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Script Templates: A Practical Approach to Script Training in Aphasia

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Abstract

Purpose—Script training for aphasia involves repeated practice of relevant phrases and sentences that, when mastered, can potentially be used in other communicative situations. Although an increasingly popular approach, script development can be time-consuming. We provide a detailed summary of the evidence supporting this approach. We then describe a method in which scripts at various levels of difficulty are created by systematically manipulating readability and grammatical and semantic components. We assess the appropriateness of using these template-based scripts with persons with aphasia of differing severities.

Method—We evaluated the oral reading performance of eight individuals with chronic non-fluent aphasia on scripts developed from the templates. Scripts were either of high or low difficulty relative to their aphasia severity, and personalized by inserting the participant's town and the name of an acquaintance. Oral reading probes were taken on three separate days within a week and performance within and across participants was examined.

Results—Regardless of the participant's aphasia severity, scripts in the low-difficulty condition were read with significantly greater accuracy than scripts in the high-difficulty condition.

Discussion—These findings support the use of graded script templates to ensure that appropriately challenging scripts are delivered to persons with aphasia for both clinical practice and research.

Script training in aphasia is a treatment approach that focuses on improving communication in everyday activities. It typically involves the repeated practice of words, phrases, and sentences embedded within a monologue or dialogue that is individualized to the person

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with aphasia. Script practice can be accomplished in various ways, including listening to the script, repeating the target utterances, reading them aloud, producing them from memory, or performing a combination of these activities. Based on the Instance Theory of Automatization (Logan, 1988), the premise of this approach is that words or phrases within a script can be successfully mastered with repetitive, cue-based massed drilling. They become “islands of relatively fluent automatic speech” that are then produced in real-life discourse (Youmans, Youmans, & Hancock, 2011).

An increasing number of studies have found support for script training in aphasia, using both objective measures and reports from persons with aphasia, their family, and friends. Table 1 provides a summary of 13 publications that provide evidence for this approach (Bilda, 2011; Cherney & Halper, 2008; Cherney, Halper, Holland, & Cole, 2008; Cherney, Halper, & Kaye, 2011; Cherney, Kaye & Van Vuuren, 2014; Cherney, Kaye, Lee, & Van Vuuren, 2015; Goldberg, Haley, & Jacks, 2012; Lee, Kaye, & Cherney, 2009; Manheim, Halper, & Cherney, 2009; Nobis-Bosch, Springer, Radermacher, & Huber, 2011; Van Vuuren & Cherney, 2014; Youmans, Holland, Munoz, & Bourgeois, 2005; Youmans et al., 2011). It is important to note that several of the publications present different analyses of data from the same set of subjects (e.g., Cherney et al., 2014, 2015; Van Vuuren & Cherney, 2014); however, overall, the studies were conducted by five different research groups and include over 60 unique participants. Participant characteristics, specifics of the intervention, outcome measures, and results are compared in Table 1. Successful acquisition of scripts occurred in all studies. This was true whether or not the scripts were personalized, and whether practice was principally or exclusively completed with a live therapist, or with independent practice at home that was supported by technology. Maintenance of the scripts also was successful to a large extent. Generalized use of specific trained phrases and sentences in different situations and with different communication partners was generally limited. However, participants across several studies reported increased confidence in their ability to communicate and overall improved communication in everyday situations (Bilda, 2011; Cherney et al., 2011; Youmans et al., 2011).

Essential to any type of script training is the development of a script that is relevant to the person with aphasia and appropriate for the severity of his or her aphasia. Script development is best done as a collaborative process together with the person with aphasia (Holland, Halper, & Cherney, 2010). However, writing an individualized script for each person is time-consuming, and in the current climate of limited insurance benefits, such an approach may not even be possible. As an alternative, using a standard script for everyone may be cost-efficient, and may still impart some of the same benefits as a customized script. However, if the same script is given to all people with aphasia, and that script is at a single level of difficulty, those who are more severe or those who are too mild may not benefit. The script may be too difficult for those with a severe aphasia and too simple for those with a mild aphasia.

A similar problem can occur in research studies, where consistency of all but the treatment variable is essential. If participants with different severities of aphasia are given the same script, there may be great variability in their pre-treatment level of performance. We confronted this problem in our own studies. Although participants who were less severe

received longer scripts, their initial performance accuracy was still considerably higher than those who were more severe (64% versus 26.2%), making it difficult to compare absolute gains across participants (Cherney et al., 2014). In addition, participants who were milder and started the intervention at a baseline accuracy greater than 80% quickly reached ceiling.

In this report, we describe a method of systematically developing scripts of varying levels of difficulty for persons with different aphasia severities as determined by the Aphasia Quotient (AQ) of the Western Aphasia Battery-Revised (WAB-R) (Kertesz, 2006). The method begins with a simple script template that is systematically modified in terms of readability and grammatical and semantic difficulty. Personalized content is added to each script so it becomes more meaningful to the person with aphasia. We also assess oral reading of these template-based scripts to determine whether or not they are practical to use with participants who differ in the severity of their aphasia.

CREATING SCRIPTS

Script Templates

To create the scripts, we chose two topics representing typical situations for most people in our region: Ordering pizza in a restaurant (with the person with aphasia speaking to a server) and planning to buy groceries (with the person speaking to a close acquaintance). We next developed a script template for each topic--a dialogue of 10 turns between the person with aphasia and the server or acquaintance, with the person with aphasia as the responder in each turn. The responses of the person with aphasia were written at five different levels of difficulty by modifying the readability and grammatical and semantic complexity as described below. The responses of the conversational partner remained the same at all levels.

