Research Article

Script Training Treatment for Adults With Apraxia of Speech

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Purpose: Outcomes of script training for individuals with apraxia of speech (AOS) and mild anomic aphasia were investigated. Script training is a functional treatment that has been successful for individuals with aphasia but has not been applied to individuals with AOS. Principles of motor learning were incorporated into training to promote long-term retention of scripts.
Method: Three individuals with AOS completed script training. A multiple-baseline, across-behaviors design examined acquisition of client-selected scripts. Errors and speaking rates were also analyzed. Random practice and delayed feedback were incorporated into training to promote motor learning. Probes for long-term retention were elicited up to 6 months after treatment.
Results: All clients successfully acquired their scripts, and probes demonstrated script retention 6 months after treatment. Errors generally decreased but remained variable even during maintenance and retention probes. Speaking rate increased for 2 clients but also remained variable.
Conclusions: Script training was successful and functional for clients with AOS. Clients reported increased confidence, speaking ease, and speech naturalness. Although scripts did not become errorless, clients retained their scripts and reported using them frequently. Whether principles of motor learning may have promoted the long-term retention of scripts exhibited by participants must be determined through future research.

Key Words: script training, apraxia of speech, motor learning

Script training is a relatively new, functional approach to the treatment of neurogenic communication disorders. Script training was initially developed by Holland and colleagues (Holland, Milman, Munoz, & Bays, 2002) to facilitate verbal communication on client-selected topics. As compared to a total communication approach to therapy, script training focuses more narrowly on reinjecting islands of relatively fluent, automatic speech into the conversation of individuals for whom speech production is no longer automatic. Script training is intended for those individuals who wish to speak relatively normally, within the limited context of a few practiced, reautomatized phrases, on a few personally important topics.

Youmans, Holland, Munoz, and Bourgeois (2005) investigated script acquisition and automatization in two individuals with chronic, moderately severe, nonfluent aphasia. Client-selected scripts were trained phrase-by-phrase in a cumulative manner, using a cuing hierarchy that began with in-unison production and ended with independent production. A single-subject, multiple-baseline, across-behaviors design was employed in this study. Each participant mastered three scripts, and mastered script productions were judged to be automatic as measured by stability of performance, relatively errorless productions, speaking rate, and speech naturalness. A 90% script acquisition criterion was used. Treatment time ranged from 3 to 4 weeks of hour-long, twice weekly sessions, and both clients reported using their scripts frequently to communicate in daily situations. In addition, social validity raters judged posttreatment speech productions to be significantly more natural and more informative than baseline speech productions. Therefore, script training was practical and functional for the two individuals with nonfluent aphasia.

Script training was initially based on the instance theory of automatization (Logan, 1988). Instance theory defines automaticity as the retrieval from memory of complete, context-bound, skilled performances. Each performance of a task is stored in memory as an "instance" representation, and skills become more automatic as a learner shifts from reliance on a general learning algorithm to reliance on recall of past performances. Because instance theory supposes recall of integrated performances, it predicts that to become automatic, skills must be practiced in a holistic fashion rather than in a dissected, component-based manner. In this view, tasks are not broken down and practiced as component skills, such as naming, grammatical rule use, and isolated sound productions, because the development of automaticity does not depend on improvement of such underlying processes; automatization of a skill is item-based rather than process-based. Following this theoretical paradigm, scripts in the Youmans et al. (2005) study were practiced at the phrase level rather than at the level of syllables or phonemes.

In addition, instance theory predicts that repetitive, specific practice is necessary to establish automatic, item-based recall of past performances. Therefore, blocked practice of targeted phrases was used, with more random practice introduced only as completely mastered scripts were generalized to conversational contexts. Also, feedback during script training was given immediately and consistently, in an errorless learning style, to promote rapid script acquisition, to decrease learning of persistent errors, and to decrease client frustration.

More recently, Cherney, Halper, Holland, and Cole (2008) investigated a computerized version of script training with three participants: one classified with nonfluent Broca's aphasia and the other two with fluent anomic and Wernicke's type aphasias. As in the previous study by Youmans et al. (2005), individualized scripts were selected by the study participants and then practiced primarily at the phrase level in blocked fashion, following tenets of the instance theory of automatization. Script training was relatively successful for all three participants. Analysis of pre- and posttreatment script productions indicated marked improvement on topic content, grammatical productivity, and speaking rate for all scripts. In addition, clients and families reported increased communication across a variety of situations, increased confidence, and general satisfaction with the computer-based script training approach to therapy.

Although positive script acquisition data have been reported, studies have not yet systematically explored long-term retention of acquired scripts. It also remains to be seen whether blocked training and errorless learning techniques are the most appropriate practice conditions for script training, and whether practice and feedback conditions should be varied across different neurogenic populations. Because initial applications of script training have been successful, script training should be further explored with individuals who exhibit a variety of aphasia profiles, as well as with individuals who present with coexisting motor speech disorders.

Acquired apraxia of speech (AOS) commonly occurs concomitant with Broca's, anomic, or nonclassified aphasia (Wertz, LaPointe, & Rosenbek, 1984). AOS is a disorder of motor speech characterized by disruption of automatic programming and sequencing of oral motor patters for speech (Darley, Aronson, & Brown, 1975; Johns & LaPointe, 1976; Kent, 2000). This disruption of sensorimotor plans or programs causes speech to be phonetically and prosodically distorted because phonological representations of speech are inadequately programmed and executed (Duffy, 2005). Because AOS involves a fundamental loss of automaticity of speech production, script training may be an appropriate and functional approach to the treatment of this disorder in isolation, or as it co-occurs with aphasia.

Motor learning theories emerged from studies of skilled motor behaviors in normal individuals, often limb movements for sports training (Schmidt, 1991). These theories posit that the skill acquisition phase, which is the focus of the instance theory and most other learning theories of automaticity, may not best represent learning. Instead, long-term retention and generalization are invoked as the true indices of motor skill learning (Schmidt, 1975; Schmidt & Lee, 1999). Motor learning literature identifies specific practice conditions that may enhance retention and transfer of acquired motor skills, including random practice rather than blocked practice (Knock, Ballard, Robin, & Schmidt, 2000) and practice specific to the target, such as focusing on complete actions instead of isolated muscles (Clark, 2003). Motor learning theories also predict that certain feedback conditions will facilitate motor learning, including delayed feedback rather than immediate feedback, and summary feedback after multiple trials rather than feedback following individual trials (Adams, Page, & Jog, 2002; Wulf, Schmidt, & Deubel, 1993).

There is much empirical evidence supporting motor learning theory in sports training and limb rehabilitation (Buxbaum et al., 2008; Gilmore & Spaulding, 2001; Krakauer, 2006; Langhammer & Stanghelle, 2000; Platz, Denzler, Kaden, & Mauritz, 1994; Smania et al., 2006), and relatively recently researchers have suggested that the integration of motor learning principles with existing treatment protocols may be particularly beneficial for clients who present with AOS (Knock et al., 2000; McNeil, Robin, & Schmidt, 1997). However, because principles of motor learning are based on novel skill acquisition in normal, healthy individuals, the question arises as to how and to what degree these learning principles apply to skill relearning in neurologically impaired populations, and to speech relearning in particular. To this end, researchers have begun to systematically apply principles of motor learning to the treatment of individuals with AOS.

