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Supplement

Dosing of a Cued Picture-Naming Treatment for Anomia

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Purpose: Recent investigations into effects of intensity or distribution of aphasia therapy have provided moderate evidence supporting intensive therapy schedules on aphasia treatment response. The purpose of the present study was to investigate the feasibility of creating an intensive therapy session without extending the amount of daily time a person spends in treatment.
Method: Individuals who presented with chronic anomia poststroke ($N = 8$) participated in 2 weeks of a computerized, therapist-delivered, cued, picture-naming treatment. Dosing parameters for each session were 8 presentations of 50 pictures, totaling 400 teaching episodes per session.
Results: Of the 8 participants, 6 achieved significant increases from baseline on trained items after 400 teaching episodes (i.e., 1 treatment hr), and the remaining 2 participants achieved significant increases from baseline after 1200 teaching episodes (i.e., 3 treatment hr). Maintenance data from 7 of the participants indicated that 6 participants maintained significant improvement from baseline on trained items.
Conclusions: Given an intensive and saturated context, anomic individuals were surprisingly quick at relearning to produce problematic words successfully. Most participants demonstrated retention of the gains 2 months after treatment ended. The high density of teaching episodes within the treatment session (i.e., the intensive treatment schedule) may have contributed to the behavioral gains.

Key Words: aphasia, intervention, language disorders

Previous rehabilitation work has demonstrated that dosage is potent (Byl, Pitsch, & Abrams, 2008; Humm, Kozlowski, James, Gotts, & Schallert, 1998; Lisman & Spruston, 2005). Animal studies have shown that intensity of treatment determines behavioral outcomes, as neural networks require a specific number of repetitions of a skill to instantiate lasting change (Kleim et al., 2004). Kleim and Jones (2008) pointed out that a skilled reaching task delivered 400 times per day elicited increases in the number of synapses in the motor cortex (Kleim et al., 2002), whereas the same task delivered 60 times per day did not elicit these changes (Luke, Allred, & Jones, 2004). Increases in synapse formation are thought to play a role in experience-dependent neuroplasticity (Kleim et al., 2002). Moreover, there is a large discrepancy between the number of repetitions of a skill in animal rehabilitation studies and human rehabilitation studies (Krakauer, Carmichael, Corbett, & Wittenberg, 2012; Nudo, 2011), with animal studies employing many more repetitions of skill (e.g., 300 × twice daily; Nudo, Wise, SiFuentes, & Milliken, 1996) than human studies (e.g., 32 × once daily; Lang et al., 2009). Thus, Nudo (2011) suggested that human rehabilitation therapies may be significantly underdosed.

A recent systematic review of intensity of aphasia therapy (Cherney, Patterson, Raymer, Frymark, & Schooling, 2008) found that moderate evidence existed favoring more intensive therapy schedules on behavioral outcomes. Massed practice as applied to language therapy has received recent attention, largely due to the surge of research on *constraint-induced language therapy* (CILT; also known as *constraint-induced aphasia therapy,* CIAT), a treatment paradigm that uses the principles of massed practice, constraint of language output to speech, and behavioral relevance (Pulvermüller et al., 2001). Indeed, this treatment often yields gains in word retrieval abilities by focusing on restitution of language functions, as opposed to use of gesture, writing, or other compensatory strategies. However, it is unclear whether the efficacy

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of CILT is related to the intensity of the treatment or the impact of constraint of language to the verbal modality (Cherney et al., 2008). Due to the strong connections between motor and language systems in the brain, some researchers have questioned whether constraining language to the verbal modality is indeed more beneficial to individuals with aphasia than "unconstrained" treatment techniques. (For a review, see Rose, 2013.)