Increasing Readability Difficulty

We used the Flesch-Kincaid Grade Level Formula to calculate an overall measure of ease of readability (Kincaid, Fishburne, Rogers, & Chissom, 1975). This formula uses three components — syllables, words, and sentences — to create a sentence difficulty measure (average sentence length, or ASL) and a word difficulty measure (average syllables per word or ASW) that are then combined to derive a grade level score. The specific formula is $(0.39 \times \text{ASL}) + (11.8 \times \text{ASW}) - 15.59$. We began with a simple script of 10 turns, with approximately 5 words per sentence and 1.2 syllables. This corresponded to a Flesch-Kincaid grade level score of about 0.50 for each of the two scripts. Beginning at this lowest grade level (level 1), we gradually added more words, sentences, and syllables to each turn. For example, from level 1 to 2, the restaurant script increased from a total of 62 to 82 words and 71 to 100 syllables. A spreadsheet was designed so that any change in word, sentence, or syllable count automatically recalculated the Flesch-Kincaid score. Table 2 shows how these measures increased with each grade level, and how the restaurant and grocery scripts at each level were closely matched.

Increasing Grammatical Difficulty

We used morphemes per word as a measure of grammatical difficulty, based in part on the reasoning that such a measure would capture inflections on verbs (among other morphemes)

and that more verbs represent greater clausal complexity. Beginning with the grade 1 scripts, which had 62 and 56 words, and 74 and 66 morphemes (1.19 and 1.18 morphemes per word), we added more multi-morpheme words to each level, so that level 5 had 175 and 172 words, and 230 and 226 morphemes (1.31 morphemes per word).

Increasing Semantic Difficulty

To systematically increase semantic difficulty, the templates contained noun category slots at various places within the scripts. The words filling each category slot decreased in frequency of occurrence (and therefore increased in difficulty) at each grade level, while the meaning of each remained roughly the same. The estimate of a word's semantic difficulty was derived from the Corpus of Contemporary American English (Davies, 2008). The less frequent the word, the more semantically difficult it is. The ten categories, the five words within each category, and the frequencies of those words are listed in Table 3.

Below is an example from the pizza restaurant script showing how the words were integrated into the script at the different levels of difficulty. In this example, the target word is “idea;” other less frequent words are substituted for *idea* as the difficulty level increases. Note that other measures of difficulty such as words and sentences per turn, morphemes per word, words per sentence, and syllables per word increased along with semantic difficulty.

Semantic category: *idea*

Server:

All Levels: Then you better get the thin crust.

Person with aphasia:

Level 1: Good *idea*.

Level 2: That's a good *thought*.

Level 3: That's good *advice*. Eating's not enjoyable when you're rushing.

Level 4: That's a very good *suggestion*. Eating's not enjoyable when you're rushing.

Level 5: That's a good *recommendation*. When I'm hungry, I can't really enjoy my food.

Personalizing Content

To add a degree of personalization to the scripts, without changing the structural properties or grade level, we inserted the names of the participant's town and a close acquaintance into each script. Supplemental Digital Content A includes both scripts in their entirety, showing how each sentence was modified at each level of difficulty.

Matching script level with aphasia severity

As a starting point in matching script difficulty level with aphasia severity, we estimated that an appropriate or “standard” difficulty level of a script with which to begin training would be

one where the participant's independent oral reading accuracy was about 30% on first presentation. A script at this difficulty level would be sufficiently challenging for the participant, and baseline scores of 30% would minimize the potential for a ceiling or capping of the gains. We selected oral reading as the task on which to measure performance to minimize errors in production that could occur from problems in auditory working memory (e.g., in a repetition task).

To evaluate the parameters of such a script in relation to aphasia severity we reviewed a prior study of script training (Cherney et al., 2014). In this study, eight participants with aphasia, with WAB-R AQs of 20–80, were given scripts of ten turns but of varying lengths within each turn depending upon the participant's severity. Two participants with more severe aphasia (AQs of 20–40; mean 31.7) and two participants with moderate aphasia (AQs of 50–60; mean 54.7) had an almost identical mean accuracy of performance on independent oral reading of the script (25.7% and 26.6% respectively) at baseline. Analysis of the difficulty of the scripts showed that syllables, morphemes and words per turn were higher in the scripts given to the 50–60 AQ group as compared to the 20–40 AQ group (7.3 vs. 6.1 words, 8.7 vs. 7.7 syllables, and 7.9 vs. 6.6 morphemes per turn). We judged that the parameters of these two script levels were appropriate for the participants with aphasia at these severity levels. Since no participants had AQs of 40–50, we expanded the upper severity limit of the more severe aphasia group to an AQ of 50 for purposes of matching script difficulty to aphasia severity.

In contrast, the pretreatment mean oral reading performance of the four subjects whose aphasia levels were less severe (AQs of 60–80; mean 72.8) was 64.8% accuracy, with scripts containing 11.2 words, 13.3 syllables, and 13.2 morphemes per turn. We concluded that the parameters of these scripts needed to be adjusted to increase script difficulty in order to achieve the target 30% pre-treatment accuracy.