To date, only one study has compared practice conditions based on motor learning to traditional practice conditions during AOS treatment. Knock and colleagues (2000) compared a traditional model of blocked practice to random practice during Phonetic Placement Therapy (Van Riper & Irwin, 1958) for two individuals with severe AOS and coexisting aphasia. Using a single-subject, alternating-treatment design, these authors determined that single syllables trained during random practice were retained more robustly at probes 4 weeks after the termination of treatment. In addition, these authors observed transfer to similar but untrained stimuli for randomly practiced syllables for one of the two individuals with AOS.

One study has also examined motor skill retention and transfer under varying frequency and timing of feedback conditions. Austermann-Hula, Robin, Maas, Ballard, and Schmidt (2008) compared acquisition of nonsense, single-, and multisyllabic productions during Phonetic Placement Therapy for four individuals with AOS under a traditional high-frequency feedback condition (feedback after each trial) to a low-frequency feedback condition (60% of trials received feedback) prescribed by motor learning theory. Two of the four participants demonstrated stronger retention of stimuli trained with low-frequency feedback, one at 4 weeks after treatment and the other at 8 months posttreatment, and one of the four participants demonstrated stronger transfer to untrained items after low-frequency feedback. Results were also mixed for the timing of feedback effects; only one of the two participants clearly demonstrated greater transfer and retention of syllables trained under delayed feedback conditions.

In the current study, we investigated whether a script training approach, to date only applied to individuals with aphasia, might benefit individuals with a primary diagnosis of AOS and co-occurring, mild aphasia. Because emerging evidence suggests that well-established principles of motor learning in normal individuals may apply to impaired motor systems, we modified the script training approach to include principles of motor learning in an effort to promote long-term retention of acquired scripts.

Method

Participants

Three participants whose primary diagnoses were AOS were included in this investigation. Evaluation and diagnosis of all participants was completed by speech-language pathologists with extensive experience in motor speech disorders. Participant 1 (P1) was 81 years old, right-handed, and female; 15 months earlier she had experienced a left cerebrovascular accident (CVA). Her scores on the Western Aphasia Battery (WAB; Kertesz, 1988) indicated that she had Broca's aphasia (Aphasia Quotient [AQ] = 50.3). However, most of her errors occurred on tasks that required a verbal response, such as spontaneous speech, repetition, and object naming, and most of these errors were judged as secondary to AOS rather than aphasia. She demonstrated comparably good word finding, accurately producing eight of 10 items and approximating the spelling of the remaining two, when she was allowed to write her responses and did not need to struggle for speech productions. As she did not exhibit grammatical difficulties typical of Broca's aphasia, P1 was diagnosed with a mild anomic aphasia. The Apraxia Battery for Adults (ABA; Dabul, 1979) was administered, resulting in a diagnosis of moderate to severe AOS. During conversation and testing, this participant presented with five out of five speech characteristics identified by McNeil et al. (1997) as cardinal features of AOS. For the testing profile of P1, please refer to Table 1.

Participant 2 (P2) was a 40-year-old, right-handed woman who 3 years earlier had experienced a left CVA. The WAB was administered, resulting in an AQ of 75.6; in accordance with the WAB profile, P2 was diagnosed with mild anomic aphasia. This participant had a mild word-finding impairment and an occasional difficulty with letter transpositions in her writing, in the absence of other aphasic errors. Her speech and writing were free of the syntactic/morphological errors that would suggest an underlying language formulation difficulty. The ABA was given, resulting in a designation of mild to moderate AOS. P2 exhibited each of the five cardinal speech characteristics of AOS from McNeil and colleagues (1997), although she exhibited one of these, an abnormally slow speaking rate, somewhat inconsistently. This was most likely due to her less involved, mild to moderate AOS impairment level. This participant's communication errors were primarily attributable to AOS. Table 1 contains testing profile information for P2.

Participant 3 (P3) was a 51-year-old, right-handed man who had experienced a left CVA six years earlier. WAB results indicated an AQ of 62 and a classification of Broca's

TABLE 1. Evaluation results for each of the participants.

		Participants		
Test/checklist	Subtest	1	2	3
WAB	Spontaneous Speech	9/20	18/20	13/20
	Information Content	5/10	9/10	9/10
	Fluency	4/10	9/10	4/10
	Auditory Comprehension	9.05/10	9.1/10	7/10
	Repetition	2.4/10	8.3/10	3.3/10
	Naming/Word Finding	4.7/10	9.5/10	7.8/10
	Aphasia Quotient	50.3	75.6	62
ABA	Diadochokinetic Rate	Mild–mod.	Mild–mod.	Severe–prof.
	2 Syllable Average	Severe–prof.	Mild–mod.	Severe–prof.
	Limb and Oral Apraxia	Mild–mod.	Mild–mod.	Mild–mod.
	Utterance Time	Severe–prof.	Mild–mod.	Mild–mod.
McNeil checklist	Slow rate	Present	Inconsistent	Present
	Prolonged segment/intersegment durations	Present	Present	Present
	Distortions/distorted sound substitutions	Present	Present	Present
	Errors consistent in type	Present	Present	Present
	Prosodic abnormalities	Present	Present	Present

Note. WAB = Western Aphasia Battery (Kertesz, 1988); ABA = Apraxia Battery for Adults (Dabul, 1979); mod. = moderate; prof. = profound.

aphasia, and the participant was clinically diagnosed with anomic aphasia when apraxic errors were taken into account. P3 exhibited mild word-finding difficulties, as well as mild auditory comprehension errors, and did not exhibit errors indicative of an underlying difficulty with grammatical formulation of language. This participant presented with all five of the cardinal features of AOS (McNeil et al., 1997). The ABA was administered, and the patient was diagnosed with moderate to severe AOS. As with the first two participants, most of P3's communication errors were secondary to AOS. Please see Table 1 for the testing profile of P3.

Procedures

Prior to the initiation of this study, approval for all procedures was granted by the institutional review boards associated with the authors' university affiliations. All sessions took place in well-lit, quiet, distraction-free settings. Two of the participants were seen by the same speech-language pathologist, and the third participant was seen by a different speech-language pathologist. Both speech-language pathologists had experience working with adults with acquired motor speech disorders. All procedures were consistent for all of the clients with few exceptions; the exceptions will be highlighted.

Prior to data collection, topics and scripts were created. The participants were asked to decide on three functional topics. Suggestions and feedback were given to the participants about their choices; however, the participants were encouraged to generate ideas that were personally relevant. Scripts were then constructed collaboratively to reflect what participants wanted to say in their own wording. The scripts are presented in the Appendix.

Treatment session structure. Each participant was seen individually for two or three 60-min sessions each week. Treatment sessions were structured to allow at least three 10-min episodes of concentrated script training practice, interspersed with approximately four brief periods of relaxed, open conversation. At the beginning of each session, the participants were audio-recorded while speaking on each of their three chosen script topics. The participants were not cued or given feedback during this data collection, with the exception of P3, who required first word cuing on three occasions during training. (This will be further discussed in the Results section.) As scripts became mastered and entered a random practice phase (see below), treatment sessions ended with approximately 10 min of script conversation practice to promote flexible use of scripts. Additionally, home practice sessions were prescribed twice daily for 15 min, during which the participants practiced their scripts via a tape recorder and written cue cards. Participants reported consistency of home practice weekly.