Several studies have compared CILT/CIAT with other therapies using intensive treatment schedules (Barthel, Djundja, Meinzer, Rockstroh, & Eulitz, 2006; Barthel, Meinzer, Djundja, & Rockstroh, 2008; Kurland, Baldwin, & Tauer, 2010; Kurland, Pulvermüller, Silva, Burke, & Andrianopoulos, 2012; Maher et al., 2006; Sickert, Anders, Münte, & Sailer, 2014) in order to attempt to parse out the effects of intensity versus treatment technique. Two studies investigated the effects of CIAT (n = 27) and model-oriented aphasia therapy (n = 12), each delivered by a massed practice schedule on the standardized Aachen Aphasia Test (Barthel et al., 2008) and on connected speech (Barthel et al., 2006, as cited in Meinzer, Rodriguez, & Gonzalez Rothi, 2012). Both studies found no significant differences between groups, suggesting that CILT may be equivalent to other treatment techniques delivered with an intensive treatment schedule. Kurland et al. (2010) investigated PACE and CILT delivered to the same individual with Wernicke's aphasia, sequentially, for the same intensity. They found that naming trained items improved for both treatments. A recent, randomized controlled trial by Sickert et al. (2014) examined CIAT (n = 50) versus standard aphasia therapy (n = 50), which consisted of exercises including sentence completion, improving lexical retrieval, learning sentence patterns, conversation on current topics, listening to words, and repeating and following instructions. Conventional therapy addressed patient-specific needs and was delivered in a group fashion, as was the CIAT. Both treatments were delivered over the same treatment schedule of 2 hr of training over 15 days. Results indicated that CIAT and conventional therapy produced significant increases on all subtests of the Aachen Aphasia Test (AAC) battery, with no significant differences noted across treatment groups. These studies support that intensive treatment is beneficial, regardless of therapy type.

By contrast, other studies conducting direct comparisons between CIAT and PACE have found that CIAT facilitates greater improvements. Maher et al. (2006) compared CILT (n = 4) with PACE (n = 5), each delivered by a massed practice schedule, and found that standardized measures yielded similar gains (e.g., Boston Naming Test [BNT], Kaplan, Goodglass, & Weintraub, 1983; Western Aphasia Battery [WAB], Kertesz, 1982), but the CILT group made greater improvements on narrative discourse measures. Similarly, Kurland et al. (2012) investigated PACE versus CIAT for the same intensity in two individuals with aphasia and found that both treatments yielded large effect sizes, but CIAT produced a greater effect than PACE.

In addition to the research on CILT, researchers have used other aphasia treatment techniques to investigate the impact of an intensive therapy schedule on therapy outcomes (Basso & Caporali, 2001; Harnish, Neils-Strunjas, Lamy, & Eliassen, 2008; Hinckley & Carr, 2005; Hinckley & Craig, 1998; Lee, Kaye, & Cherney 2009; Ramsberger & Marie, 2007; Raymer, Kohen, & Saffell, 2006; Sage, Snell, & Lambon Ralph, 2011). Of the studies that looked specifically at the effects of intensity of treatment on word retrieval outcomes, Ramsberger and Marie (2007) and Raymer et al. (2006) reported similar results between intensive and nonintensive treatment, whereas Sage et al. (2011) reported more favorable outcomes with nonintensive treatment. See Cherney (2012) for a review.

Some investigators have studied intensive schedules across semantic (Kurland & Falcon, 2011; Kurland et al., 2012; Marcotte et al., 2012; Marcotte, Perlbarg, Marrelec, Benali, & Ansaldo, 2013), phonological (Vitali et al., 2007), and more comprehensive treatments paradigms incorporating a variety of treatment tasks (Wilson et al., 2012). These treatments utilized an intensive schedule, but did not investigate the contribution of intensity by comparing with less intensive schedules. Results indicated that these intensive treatment paradigms promoted behavioral changes (Kurland & Falcon, 2011, Kurland et al., 2012, Marcotte et al., 2012; Marcotte et al., 2013; Vitali et al., 2007; Wilson et al., 2012) and neural changes as seen by functional magnetic resonance imaging (fMRI; Marcotte et al., 2012, Marcotte et al., 2013; Vitali et al., 2007) and EEG (Wilson et al., 2012). Nevertheless, the extent to which high intensity of therapy contributed to these neural changes is unclear.

Massed practice is considered a key feature of CILT/CIAT; however, intensive treatment schedules are often less feasible in a clinical setting due to clinical demands and schedules, participant fatigue, and insurance reimbursement rates. This leads us to ask whether it might be feasible to incorporate a high number of therapeutic trials, or teaching episodes, in a shorter amount of time in order to saturate practice for an individual. Could we create an "intensive" therapy session without extending the amount of daily time a person spends in treatment?