DATA COLLECTION AND ANALYSIS

To evaluate the usefulness of this framework, we examined how persons with aphasia would perform before any treatment was given. We contrasted performance on two different levels of difficulty, high and low, relative to the person's severity of aphasia. After determining parameters for a typical or "standard" level of difficulty based on the prior study as described above, we defined low difficulty as one level below "standard," and high difficulty as one level above "standard." Assignment of script level based on WAB-R AQ is shown in Table 4. Note that script level 3 was considered low difficulty for persons with AQs from 60–80 and high difficulty for persons with AQs from 35–50.

A WAB-R AQ score of 60 was used as a cut-off to divide participants into more and less severe aphasia groups. Within each severity group, participants were then randomized to either a low- or high-difficulty script condition.

We used measures of oral reading accuracy to evaluate script performance on the low- and high-difficulty scripts. We expected that participants who received low-difficulty level scripts relative to their aphasia severity would perform similarly. We also expected that

participants who received high-difficulty level scripts relative to their aphasia severity would perform similarly, and that their performance would differ from the performance of those who received low-difficulty scripts.

Oral reading probes of the written script were taken on three separate days within a week. A version of the AphasiaScripts® treatment software was modified to allow the delivery and recording of the probes on pre-specified dates via computer. An anthropomorphically accurate digital “therapist”, who was capable of visually modeling speech, interactively guided the probes. Delivering the probes via computer removed clinician-related variables (e.g., clinician expertise, personality factors) that could potentially influence fidelity of probe administration.

A probe from script level 3 is illustrated in Figure 1. After the digital therapist spoke her turn, the person with aphasia read aloud his/her part without any cues from the digital therapist. The participant then pressed the space bar to go to the next turn, until all ten turns of the script were read. High-quality recordings of the probes were captured by the computer program.

Each word of the recorded probes was scored on the Naming and Oral Reading for Language in Aphasia (NORLA-6) scale (Gingrich et al., 2013), where 0 = no response; 1 = unintelligible or unrelated response; 2 = semantic or phonological paraphasia; 3 = appropriate and intelligible responses with minor errors such as the omission of a grammatical morpheme; 4 = accurate but delayed or self = corrected response; and 5 = accurate and immediate response. Evidence of the validity and reliability of the NORLA-6 has been previously demonstrated (Cherney et al., 2014, Gingrich et al., 2013).

Each script was scored for percent accuracy derived from the total NORLA-6 accuracy score achieved by the participant divided by the maximum possible score for the script (i.e., 5 points per word $\times$ the number of words in the script).

RESULTS

Participants

Eight non-fluent individuals with chronic aphasia due to a left-hemisphere stroke participated. They were native speakers of English, had passed a vision and hearing screen, and had received no other speech-language therapy services for one month prior to their participation. Table 5 shows the demographic data for each participant. Their aphasia severity, based on the WAB-R AQ ranged from 38.0 to 80.8 ($M=60.4$; $SD=16.8$).

The four participants assigned to the relatively high-difficulty scripts were BERJE, DAVAR, MCCLA, and SCOLI. The four participants assigned to the relatively low-difficulty scripts were CLEJO, CORLA, DALRU, and KARYA.

Script Performance

There was no significant difference ($p=.48$) in mean AQ between participants in the high-difficulty (mean AQ=55.8; $SD=19.3$) and low-difficulty (mean AQ=65.1, $SD=15.0$)

conditions. Figure 2 shows the oral reading accuracy for each participant at each probe day. As expected, the level of difficulty of the script relative to aphasia severity resulted in consistent oral reading accuracy across participants, except for one outlier (MCCLA).

Visual inspection of each participant's performance indicates little difference in performance between probe days 1, 2, and 3. In addition, mean performance by each participant was not significantly different on the restaurant versus the grocery scripts ($p=.60$ on a two-tailed paired t-test). For this reason, the three probe days and two scripts were combined into one mean probe score for each participant. Mean accuracy per participant is listed in Table 6. The mean percent accuracy was 26.4% (SD= 21.1%) for the high-difficulty group and 54.3% (SD= 8.8%) for the low-difficulty group. One-tailed t-tests indicated significantly greater accuracy in oral reading of low-difficulty over high-difficulty scripts ($p<.05$). The effect size for low-over high-difficulty scripts was 1.73, which is considered to be large (Cohen 1988).

Visual examination of Figure 2 also shows that MCCLA performed differently from the other participants who were randomized to scripts of high difficulty. Her score of 58% is an outlier within the high-difficulty condition, as compared to the three other participants' scores of 16.8%, 14.5% and 16.1%. Using Dixon's Q-test, MCCLA's score is characterized as an outlier at the 99% confidence level for $n=4$ (Dean & Dixon, 1951; Rorabacher, 1991). When MCCLA's scores are omitted, the mean accuracy of the high-difficulty group decreases to 15.8% (SD=1.2%), and the difference between the high- and low-difficulty conditions becomes highly significant ($p<.0005$) in a one-tailed t-test, with a very large effect size of 6.1 (Cohen, 1988).

Using the restaurant script, we also examined performance on the target words listed in Table 3 that decreased in frequency at each grade level. Mean accuracy was 31.5% for words in the high-difficulty condition and 45.0% for words in the low-difficulty condition. (Note that the same word could be in the high-difficulty or low-difficulty condition depending on the participant's AQ.) A one-tailed t-test indicated no significant difference between the two conditions ($p=0.24$). However, once MCCLA, as an outlier, was excluded, a one-tailed t-test indicated a significant difference between the words in high- and low-difficulty conditions ($p<.05$), with a large Cohen's d effect size of 2.56. Mean accuracy for the high-difficulty condition then became 15.1%, in contrast to 45.0 % for the low-difficulty condition.