Blocked practice. As script practice began, scripts were trained one phrase at a time, using a blocked practice approach to promote acquisition. For this blocked practice, the cuing hierarchy used previously for script training (Cherney et al., 2008; Youmans et al., 2005) was followed—that is, clinician modeling of the target phrase, clinician and participant productions of the phrase in unison, clinician and participant productions of the phrase in unison with clinician fading participation, independent productions by the participant with written cue cards, and independent productions with no cuing. All cues and supports provided by the clinicians for independent phrase productions during this blocked practice were delayed, and participants were allowed to produce errors and/or struggle for 5 to 10 s before support was provided. This allowance for active error correction differed from the silent, reflective feedback interval that is often incorporated into motor learning studies. Feedback on articulator placement/positioning and on speech sound accuracy was provided after each independent production to promote successful acquisition of script phrases. Practice tapes were recorded with successive, single phrase blocks, to allow blocked practice at home.

Random practice. When three phrases of a script were produced independently—without cuing or support—with 90% accuracy, random practice of the script was initiated for these acquired phrases, with additional phrases added into random practice as they were successfully acquired. This successive addition of phrases into random practice entailed a blocked/random transitional period in which the first practice episode consisted of initial acquisition, through blocked practice, of a new script phrase, whereas the rest of the session focused on random practice of acquired phrases.

Random practice was divided into two treatment tasks, which both occurred during each session. First, the clinician randomly selected and pointed to the cue cards used to train the phrases. Participants were expected to produce each phrase in the order in which it was indicated. Participants were instructed to attempt each phrase only once before moving on to the next phrase, regardless of the accuracy of their production. This task was completed two to three times per session in 5–10-min practice episodes, each including a minimum of five trials of each phrase. Intertrial intervals were not timed; rather, as soon as the client produced an attempt at a target, the clinician indicated the next target. This was to eliminate repeated self-practice, which tended to occur when an intertrial interval was imposed and which, as a type of blocked practice, could interfere with random practice. Feedback on the accuracy of speech sound production and articulator placement/positioning was provided in a summary fashion after each episode of random practice. In the second random practice task—which usually occurred at least once, at the end of a session—the clinician and the participant engaged in a structured conversation in which the client was expected to produce, in a random order, the phrases of the script being practiced in order to meet various changing conversational demands. Summary feedback on speech production accuracy was provided after each conversation. In addition, during this random practice phase, home practice tapes were rerecorded in a fixed random rather than blocked order.

Dependent Measures

The data were collected via digital recorder at the beginning of each session and later transcribed orthographically. A second transcriber reviewed the transcripts to ensure accuracy. A third transcriber reviewed and resolved any transcript differences between the first two transcribers. The transcripts were then analyzed, and the dependent variables of percentage of script words produced correctly (PSC), errors, and speaking rate (defined below) were measured for each of the scripts at the beginning of each of the sessions. A data point for each of the dependent variables was plotted on each graph for every session for visual inspection.

PSC was measured by dividing the total number of words in the script that the participant produced correctly by the total number of words in the script and multiplying the quotient by 100. PSC was a measure of each participant's accuracy of script production and as such was the primary behavior of interest. Accuracy for PSC for purposes of initial scoring and reliability scoring was defined as script word productions having no more than one obvious sound production error (substitution, distortion, addition, or omission). In addition, if the one error changed the meaning or distorted the production so that it was judged unintelligible by the rater, the utterance was considered an error rather than a script correct utterance.

Error production was also a variable of interest. Errors were defined as word or phrase repetitions that were deemed as noncommunicative, pauses greater than 3 s, unintelligible utterances, and interjections. Errors were viewed as a reflection of how much the participant struggled while attempting to produce scripts. The error count was not simply an inverse of words correct. A client could produce many errors (pauses, repetitions, etc.) or no errors, within any given script production attempt.

Speaking rate in words per minute was calculated for each of the scripts during each session. Speaking rate was calculated by summing the number of nonerror, communicative words produced during the script attempt, whether part of the script or not. This count was then divided by the number of minutes of the production attempt.

Experimental Design

A single-subject, multiple-baseline, across-behaviors experimental design was employed to determine the efficacy of script training for each participant. The examiner monitored the data for stable baselines before initiating treatment and for visually evident changes in the primary behavior of interest, PSC, once treatment was initiated. For the second and third scripts, treatment was initiated after mastery of the preceding script was demonstrated. Script mastery was defined as an independent production of at least 90% of the entire script for a given topic across a minimum of two consecutive sessions.

Mastered scripts were then placed in the maintenance phase. The maintenance phase consisted of data collection at the beginning of sessions but no direct therapeutic intervention from the clinician. Additionally, long-term maintenance probes for P1 and P3 were collected at 2 weeks, 2 months, 4 months, and 6 months after the cessation of treatment, following the same data collection procedures used in the previous phases of this study. Script 3 maintenance probes were not collected for P2 due to attrition: She relocated to a different country.

Reliability

Interjudge reliability was calculated to ensure reliability of the measurements. Following the data analysis of the primary judge, a second judge was trained to measure the dependent variables until he reached 90% level of agreement with the first judge. The second judge then reanalyzed 30% of the data. Bivariate correlations were then calculated to determine the relations between the ratings of the two judges for each of the variables. The results indicated a strong correlation between the raters on PSC (r = .99, p < .001), errors (r = .99, p < .001), and words (r = .99, p < .001), thus indicating robust interjudge reliability.

Participant Self-Ratings

Participants rated their confidence, speech naturalness, and speech production ease while speaking on their chosen script topics. Participants were instructed to mark a 23-cm unscaled line that had descriptive adjectives (such as *easy* and *hard*) at either end and a question about their speech production (such as "How hard is it to say what you want?") printed above it. The distance from the leftmost point of the line to the participant's mark was then measured and converted to a percentage of the total line length. High percentages indicated ratings of high confidence, speech production ease, and speech naturalness. P1 and P2 completed pre- and posttreatment ratings; however, P3 did not complete these ratings.

Results

Script Acquisition and Retention

All of the participants had a marked increase in their PSC for each of their scripts when they moved from the baseline to the treatment phase per visual inspection of the graphs (see Figures 1, 2, and 3). All of the participants reached the mastery criterion for each of their scripts, set at production of 90% of the script correct across at least two consecutive sessions.

The training time required for script mastery varied for each of the participants. P1 required 44 sessions to master all three scripts. P2 required 22 sessions, and P3 required 31 sessions. P1 acquired her three individual scripts in 19 sessions, 15 sessions, and 10 sessions, respectively. P2 acquired her scripts in eight sessions, eight sessions, and six sessions, respectively. P3 mastered his scripts in 14 sessions, eight sessions, and nine sessions, respectively. Throughout treatment, all participants reported consistent home practice for the prescribed time: P1 reported that she practiced twice daily without fail, P2 failed to practice only for a 2-day interval during acquisition of Script 3, and P3 reported that he practiced every day throughout treatment, although the time of day and time devoted to practice varied for this participant.

