Language Pathology*, *17*(1), 19-34. https://doi.org/10.1044/1058-0360(2008/003)

Cherney, L. R., Halper, A. S. & Kaye, R. C., (2011). Computer-based script training for aphasia: Emerging themes from post-treatment interviews. *Journal of Communication Disorders*, *44*(4), 493-501. https://doi.org/10.1016/j.jcomdis.2011.04.002

Cherney, L. R., & Van Vuuren, S. (2012). Telerehabilitation, virtual therapists, and acquired neurologic speech and language disorders. *Seminars in Speech and Language*, *33*, 243-257. https://doi.org/10.1055/s-0032-1320044

Cherney, L. R., Kaye, R. C., Lee, J. B., & van Vuuren, S. (2015). Impact of personal relevance on acquisition and generalization of script training for aphasia: A preliminary analysis. *American Journal of Speech-Language Pathology*, *24*(4), S913-S922. https://doi.org/10.1044/2015_AJSLP-14-0162

Cherney, L. R., Braun, E. J., Lee, J. B., Kocherginsky, M., & Van Vuuren, S. (2019). Optimising recovery in aphasia: Learning following exposure to a single dose of computer-based script training. *International Journal of Speech-Language Pathology*, *21*(5), 448-458. https://doi.org/10.1080/17549507.2019.1661518

Cherney, L. R., & Van Vuuren, S. (2022) Complexity and feedback during script training in aphasia: A feasibility study. *Archives of Physical Medicine and Rehabilitation*, *103*(7), S205-S214. https://doi.org/10.1016/j.apmr.2022.03.002

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008) Developing and evaluating complex interventions: The new Medical Research Council guidance. *BMJ*, *337*, a1655. https://doi.org/10.1136/bmj.a1655

Cummings, J. J., & Bailenson, J. N. (2016). How immersive is enough? A meta-analysis of the effect of immersive technology on user presence. *Media Psychology*, *19*(2), 272-309. https://doi.org/10.1080/15213269.2015.1015740

Fridriksson, J., Hubbard, H. I., Hudspeth, S. G., Holland, A. L., Bonilha, L., Fromm, D., & Rorden, C. (2012). Speech entrainment enables patients with broca's aphasia to produce fluent speech. *Brain: A Journal of Neurology*, *135*(Pt 12), 3815-3829. https://doi.org/10.1093/brain/aws301

Giachero, A., Calati, M., Pia, L., La Vista, L., Molo, M., Rugiero, C., Fornaro, C., & Marangolo, P. (2020). Conversational therapy through semi-immersive virtual reality

environments for language recovery and psychological well-being in post stroke aphasia. *Behavioural Neurology*, *2020*, 1-15. https://doi.org/10.1155/2020/2846046

Goldberg, S., Haley, K. L., & Jacks, A. (2012). Script training and generalization for people with aphasia. *American Journal of Speech-Language Pathology*, *21*(3), 222-238. https://doi.org/10.1044/1058-0360(2012/11-0056)

Grasso, S. M., Cruz, D. F., Benavidez, R., Peña, E. D., & Henry, M. L. (2019). Video-implemented script training in a bilingual spanish-english speaker with aphasia. *Journal of Speech, Language, and Hearing Research*, *62*(7), 2295-2316. https://doi.org/10.1044/2018_JSLHR-L-18-0048

Grechuta, K., Rubio, B., Duff, A., Oller, E., Pulvermuller, F. & Verschure, P. (2016) Intensive language-action therapy in virtual reality for a rehabilitation gaming system. *Journal of Pain Management*, *9*(3), 243-254.

Grechuta, K., Bellaster, B., Munne, R., Bernal, T., Hervas, B., Segundo, R., & Verschure, P. (2017) The effects of silent visuomotor cuing on word retrieval in Broca's Aphasics: A Pilot Study. *International Conference on Rehabilitation Robotics (ICORR)*. London, UK. https://doi.org/10.1109/ICORR.2017.8009245

Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., Altman, D. G., Barbour, V., Macdonald, H., Johnston, M., Lamb, S. E., Dixon-Woods, M., McCulloch, P., Wyatt, J. C., Chan, A., & Michie, S. (2014). Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. *BMJ*, *348*(mar07 3), g1687-g1687. https://doi.org/10.1136/bmj.g1687

Holland, A., Frattali, C., & Fromm, D. (1999). *Communication activities of daily living-2*. Austen TX: Pro-Ed.

Holland, A. L., Halper, A. S. & Cherney, L. R., (2010). Tell me your story: Analysis of script topics selected by persons with aphasia. *American Journal of Speech-Language Pathology*, *19*(3), 198-203. https://doi.org/10.1044/1058-0360(2010/09-0095)

Hubbard, H. I., Nelson, L. A., & Richardson, J. D. (2020). Can script training improve narrative and conversation in aphasia across etiology? *Seminars in Speech and Language*, *41*(1), 099-124. https://doi.org/10.1055/s-0039-3401030

Landis, R., & Koch, G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159-174. https://doi.org/10.2307/2529310

Lee, J. B., Kaye, R. C., & Cherney, L. R. (2009). Conversational script performance in adults with non-fluent aphasia: Treatment intensity and aphasia severity. *Aphasiology*, *23*(7-8), 885-897. https://doi.org/10.1080/02687030802669534

Maresca, G., Grazia Maggio, M., Latella.D., Cannavo, A., De Cola, M., Portaro, S., Stagnitti, M., Silvestri, G., Torrisi, M., Bramanti, A., De Luca, R., & Calabro, R. (2019). Toward improving poststroke aphasia: A pilot study on the growing use of telerehabilitation for the continuity of care. *Journal of Stroke and Cerebrovascular Diseases*, *28*(10), 104303. https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.104303