Finally, a minimal amount of personalization seemed to enhance the participants' sense of the script's individualization. While only anecdotal, the majority of participants remarked on how the insertion of the name of the acquaintance and town made the script feel more relevant to them.

DISCUSSION

Script training is an efficacious approach to aphasia treatment, but script development can be a time-consuming process. We describe a method in which script templates with five levels of difficulty were created by systematically manipulating readability and semantic and grammatical difficulty. Eight participants with chronic non-fluent aphasia were presented

with the scripts at a level that was either of high difficulty (four participants) or low difficulty (four participants) relative to their WAB-R AQ. Performance was evaluated by oral reading accuracy of each script. Regardless of the participant's aphasia severity, scripts in the low-difficulty condition were read with significantly ($p < .001$) greater accuracy (54.4%) than scripts in the high-difficulty condition (15.8%), with a Cohen's d effect size for low over high difficulty of 6.4. These findings support the use of script templates and quantifying difficulty to ensure consistent performance before treatment.

The main advantage of using script templates over customized scripts is efficiency. Once a participant's aphasia severity is known, therapists can choose a previously created script at a level based on the oral reading accuracy they wish the participant to demonstrate before beginning treatment. Researchers comparing script learning under different treatment conditions can also use templates to ensure that participants in all treatment conditions perform at the same baseline level of accuracy. Treatment fidelity also can be increased by using script templates instead of customized scripts. Script creation can be further streamlined with fewer turns per script, and a minimal level of personalization may be achieved by simply including names of the participant's town and close acquaintance.

The purpose of using script templates and varying their difficulty is to achieve a cost-efficient method of creating scripts that would share the same benefits as time-intensive customized scripts: (1) being at an appropriate level for the person with aphasia; and (2) feeling relevant to the person's everyday life. The first criterion was addressed by systematically creating five difficulty levels that match the participant's aphasia severity. The second criterion was addressed by using templates involving activities common to most people in the region, and by adding the names of the participant's town and someone close to them. There are, however, no studies comparing the effectiveness of treatment with customized scripts versus template-based scripts, or whether the additional benefits of customized scripts—if there are any-- outweigh the cost in therapist time.

There are several limitations to these preliminary findings. Foremost is their generalizability. Our sample of eight participants with aphasia was small and they were all non-fluent. While restaurant and grocery scripts at each difficulty level yielded nearly identical performance, we cannot be certain that this would apply to a wider range of scripts. Future steps to confirm and refine these findings would involve a larger number of participants and a larger variety of scripts. Results with fluent participants are also unknown, but they are now being explored by our research team.

Additionally, script difficulty yielded a consistent pattern of results except for one outlier (MCCLA) who was randomized to the high-difficulty condition, but performed more like a participant in the low difficulty condition. This participant's oral reading was nearly perfect (19/20) as measured by the score on the WAB-R Reading Commands subtest, and better than that of any other participant. The high-difficulty script may have actually been low-difficulty relative to her abilities. This suggests that the WAB-R oral reading score, rather than the WAB-R AQ, may be a more accurate determinant of which script level to give to the participant with aphasia to yield consistent results. More support for this is evident from a comparison of DALRU and CORLA, who were both assigned level 3 scripts in the low-

difficulty condition. While CORLA's AQ (80.8) was higher than DALRU's (74.5), his WAB-R oral reading score (75% of maximum) was lower than DALRU's (85% of maximum). CORLA's probe accuracy (67.1%), like his WAB-R oral reading but unlike his WAB-R AQ, was also lower than DALRU's (49%). The evaluation of the WAB oral reading score and other measures of performance (e.g., auditory comprehension) for matching the level of script difficulty requires further study.

Another issue is the Flesch-Kincaid score's sensitivity to minimal text changes when only a small text sample is analyzed. To demonstrate, we increased the level 2 restaurant script from grade 1.7 to 2.7 by simply adding the common words *about*, *very*, *really*, *dinner*, and *probably*, and substituting *We haven't ever* for *We've never*. A more straightforward and robust set of measures may be the number of words, syllables, and morphemes per ten turns. By averaging the counts of the restaurant and grocery scripts, we found that levels 1 through 5 could be closely achieved by starting level 1 with approximately 60 words, 70 syllables, and 70 morphemes per ten turns. These counts could then be multiplied by 1.4, 2, 2.5 and 3.25 to approximate levels 2 through 5 respectively. For example, level 2 would be expected to have 84 words per ten turns (60×1.4), 98 syllables (70×1.4), and 98 morphemes (70×1.4).

The present investigation demonstrates a method of creating scripts from templates that are systematically altered to produce five levels of measurable difficulty. Performance on oral reading probes provided evidence to validate these levels of difficulty. Identifying the appropriate level of difficulty that will promote optimum outcomes that include generalization to authentic communication situations is a next step in understanding how best to implement script training. Future steps also would include studying a larger number of subjects, a greater variety of conversational topics, fluent as well as non-fluent persons with aphasia, and the effects of modifying various other parameters (e.g., phonetic complexity of the words) that may contribute to difficulty levels. In addition, comparing treatment outcomes using customized versus template-based scripts could yield valuable information about the costs and benefits of script training,

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Screenshot of a probe. The digital therapist speaks her turn, then the participant reads the response aloud without cues.