All of the participants maintained script production accuracy, as measured by PSC, on all scripts for which maintenance data were collected (the exception being P2's third script). Some fluctuations of PSC in maintenance occurred during acquisition of succeeding scripts, but the fluctuations generally stabilized. For P1 and P3, retention on all long-term probes (at 2 weeks, 2 months, 4 months, and 6 months) was robust, with PSC ranging from 72% to 100%. At 6 months, P1 produced her three scripts with 100%, 92%, and 100% PSC, respectively, and P3 produced his three

FIGURE 1. Percentage of script words produced correctly (PSC) and error for Participant 1 (P1) on each topic. The solid line indicates PSC. The dashed line indicates errors. The gray vertical lines indicate phase changes (baseline, treatment, maintenance, and probe). For P1, the four probes indicate data collected at 2 weeks, 2 months, 4 months, and 6 months.

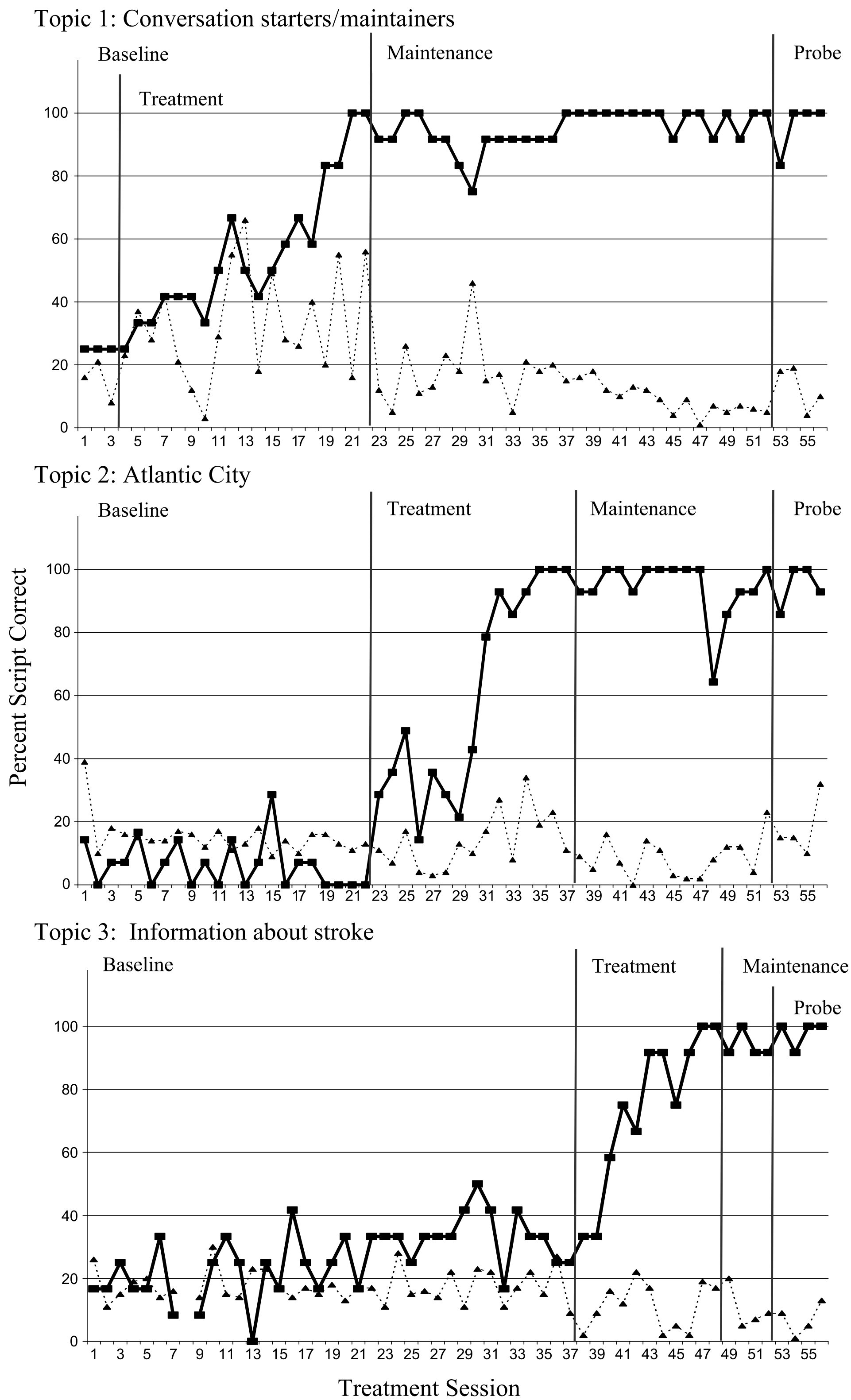


FIGURE 2. PSC and error for Participant 2 (P2) on each topic. The solid line indicates PSC. The dashed line indicates errors. The gray vertical lines indicate phase changes (baseline, treatment, and maintenance). No probes were elicited from P2.