Marshall, J., Booth, T., Devane, N., Galliers, J., Greenwood, H., Hilari, K., Talbot, R., Wilson, S., & Woolf, C., (2016). Evaluating the benefits of aphasia intervention delivered in virtual reality: Results of a quasi-randomised study. *PloS One*, *11*(8). https://doi.org/10.1371/journal.pone.0160381

Marshall, J., Devane, N., Edmonds, L., Talbot, R., Wilson, S., Woolf, C., & Zwart, N., (2018). Delivering word retrieval therapies for people with aphasia in a virtual communication environment. *Aphasiology*, *32*(9), 1054-1074. https://doi.org/10.1080/02687038.2018.1488237

Marshall, J., Devane, N., Talbot, R., Caute, A., Cruice, M., Hilari, K., MacKenzie, G., Maguire, G., Patel, A., Roper, A., & Wilson, S. (2020). A randomised trial of social support group intervention for people with aphasia: A Novel application of virtual reality. *PloS One*, *15*(9). https://doi.org/10.1371/journal.pone.0239715

NHS Digital (2019) Hospital Outpatient Activity 2018-2019. [pdf] https://files.digital.nhs.uk/33/EF9007/hosp-epis-stat-outp-summ-rep-2018-19-rep.pdf (Accessed 4.5. 2020)

Nobis-Bosch, R., Springer, L., Radermacher, I., & Huber, W. (2011). Supervised home training of dialogue skills in chronic aphasia: A randomized parallel group study. *Journal of Speech, Language, and Hearing Research*, *54*(4), 1118-1136. https://doi.org/10.1044/1092-4388(2010/09-0204)

Øra, H. P., Kirmess, M., Brady, M. C., Partee, I., Hognestad, R. B., Johannessen, B. B., Thommessen, B., & Becker, F. (2020). The effect of augmented speech-language therapy delivered by telerehabilitation on poststroke aphasia—a pilot randomized controlled trial. *Clinical Rehabilitation*, *34*(3), 369-381. https://doi.org/10.1177/0269215519896616

Øra, H. P., Kirmess, M., Brady, M. C., Sørli, H., & Becker, F. (2020). Technical features, feasibility, and acceptability of augmented telerehabilitation in post-stroke Aphasia—Experiences from a randomized controlled trial. *Frontiers in Neurology*, *11*, 671-671. https://doi.org/10.3389/fneur.2020.00671

Pitt, R., Theodoros, D., Hill, A. J., & Russell, T. (2018). The impact of the telerehabilitation group aphasia intervention and networking programme on communication, participation, and quality of life in people with aphasia. *International Journal of Speech-Language Pathology*, *21*(5), 513-523. https://doi.org/10.1080/17549507.2018.1488990

Quique, Y. M., Evans, W. S., Ortega-Llebaría, M., Zipse, L., & Dickey, M. W. (2022). Get in Sync: Active Ingredients and Patient Profiles in Scripted-Sentence Learning in Spanish Speakers with Aphasia. *Journal of Speech, Language, and Hearing Research*, *65*(4), 1478-1493. https://doi.org/10.1044/2021_JSLHR-21-00060

Repetto, C., Paolillo, M. P., Tuena, C., Bellinzona, F., & Riva, G. (2021). Innovative technology-based interventions in aphasia rehabilitation: A systematic review. *Aphasiology*, *35*(12), 1623-1646. https://doi.org/10.1080/02687038.2020.1819957

Rhodes, N. C., & Isaki, E., (2018). Script training using telepractice with two adults with chronic non-fluent aphasia. *International Journal of Telerehabilitation*, *10*(2), 89-104. https://doi.org/10.5195/ijt.2018.6259

Rochon, E., Saffran, E. M., Berndt, R. S., & Schwartz, M. F., (2000). Quantitative analysis of aphasic sentence production: Further development and new data. *Brain and Language*, *72*(3), 193-218. https://doi.org/10.1006/brln.1999.2285

Rose, T. A., Worrall, L. E., Hickson, L. M., & Hoffmann, T. C. (2012). Guiding principles for printed education materials: Design preferences of people with aphasia. *International Journal of Speech Language Pathology*, *14*(1), 11-23. https://doi.org/10.3109/17549507.2011.631583

Swinburn, K., Porter, G., & Howard, D. (2004). *Comprehensive aphasia test*. Taylor & Francis.

Weidner, K., & Lowman, J. (2020). Telepractice for adult speech-language pathology services: A systematic review. *Perspectives of the ASHA Special Interest Groups*, *5*(1), 326-338. https://doi.org/10.1044/2019_PERSP-19-00146

Wilson, S., Roper, A., Marshall, J., Galliers, J. R., Devane, N., Booth, T., & Woolf, C. (2015). Codesign for people with aphasia through tangible design languages. *CoDesign*, *11*(1), 21-34. https://doi.org/10.1080/15710882.2014.997744

Woolf, C., Caute, A., Haigh, Z., Galliers, J., Wilson, S., Kessie, A., Hirani, S., Hegarty, B., & Marshall, J., (2016). A comparison of remote therapy, face to face therapy and an attention control intervention for people with aphasia: A quasi-randomised controlled feasibility study. *Clinical Rehabilitation*, *30*(4), 359-373. https://doi.org/10.1177/0269215515582074

Youmans, G., Holland, A., Muñoz, M., & Bourgeois, M. (2005). Script training and automaticity in two individuals with aphasia. *Aphasiology*, *19*(3-5), 435-450. https://doi.org/10.1080/02687030444000877