Figure 2. Accuracy of probes 1, 2, and 3 for each subject in the high-difficulty (n=4) and low-difficulty (n=4) script conditions.

Table 1

Summary of aphasia script studies (in chronological order)

Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
Script training and automaticity in two individuals with aphasia. Yehmans et al. (2005).	2	Broca's, AQ 48.7 Conduction, AQ 68.8 At least 10 years post-stroke	Single subject, multiple baseline	3 scripts per participant Scripts were 3–4 sentences and 13–32 words Personalized: Participant and clinician collaborated on topics and wording.	Per script: • Clinic: 30–45 min/session 3 sessions/wk • Home: 15 min/day 1 script begun after mastery of previous script.	Sessions in clinic with therapist using repetition and memorization. Practice at home with support of audiotapes from client-clinician practice. Practiced scripts as monologues, then in conversational contexts with therapist.	Probes of script production without support Percent script correct Rate of script-related words Errors	3 scripts mastered in 25–26 sessions by each person with aphasia. (Mastery = scripts produced from memory with 97–100% accuracy) Increased speaking rate Relatively errorless production. Generalized to conversations, novel partners and cues only in a limited fashion.
Computerized script training for aphasia: Preliminary results. Cherney et al. (2008).	3	Broca's, Wernicke's, Anomic WAB AQ range 50.4–73.2 At least 6 months post-stroke	Single subject, multiple baseline across scripts	1 monologue & 2 dialogues per person w aphasia. Scripts were 8–10 turns, with 40–140 words per script. Personalized: Person w aphasia and clinician collaborated on topics and wording.	Per script • Clinic 1 30-min visit/wk • Home 30 min/day minimum 6 days/wk for 3 wks Scripts practiced consecutively	Person with aphasia practiced with virtual therapist on computer, cued by written words, choral speaking, and oral-motor movements of the virtual therapist. Cues gradually removed each week.	Probes of oral reading of scripts: Content (# and % of script-related words) Grammatical productivity (# of morphemes, nouns, verbs, modifiers) Rate of script-related words WAB AQ, CADL-2, QCL scale	All participants showed positive changes in the content, grammatical productivity, and rate of script production. 2 of 3 participants showed clinically significant improvements on the WAB AQ No improvement on CADL-2 or QCL
Novel technology for treating	3	2 Nonfluent 1 Fluent	Single subject,	1 monologue & 2 dialogues per	Per script	Person with aphasia practiced with virtual therapist on computer, cued	Probes of oral reading of scripts:	Variability across scripts; 2

Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
individuals with aphasia and concomitant cognitive deficits, Cherney & Halper (2008).		WAB AQ = 51.4 and 51.9 for Nonfluent; 81 for Fluent At least 6 months post-stroke	multiple baseline across scripts	person w aphasia. Scripts were 8–10 turns, with 40–140 words per script. Personalized: Person w aphasia and clinician collaborated on topics and wording.	<ul style="list-style-type: none"> Clinic 1 30-min visit/wk Home 30 min/day minimum 6 days/wk for 3 wks <p>Scripts practiced consecutively</p>	by written words, choral speaking, and oral-motor movements of the virtual therapist. Cues gradually removed each week.	Content (# and % of script-related words) Grammatical productivity (# of morphemes, nouns, verbs, modifiers) Rate of script-related words WAB AQ, CADL-2, QCL scale	participants improved on 2 of 3 scripts in measures of content, grammatical productivity, and rate of script production. 1 of 3 participants showed clinically significant improvements on the WAB AQ
Patient-reported changes in communication after computer-based script training for aphasia. Manheim et al., (2009)	20	14 Non-fluent, 6 Fluent WAB AQ 30.5–85.3 Mean 64.57, SD 15 At least 6 months post-stroke	Single subject, multiple baseline across scripts	1 monologue & 2 dialogues per person w aphasia Scripts were 8–10 turns, with 40–140 words per script. Person w aphasia and clinician collaborated on topics and wording.	<p>Per script</p> <ul style="list-style-type: none"> Clinic 1 30-min visit/wk Home 30 min/day minimum 6 days/wk for 3 wks <p>Scripts practiced consecutively</p>	Person with aphasia practiced with virtual therapist on computer, cued by written words, choral speaking, and oral-motor movements of the virtual therapist. Cues gradually removed each week.	Communication Difficulty (CD) subscale of the Burden of Stroke Scale (BOSS)	There was a statistically significant decrease in the CD subscale of the BOSS. Maintained 6 wks later
Conversational script performance in adults with non-fluent aphasia: Treatment intensity and aphasia severity Lee et al., (2009)	17*	Non-fluent WAB AQ 30.5–85.3 Mean 65.1, SD 15.3 At least 6 month post-stroke	Single subject, multiple baseline across scripts	1 monologue & 2 dialogues per person w aphasia Scripts were 8–10 turns, with 40–140 words per script. Person w aphasia and clinician collaborated on topics and wording.	<p>Per script</p> <ul style="list-style-type: none"> Clinic 1 30-min visit/wk Home 30 min/day minimum 6 days/wk for 3 wks <p>Scripts practiced consecutively</p>	Person with aphasia practiced with virtual therapist on computer, cued by written words, choral speaking, and oral-motor movements of the virtual therapist. Cues gradually removed each week.	Probes of oral reading of scripts: Content (# and % of script-related words) Rate of script-related words	Amount of practice hours significantly correlated with gain in the % of script-related words in more severe aphasia, and with rate of script-related words in less severe aphasia

Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
Computer-based script training for aphasia: Emerging themes from post-treatment interviews. Cherney et al. (2011). <i>Top Lang Disord.</i> Author manuscript; available in	23 ^{**}	15 Nonfluent, 8 Fluent WAB AQ 30.5–90 At least 6 months post-stroke	Single subject, multiple baseline across scripts	1 monologue & 2 dialogues per person w aphasia Scripts were 8–10 turns, with 40–140 words per script. Person w aphasia and clinician collaborated on topics and wording.	Per script • Clinic 1 30-min visit/wk • Home 30 min/day minimum 6 days/wk for 3 wks Scripts practiced consecutively	Person w aphasia practiced with virtual therapist on computer, cued by written words, choral speaking, and oral-motor movements of the virtual therapist. Cues gradually removed each week.	Post-treatment interviews of persons with aphasia and/or significant other person were recorded, transcribed, and categorized.	584 coded comments were categorized into 10 themes, including improved verbal and written communication, increased confidence, participation in ADL and community activities, and changes noticed by others. Other themes included satisfaction with the overall study, personalization of scripts, and use of computer.
Video-based conversational script training for aphasia: A therapy study. Bida (2011). April 01.	5	Broca's, Wernicke's, Anomic At least 1 year post-stroke Large range of severity as measured by AAT subtests	Case-series	20 scripts trained; 28 untrained; 2 served as practice examples Scripts were 3 turns with 3–7 words per turn. Nonpersonalized	Scripts presented consecutively for 3 hours/day for 10 days All training in clinic	Person with aphasia heard and saw videos of actors speaking scripts in real-life scenes. Cues increasingly removed until participant mastered a conversation with the video partner. Different scripts were practiced consecutively during a session. Clinician managed program and motivated participant.	Target sentence in each script scored w the 0–3 scoring scale of the Naming subtest of the AAT, CAL, CETI, ANELT, SAQOL	Statistically significant improvement in target phrase production Improvement maintained at 4 wks and 6 mo post. Less, but still significant, improvement in untrained scripts. Improvements on the naming and repetition subtests of the AAT. Increased confidence and improvement in communication skills in everyday

Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
Supervised home training of dialogue skills in chronic aphasia: A randomized parallel group study. Nobis-Bloch et al., (2011).	18	Broca's, Transcortical or Global. At least 6 months post-stroke. AAT: Naming subtest below 50 percentile; Repetition and Speech subtests above 30 percentile.	Crossover	48 scripts. Scripts were 3 turns of 3-5 words per turn. Non-personalized	<p>The crossover conditions were script vs. nonlinguistic cognitive training. Randomly ordered presentation of conditions.</p> <ul style="list-style-type: none"> Clinic: 1 hr/wk 4 wks Home: 1 hr/ session, 2 sessions/day, 4 days/wk 4 wks <p>4 wk washout between conditions</p>	<p>In each 3-turn script, 2 dialogue partners were depicted by icons with speech bubbles containing bar codes. After person w aphasia scanned the barcode, the pictured person spoke his /her lines. Persons w aphasia then read their response and repeated it.</p> <p>Each script had to be practiced first with writing, then without.</p> <p>Wks 1 & 3: 24 food & shopping scripts; Wks 2 & 4 : 24 health-related scripts. Related vocabulary drills with all scripts.</p> <p>Nonlinguistic cognitive training had same intensity duration as script training.</p>	<p>Therapist posed questions which had to be answered by person w aphasia without support.</p> <p>Dialogue rated on separate scales of 1-4 for communicative success and linguistic accuracy.</p> <p>Word fluency</p> <p>Pattern recognition and visual scanning</p> <p>Auditory & visual memory span</p> <p>Spontaneous speech analyzed re basic linguistic parameters</p> <p>ANELT, AAT, CETI</p>	<p>Significant improvements in linguistic and communicative abilities using B.A. Bar training but not with nonlinguistic training.</p> <p>The transfer to general linguistic and communicative performance remained limited.</p>
Script training treatment for adults with apraxia of speech. Yilmaz et al., (2011).	3	AOS and mild Anomic aphasia WAB AQ 50.3-75.6 At least 1 year post-stroke	Single subject, multiple baseline	<p>3 scripts. Scripts were 3-7 turns, with 12-51 words per script.</p> <p>Personalized: Person w aphasia and clinician collaborated on topics and wording.</p>	<p>Per script:</p> <ul style="list-style-type: none"> Clinic: 2-3 hrs/wk with clinician Home: 15 min/ session, 2 sessions/day, 7 days/wk <p>Scripts practiced consecutively; 1 script begun after mastery of previous script.</p>	<ul style="list-style-type: none"> Clinic: At least 3 10-min episodes of concentrated script training practice, interspersed w brief periods of relaxed, open conversation. Beginning of each session, persons w aphasia were audio-recorded while speaking on each of their 3 topics. Home: Persons w aphasia 	<p>Probes of spontaneous production while speaking on each script topic:</p> <ul style="list-style-type: none"> % of script words produced correctly Rate of script-related words <p>Errors</p> <p>Self-report ratings on confidence and production for each script topic</p>	<p>All successfully acquired their scripts, and demonstrated script retention 6 months later.</p> <p>Errors remained variable as did speaking rate.</p> <p>Time for a person w aphasia to master all 3 scripts ranged from 22-44 sessions.</p> <p>All reported increased confidence and speaking ease.</p>

Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
Script training and generalization for people with aphasia. Goldberger et al., (2012).	2	Broca's, post-TBI, WAB AQ 57.2 6 yrs post-onset Conduction WAB AQ 87.5 5 yrs post-onset	Single subject, multiple baseline	2 scripts Scripts were 4-9 turns, with 28-88 words per script Personalized: Person w aphasia and clinician collaborated on topics and wording.	Per script: • Clinic: 3 sessions/wk for 3 wks. 4 hrs per script total • Home: 15 min/day using clinician recording of script as support Scripts practiced consecutively	Sessions with therapist in person combined with videoconferencing. Cuing gradually removed	Probes of oral reading of scripts: • % correct of script-related words • % w grammatical morphemes Disfluencies per word Rate of script-related words Generalization: Person w aphasia tried to converse about script topic with partners who didn't follow the script.	Improvement on all measures during and after treatment phase. Generalization samples showed improved grammatical morpheme use and increased rate of speech
Acquisition and maintenance of scripts in aphasia: A comparison of two cuing conditions. Cherney et al., (2014).	8	7 Nonfluent, 1 Fluent WAB AQ 28.1-80.1 At least 6 months post-stroke	Crossover	1 trained script, 2 untrained scripts Scripts were 10 turns, with 50-125 words per script Clinician determined topic and wording, adding 4 personalized items to each script	The crossover conditions were script training in a high vs. low cue condition. Randomly ordered presentation of conditions Per script: • Clinic: 30 min/wk • Home: 30 min/session; 3 sessions/day 6 days/wk for 3 wks 3 wks washout between conditions.	Person w aphasia practiced with virtual therapist on computer. In high-cue condition, persons w aphasia were cued by written words, choral speaking, and oral-motor movements of the virtual therapist. In low-cue condition, persons w aphasia practiced sentences with written cues only, followed by hearing and seeing each sentence read by the virtual therapist.	Probes of oral reading of scripts: • % accuracy • Rate of script-related words	Significant improvement in both accuracy and rate from baseline to post-tx and maintenance in both conditions. No statistically significant difference between high vs. low cue, although consistently better performance in acquisition phase under high cue condition. Difference in magnitude of

Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
A virtual therapist for speech and language therapy. Vuuren & Cherney (2014)	8	7 Nonfluent, 1 Fluent WAB AQ 28.1–80.1 At least 6 months post-stroke	Crossover	1 trained script, 2 untrained scripts Scripts were 10 turns, with 50–125 words per script Clinician determined topic and wording, adding 4 personalized items to each script	The crossover conditions were script training in a high vs. low cue condition. Randomly ordered presentation of conditions Per script: • Clinic: 30 min/wk • Home: 30 min/session; 3 sessions/day 6 days/wk for 3 wks 3 wks washout between conditions.	Person w aphasia practiced with virtual therapist on computer. In high-cue condition, persons w aphasia were cued by written words, choral speaking, and oral-motor movements of the virtual therapist. In low-cue condition, Persons w aphasia practiced sentences with written cues only, followed by hearing and seeing each sentence read by the virtual therapist.	Probes of oral reading of scripts: • % accuracy • Rate of script-related words Mixed effects model used to analyze gains over time.	change between conditions greater for those with more severe aphasia. Subjects expressed preference for high cue condition. Performance generally maintained for 3 and 6 weeks post treatment.
Impact of personal relevance on acquisition and generalization of script training for aphasia: A preliminary analysis. Cherney et al., (2015)	8	7 Nonfluent, 1 Fluent WAB AQ 28.1–80.1 At least 6 months post-stroke	Crossover	1 trained script, 2 untrained scripts Scripts were 10 turns, with 50–125 words per script Clinician determined topic and wording, adding 4 personalized items to each script	The crossover conditions were script training in a high vs. low cue condition. Randomly ordered presentation of conditions Per script: • Clinic: 30 min/wk • Home: 30 min/session; 3 sessions/day 6 days/wk for 3 wks	Person w aphasia practiced with virtual therapist on computer. Persons w aphasia were cued by written words, choral speaking, and oral-motor movements of the virtual therapist.	Probes of oral reading accuracy of personalized and non-personalized words/phrases that were shared by trained and generalization scripts	Significant improvement in accuracy for both personalized and non-personalized words/phrases in both trained and generalization script. The gain of personalized items was

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Title, author, year	N	Aphasia type, severity & chronicity	Study design	Script design	Treatment schedule	Treatment administration	Outcome measures	Main outcomes
					day 6 days/wk for 3 wks 3 wks washout between conditions.			greater than non-personalized items in the trained but not untrained script.