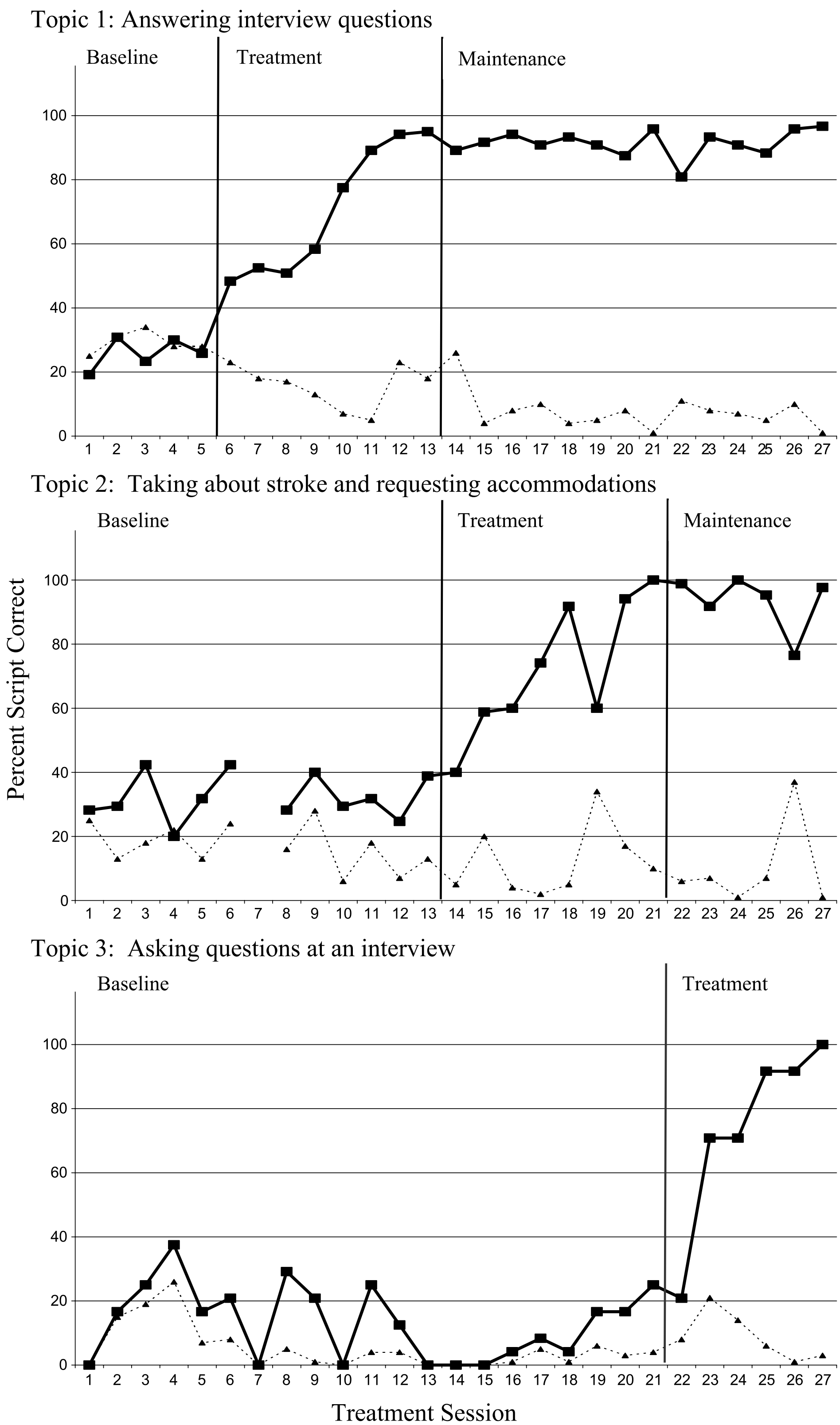
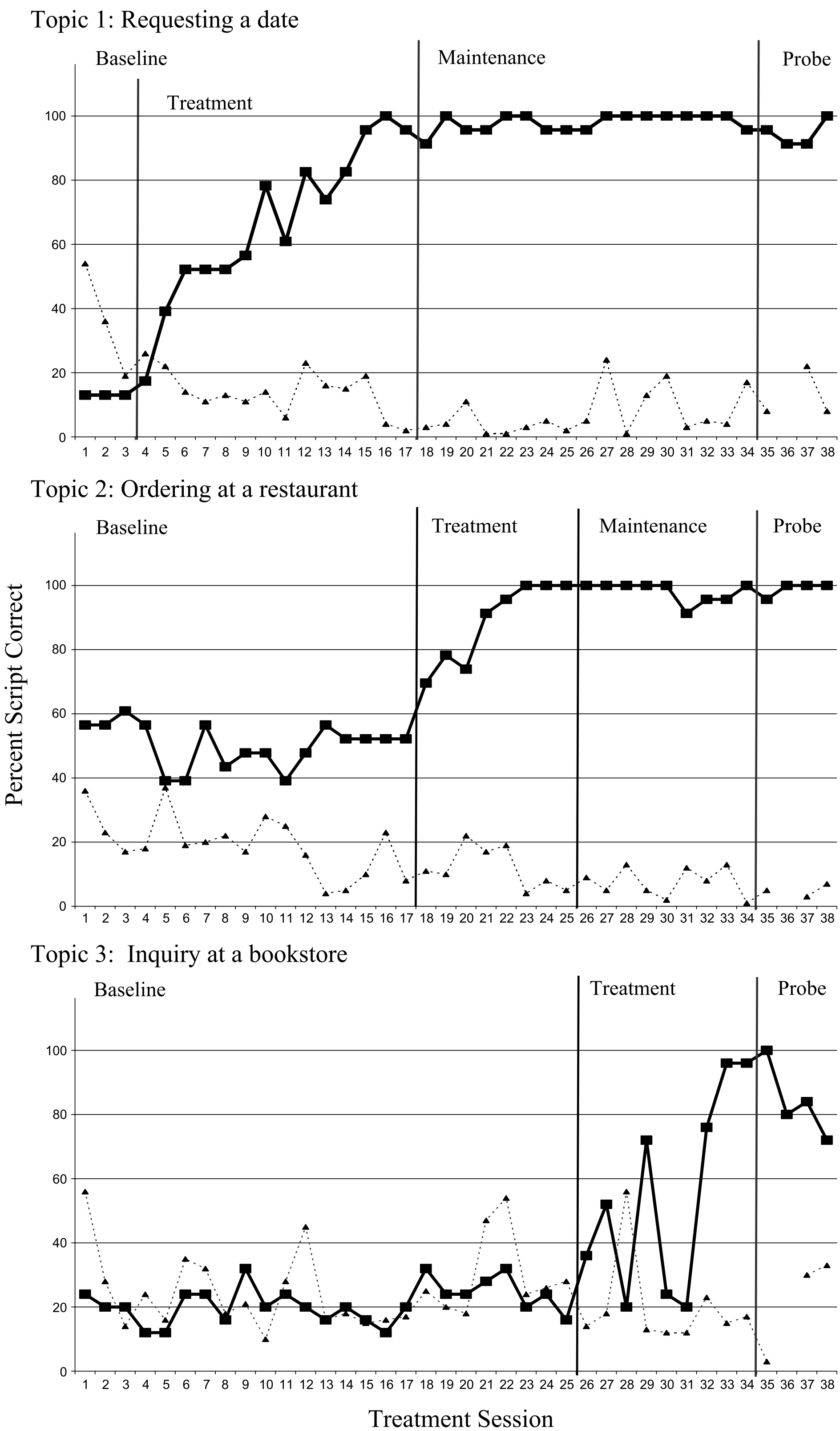


FIGURE 3. PSC and error for Participant 3 (P3) on each topic. The solid line indicates PSC. The dashed line indicates errors. The gray vertical lines indicate phase changes (baseline, treatment, maintenance, and probe). For P3, the two probes indicate data collected at 2 weeks, 2 months, and 4 months.



scripts with 100%, 100%, and 72% accuracy, respectively. P2 demonstrated maintenance phase production accuracy as measured by PSC for 12 weeks for Script 1 and for 6 weeks for Script 2; Script 3 maintenance data and long-term probe data were not available due to attrition.

On three different instances during treatment, P3 had significant difficulty initiating one of his three scripts during data collection, and on these three occasions a first word prompt was provided by the clinician. P3 required these first word prompts for Script 1 on Treatment Days 8 and 11 (first word "would") and for Script 3 on Treatment Day 28 (first word "I"). Following these initial prompts, P3 produced significant portions of his scripts correctly, without further assistance, and data from these script productions that followed the initial cue are provided herein.

Error Productions

The error data were also plotted for each of the participants (see Figures 1, 2, and 3). As a general observation, as scripts were in the baseline and treatment phases, more errors were produced. Conversely, in the maintenance and long-term probe phases, errors were generally more stable, and fewer than in the preceding phases with few exceptions. These exceptions include the maintenance phase of Script 2 for both P1 and P2, for which errors were still moderately variable. Additionally, P3 demonstrated "spikes" in errors intermittently during the later part of the maintenance phase and the probes for Script 1.

Speaking Rate

Speaking rate results were highly variable between and within participants (see Figures 4, 5, and 6). P1's speaking rate remained variable across all of the phases for each script, but she demonstrated a general increase in words per minute over time. An exception was observed during the probe phase of Script 2 in which her speaking rate declined slightly (see Figure 4). On her first script, P2 demonstrated a gradual increase in speaking rate from her baseline to her treatment phase, a generally stable speaking rate across her treatment phase, and an increase in speaking rate following script mastery into her maintenance phase. P2's Script 2 was variable during baseline, and this was followed by a gradual decrease during the treatment phase and a gradual increase during the maintenance phase. P2's speaking rate for Script 3 was highly variable across sessions (see Figure 5). P3 demonstrated slow baseline and treatment speaking rates with low variability for Script 1, with a significant increase in speaking rate and variability upon script mastery; however, a decrease in speaking rate was observed during probes. Script 2 followed a similar pattern: The baseline speaking rate was slow with low variability, with increased speaking rate and variability upon script mastery; as opposed to Script 1, Script 2 probe phases demonstrated a fast speaking rate and low variability. Speaking rate for Script 3 showed greater variability across baseline, treatment, and probe phases than during previous scripts; only a slight trend of increased speaking rate existed across time with high variability (see Figure 6). Even when rates increased, P1 and P3 continued to produce their scripts below the average in words per minute for normal speakers in conversation (M = 174.6, SD = 33.4; Walker, 1988). P3 also produced most of his scripts at a slower than normal speaking rate but did speak at the low end of this distribution for a few script productions on each topic across treatment phases.

Participant Self-Ratings

P1 rated (a) her confidence speaking on her chosen topics as increasing from 0% prior to treatment to 46% after treatment, (b) her speech production ease as increasing from 2.5% to 97%, and (c) her speaking naturalness as increasing from 0% to 48%. P2 rated (a) her confidence as increasing from 57% to 98%, (b) her production ease as increasing from 27% to 95%, and (c) her speech naturalness as increasing from 48% to 96%.

Discussion

Script Acquisition and Retention

This study investigated the effectiveness of script training for individuals with a primary diagnosis of AOS and coexisting mild aphasia. Script training, previously applied only to individuals with a primary diagnosis of aphasia, appears to be a promising treatment option for individuals diagnosed with primary AOS and coexisting mild aphasia, based on our findings. Script training was successful, functional, and practical for these participants. Time for script mastery varied from six to 19 sessions, depending on the severity of AOS and the order in which scripts were trained. These numbers are comparable to those of Youmans et al. (2005) in which participants with nonfluent aphasia mastered their individual scripts in between five and 11 sessions. The exception to this is P1, who required 19 sessions to master her initial script and 15 sessions to master her second script. For P1 and P3 in particular, markedly fewer treatment sessions were required for acquisition of their second and third scripts. This same acquisition pattern was noted for both participants in the previous study by Youmans and colleagues (2005) and may indicate an increased level of efficiency and/or confidence in the script training process itself as script training progresses.

Error Productions

Unlike the participants with nonfluent aphasia in the previous study by Youmans and colleagues (2005) whose script performances became relatively errorless, these participants with AOS continued to produce errors throughout maintenance phases and probes. Many researchers consider greater than normal variability in coarticulation, rate, articulatory accuracy, and force as "a hallmark of AOS" (Duffy, 2005, p. 324). With that in mind, mastered scripts were produced relatively fluidly, with notably less struggle and generally fewer errors as training progressed into maintenance phases. For mastered scripts, error productions usually occurred as a struggle to initiate a script; once initiated, mastered script phrases were generally produced in a relatively fluid, errorless manner. This error pattern was in contrast to the syllable-by-syllable struggles that typified initial script acquisition for all three participants. The source of the initiation difficulties in these participants was unclear, but it was most likely

FIGURE 4. Speaking rate for P1 on each topic. The gray vertical lines indicate phase changes (baseline, treatment, maintenance, and probe).

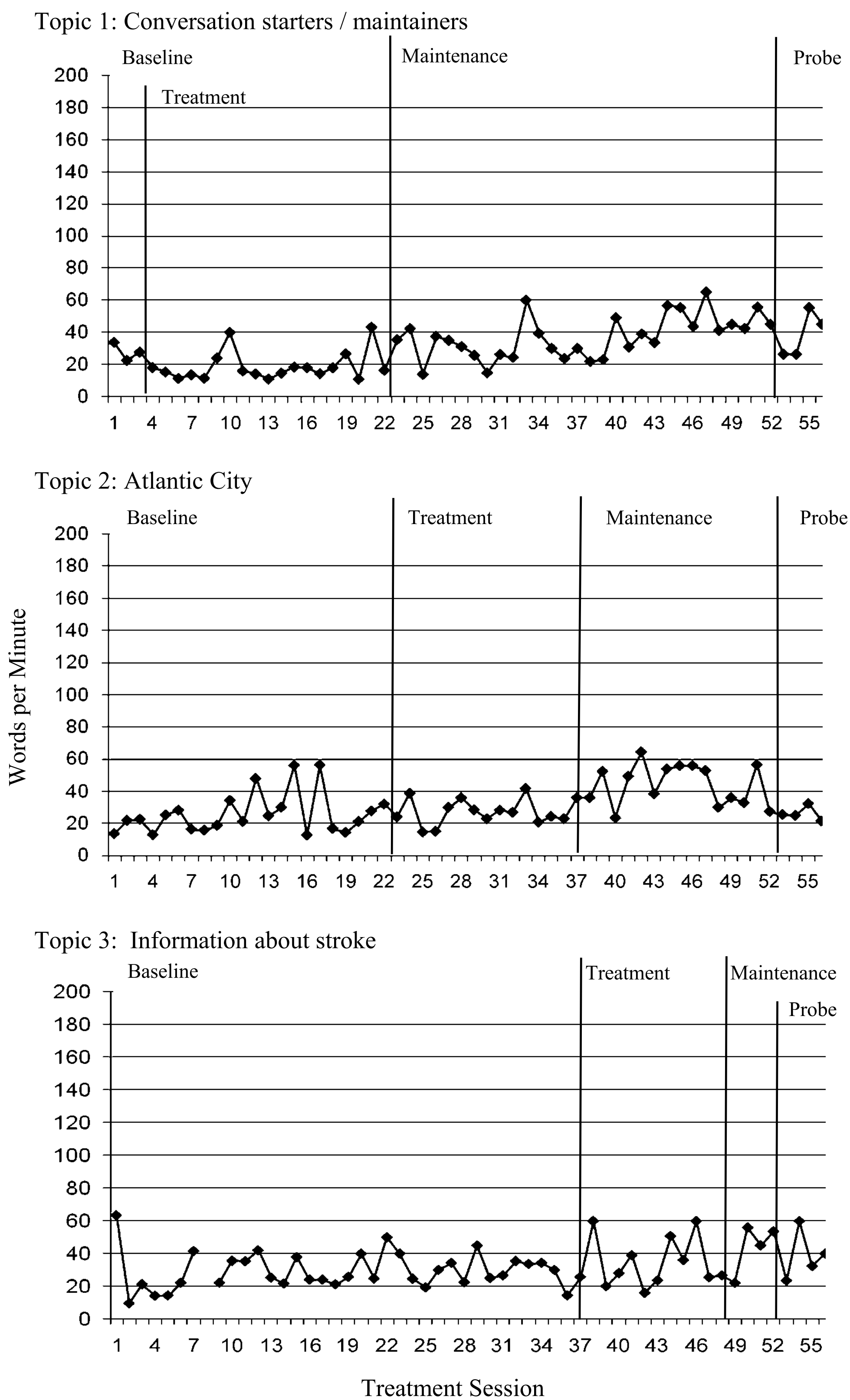


FIGURE 5. Speaking rate for P2 on each topic. The gray vertical lines indicate phase changes (baseline, treatment, and maintenance).