* Included the participants with nonfluent aphasia in Cherney (2008), Cherney & Halper (2008), and Manheim (2009)
** Included the 3 participants from Cherney (2008), and 20 participants from Manheim (2009).
AA= Aachen Aphasia Test; ANELT=Amsterdam-Nijmegen Everyday Language Test; AOS=Apraxia of speech; AQ=Aphasia Quotient; BOSS=Burden of Stroke Scale; CADL-2=Communication Activities of Daily Living; CAL=Communicative Activity Log; CETI=Communicative Effectiveness Index; QCL=Quality of Communication Life Scale; SAQOL=Stroke and Aphasia Quality of Life Scale; WA-B=Western Aphasia Battery

Table 2
Counts per ten turns in the restaurant and grocery script at five levels of difficulty

<u>Restaurant Script</u>	<u>Level 1</u>	<u>Level 2</u>	<u>Level 3</u>	<u>Level 4</u>	<u>Level 5</u>
Sentences	11	11	15	15	19
Words	62	82	114	141	175
Syllables	71	100	145	188	245
Morphemes	74	98	145	181	230
Words/sentence	5.6	7.5	7.6	9.4	9.2
Syllables/word	1.1	1.2	1.1	1.3	1.4
Morph/word	1.19	1.20	1.27	1.28	1.31
Flesch-Kincaid	0.12	1.71	2.38	3.81	4.52
<u>Grocery script</u>	<u>Level 1</u>	<u>Level 2</u>	<u>Level 3</u>	<u>Level 4</u>	<u>Level 5</u>
Sentences	11	13	14	14	16
Words	56	78	108	142	172
Syllables	69	98	144	186	241
Morphemes	66	95	133	179	226
Words/sentence	5.1	6.0	7.7	10.1	10.8
Syllables/word	1.2	1.2	1.3	1.2	1.41
Morph/word	1.18	1.22	1.23	1.26	1.31
Flesch-Kincaid	0.93	1.58	3.15	3.82	5.14

Table 3
Frequency of Occurrence in Contemporary English of the Words Within Each Category Slot of the Restaurant Template

<u>Difficulty level</u>	<u>Type of salad</u>	<u>Pizza topping 1</u>	<u>Pizza topping 2</u>	<u>Time</u>	<u>Idea</u>
1	house	213,652 peppers	24,082 cheese	20,331 six	98,285 idea
2	garden	42,083 mushrooms	7,213 sauce	18,089 seven	56,577 thought
3	greens	25,470 sausage	4,106 onions	15,995 one	49,840 advice
4	chef	12,432 spinach	3,231 garlic	13,102 forty-five	1,834 suggestion
5	antipasto	113 pepperoni	338 basil	4,708 six-thirty	186 recommendation
					12,816
<u>Difficulty level</u>	<u>Salad ingredient</u>	<u>Portion of food</u>	<u>Show</u>	<u>Dessert</u>	<u>Time of day</u>
1	tomato	16,639 size	55,904 show	96,566 cake	14,858 now
2	cucumber	8,447 amount	53,868 movie	74,861 pie	10,130 today
3	carrots	6,378 portion	16,904 play	45,361 brownies	1,422 tonight
4	radishes	850 serving	11,003 concert	14,683 cheesecake	976 afternoon
5	salami	455 helping	2,435 musical	2,321 cobbler	566 evening
					4,432
<u>Difficulty level</u>	<u>Mean frequency of all ten words</u>				
1	115,531				
2	44,191				
3	24,082				
4	9,883				
5	3,235				

Note. Frequency of occurrence in a corpus of 450 million spoken and written words in contemporary American English, from The Corpus of Contemporary American English (Davis 2008 -).

Table 4

Script Levels for Standard, Low, and High Difficulty: Assigned to participants based on their WAB-R AQ

<u>WAB-R AQ range</u>	<u>Standard difficulty</u>	<u>Script level assigned</u>	
		<u>Low difficulty</u>	<u>High difficulty</u>
35 – 50	2	1	3
50 – 60	3	2	4
60 – 80	4	3	5

Note. The WAB-R AQ is the Aphasia Quotient on the Western Aphasia Battery-Revised, (Kertesz, 2006).

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Table 5

Participant Characteristics

Subject	Age (yrs)	Gender	Race	Handedness	TPO (mos)	Education (yrs)	WAB-R AQ	WAB-R % Oral Reading	Randomized Script Difficulty
BERJE	47.09	M	B	L	8.92	12	41.7	20	High
CLEJO	76.38	M	W	R	42.48	16	49.4	10	LOW
CORLA	67.33	M	W	R	151.54	18	80.8	75	LOW
DALRU	52.59	M	W	R	29.64	16	74.5	85	LOW
DAVAR	39.59	F	B	R	54.89	17	64.6	25	High
KARYA	61.11	M	B	R	33.74	19	55.5	45	LOW
MCCLA	39.19	F	W	R	15.67	14	78.7	95	High
SCOLI	72.47	F	B	L	100.32	18	38.0	20	High
Mean	57.0				54.7	16.3	60.4	46.88	
SD	14.5				48.2	2.3	16.8	33.48	

Note: The eight non-fluent participants had chronic aphasia due to a left hemisphere stroke. All subjects except MCCLA and KARYA had some associated apraxia of speech.
M=male; F=female; B=black; W=white; L=left; R=right

Table 6
Mean % Accuracy of Oral Reading Probes, With the Restaurant and Grocery Scripts Combined

High-difficulty condition			Low-difficulty condition		
PWA	Script level	% accuracy	PWA	Script level	% accuracy
DAVAR	5	16.8	CORLA	3	49.0
BERJE	3	14.5	KARYA	2	53.4
MCCLA	5	58.0	DALRU	3	67.1
SCOLI	3	16.1	CLEIO	1	47.9
Without MCCLA:			mean	mean	54.3
			SD	SD	8.8
			mean		
			SD		