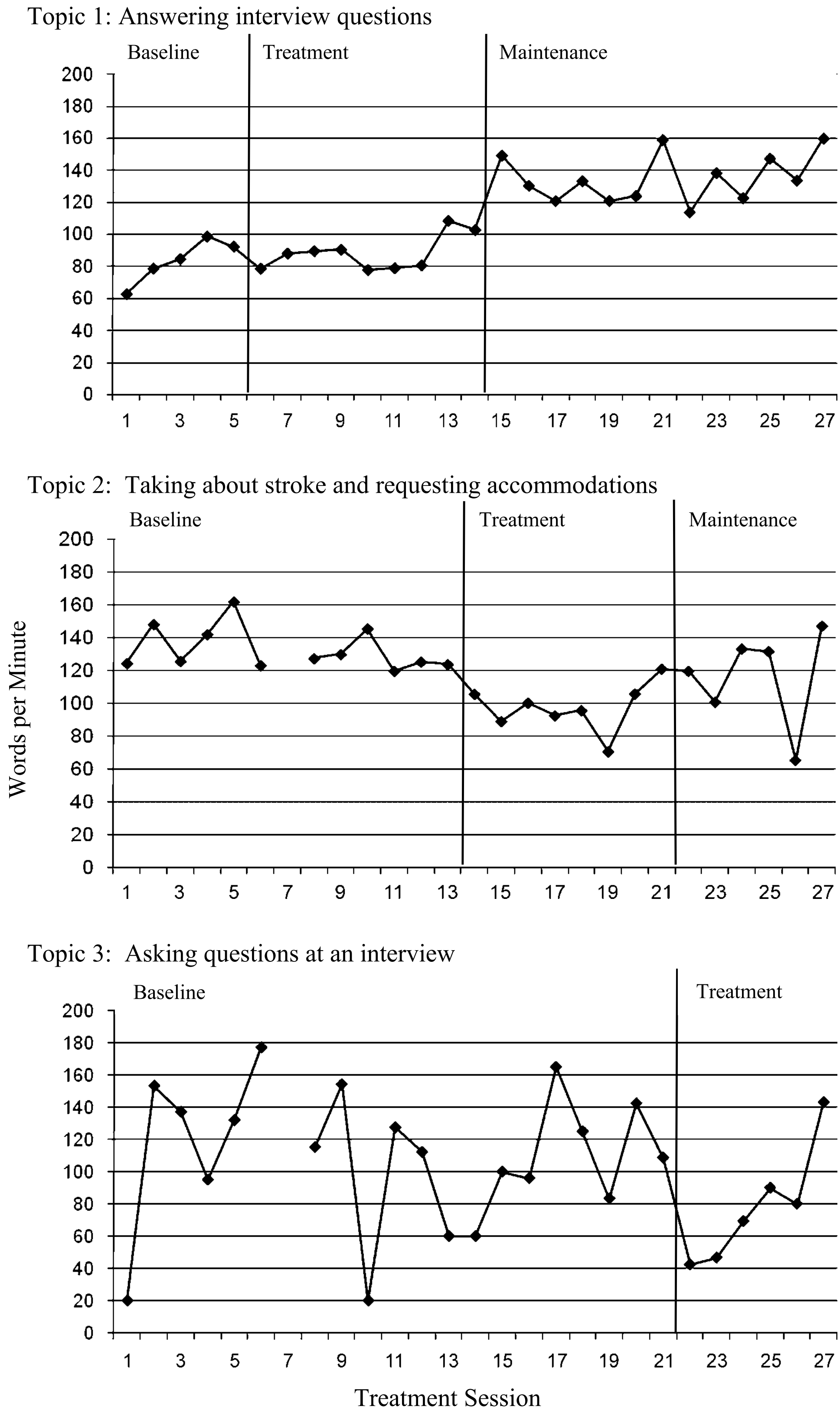
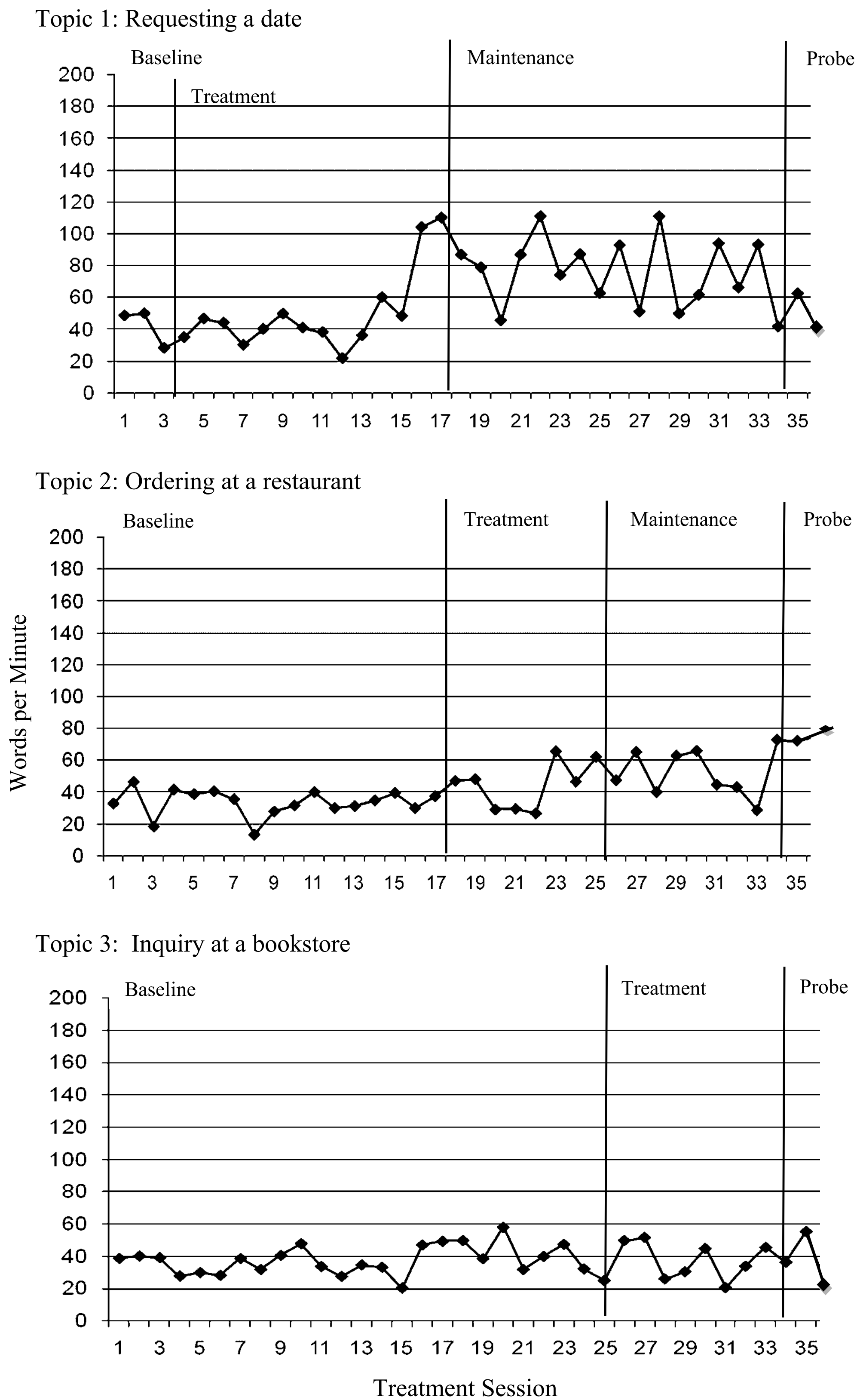


FIGURE 6. Speaking rate for P3 on each topic. The gray vertical lines indicate phase changes (baseline, treatment, maintenance, and probe).



due to motor planning problems, given that this continuing struggle to initiate mastered scripts was not observed in participants with nonfluent aphasia without significant apraxia (Youmans et al., 2005). In addition, when asked to differentiate between "trying to make your mouth move the right way" and "trying to think of/remember which word you want to say," the current participants clearly and consistently indicated a motoric rather than cognitive-linguistic difficulty.

Speaking Rate

Although speaking rate did increase from baseline to maintenance for P1 and inconsistently for P2 and P3, speaking rates did not consistently increase from baseline to maintenance, as they did for participants with nonfluent aphasia who participated in script training (Youmans et al., 2005). However, a marked session-to-session variability in speaking rate, such as that observed in the current investigation, was also present for individuals in this prior study.

Because inconsistent difficulty with script initiation persisted for all clients, mastered script productions did not become automatic, as measured by stability of performance across productions, relatively errorless productions, speaking rate, and speech naturalness. This is in contrast to individuals with nonfluent aphasia (Youmans et al., 2005) who frequently produced their mastered scripts errorlessly and without conscious effort. However, as with the individuals in that investigation, these participants with a primary diagnosis of AOS repeatedly produced their mastered scripts flexibly, in conversation with multiple partners, and also reported frequent, successful use of their script phrases outside of the therapy environment. The objective of script training is to create islands of relatively errorless, relatively fluent speech, which allow individuals with speech fluency difficulties to communicate verbally on topics of personal importance. This objective was met for all three participants.

Participant Self-Rating

Additionally, the self-rating forms completed by P1 and P2 indicated a positive change in their perceptions of their speech following therapy. The differences in their pre- to posttreatment ratings indicated that they both perceived the greatest gain to be the ease in which they produced speech. Both participants also indicated improvement in the naturalness of their speech and in confidence while speaking on their script topics. Although P1 indicated relatively low perceptions of confidence after therapy, she demonstrated an improvement from her ratings of 0% confidence at the initiation of therapy.

Motor Learning Principles

This was an investigation of the effectiveness of script training for individuals with AOS, not a comparison of script training with motor learning principles to script training without those principles, nor a comparison of motor learning theory to traditional training approaches or general learning theories. We incorporated recent research on motor learning principles in an attempt to most effectively tailor script training to individuals with AOS. To promote motor learning as measured by long-term retention, blocked practice was used during initial acquisition to provide early success, and then random practice was introduced as individual script phrases reached mastery level, and summary feedback followed this random practice. In addition, delayed feedback was provided during the blocked practice portion of the study, allowing space for participants to actively evaluate their productions and to attempt to correct their errors. Summary feedback, also indicated by motor learning theory, was provided during random practice of script productions. All three participants performed well during maintenance phases. In addition, the two participants available for follow-up produced their scripts with very high levels of PSC accuracy consistently for 6 months after training.

Because this was not a controlled, comparative study, we cannot ascribe this long-term retention to the incorporation of motor learning principles. Past research that has incorporated motor learning principles into AOS treatment has probed and demonstrated long-term retention at 4 weeks posttreatment for two participants (Knock et al., 2000) and at 4 weeks for one participant and 8 months for a second participant (Austermann-Hula et al., 2008). The scheduled 6-month long retention probes taken in the current study compare favorably with those included in these past investigations.

In addition, these extant studies that apply motor learning principles to AOS treatment have trained primarily at the syllable or single nonword level with individuals whose AOS severity ranged from mild to severe (Austermann-Hula et al., 2008; Knock et al., 2000). The current study expands the inclusion of motor learning principles to the training of functional, phrase-level utterances for individuals with a comparable level of motor speech impairment (mild to moderate to moderately severe AOS).

Future Research

Future research should continue to investigate the efficacy of script training for individuals with various types of neurogenic disorders and various levels of impairment. Script training has been successful and functional for all participating individuals to date: two individuals with moderately severe nonfluent aphasia (Youmans et al., 2005); one individual with moderately severe nonfluent aphasia, one with moderate fluent aphasia, and one with moderate anomic aphasia (Cherney et al., 2008); and the two individuals with moderate to severe AOS and one with mild to moderate AOS who participated in the present study. Script therapy continues to be prescribed for individuals who are at least several months post-CVA and who have participated in broader treatments to facilitate recovery and functional communication.

The question remains whether principles of motor learning, primarily based on data from normally functioning individuals, are appropriate for individuals with neurologically impaired motor systems. Although principles of motor learning were included in our protocol rather than systematically investigated, the incorporation of more demanding training principles such as random practice did not prohibit successful script acquisition treatment outcomes. We were initially concerned that participants would be overly frustrated by increased training demands, and therefore we delayed random practice and summary feedback until individual phrases were produced at mastery levels. The extent to which principles of motor learning may be responsible for the robust retention exhibited by these participants remains to be determined through future research.

Finally, future research might explore different practice and feedback conditions to determine which result in the greatest long-term retention and generalization for clients with different impairment profiles. Currently we used a motor learning approach, allowing blocked practice earlier in treatment and introducing random practice as clients mastered individual script phrases. This random/blocked practice order has been proposed as the optimal motor learning schedule for individuals with neurogenic impairment (Rosenbek, Lemme, Ahern, Harris, & Wertz, 1973), and even for normal learners (Lai, Shea, Wulf, & Wright, 2000). However, this has yet to be systematically investigated. It remains possible that more difficult practice conditions such as random practice and variable feedback should be applied from the beginning of treatment to produce the most robust effects. Alternatively, it is possible that more traditional approaches such as blocked practice and errorless learning may be more successful for some individuals.

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Appendix

Participant Script Examples

Participant 1

Script 1: Conversation starters/maintainers
- How are your grandchildren?
- Good morning.
- I'll see you later.
- What's new?

Script 2: Atlantic City
- Did you go to Atlantic City?
- Maybe I'll win today.
- I'm never going again!

Script 3: Information about stroke
- I had a stroke.
- Speaking is hard.
- But I can understand you.

Participant 2

Script 1: Answering interview questions
- I am organized and a hard worker.
- Also, I'm a good listener.
- I let people talk and try to understand them.
- After I got my degree, I worked as a personal assistant.
- Most recently I worked as an office manager.
- I enjoyed it, but I had to leave for health reasons.

Script 2: Requesting accommodations
- If possible, I would like to start by working half days.
- Also, I will need a left-handed computer set up.
- Multitasking is difficult for me.
- I need to take my time.
- But I am very accurate.

Script 3: Asking questions at an interview
- What are the responsibilities of this job?
- What are you looking for in an employee?
- What is the next step in this interview process?

Participant 3

Script 1: Inquiry at a bookstore
- I need your help.
- Can you look up a magazine?
- I like things about guitar, history, and computers.
- Please show me where to go.

Script 2: Requesting a date
- Would you like to have dinner together?
- How about Friday?
- What time?
- Let's meet at the Alpine Grill in Lincoln.
- Great! See you then.

Script 3: Ordering at a restaurant
- I want a large burrito bowl please.
- Rice, black beans, and steak.
- Tomatoes, corn, sour cream, hot sauce.
- And only a little lettuce.