In order to investigate the effects of treatment dosage and/or replicate previously conducted trials with a high degree of treatment fidelity, it is important to describe with great precision the dosage parameters. Hence, the need for consistent terminology with regard to dosage in treatment research exists. More intense treatment could mean (a) a greater number of therapeutic events in a shorter amount of time; (b) a greater number of hours spent in therapy in a shorter amount of time (massed practice), as opposed to fewer hours of therapy in a longer total amount of time (distributed practice); or (c) a greater number of total hours spent in therapy. Cherney (2012) and Baker (2012) highlighted the importance of considering different aspects of dosage with regard to specific treatment techniques and point the reader to Warren, Fey, and Yoder (2007), who identified these dosage parameters as dose form, dose, dose frequency, total intervention duration, and cumulative intervention intensity. The present study documented these dosage parameters in the context of a therapist-delivered, computerized, picture-naming treatment for word-retrieval difficulties. Table 1 outlines the dosage parameters proposed

Table 1. Dosage terms proposed by Warren et al. (2007) and values for the present study.

Dosage terms	Term definitions	Term values for present study
Dose form	The therapeutic task or activity that delivers the teaching episodes. *Teaching episodes include the active ingredients of the intervention.*	Dose form = picture naming Active ingredients = cueing in the form of semantic cues, phonemic cues, orthographic cues, repetition, naming after a delay, etc. (See Figure 1 for a description.)
Dose	The number of times a teaching episode or active ingredient occurs per session. *The dosage rate specifies the number of teaching episodes per unit of time.*	Dose = 50 pictures × 8 cues or presentations = 400 teaching episodes Dosage rate = 400 teaching episodes per 60 min = 6.67 episodes per min
Dose frequency	The number of intervention sessions per unit of time	Dose frequency = 4 times per week
Total intervention duration	The total period of time in which a particular intervention is provided	Total intervention duration = 2 weeks
Cumulative intervention intensity	The product of dose × dose frequency × total intervention duration	Cumulative intervention intensity = 400 teaching episodes × 4 times per week × 2 weeks = 3200 teaching episodes

by Warren et al. (2007) and includes the dosage of the present study as an example.

The treatment in the present study, a therapist-delivered, cued, picture-naming treatment, was selected because of the likelihood that individuals with impairment at different stages in the naming process and with different severities, may respond to it (Gilbert, Kendall, Raymer, Rose, & Gonzalez Rothi, 2009; Kendall, Gonzalez Rothi, Raymer, & Rose, 2009, unpublished raw data). The treatment aimed to provide multiple cues at different stages in the naming process and repetition of responses with therapist modeling to reduce the production of errors. This treatment has not previously been used to investigate intensity of treatment, but we felt it would provide a nice platform for investigating dosage due to the potential to use it with a heterogeneous group of individuals with word-retrieval impairments and the clear number of teaching episodes per treatment session.

Purpose

The purpose of the present case series was to identify individual-specific rates of successful change in naming performance during a circumscribed task of picture naming presented in a "saturated" practice schedule (i.e., a high number of teaching episodes per session). The dosage parameters for the present study were eight presentations of 50 pictures, or 400 teaching episodes, per approximately 1 hr of treatment. Hence, the dosage rate was approximately 6.67 teaching episodes per min. The dose frequency was four times per week, and the total intervention duration was 2 weeks. Therefore, the cumulative intervention intensity was 3200 teaching episodes. The aim of the present investigation was to determine the feasibility of creating an intensive therapy session without extending the amount of daily time a person spends in treatment.

Method

Participants

Prior to enrolling participants, we received approval from the local institutional review board. Participants were recruited from the community and a Veterans Affairs hospital database of stroke survivors who volunteered to be contacted for future research studies. All participants demonstrated picture-naming impairment consistent with a BNT raw score of less than 46, but greater than 3. Participants had at least minimally intact auditory-verbal comprehension, as indicated by a score of no less than 2 *SD*s below norms on the Auditory Verbal section of the WAB. Individuals were 6 or more months post onset from their most recent neurological event permanently affecting the brain, and must not have been suspected of having diffuse injury or disease of the brain (e.g., history of closed head trauma with more than 6 hr of unconsciousness, probable Alzheimer's disease, or history of encephalitis) based upon medical records review and interview of the patient and a close relative. They were premorbidly right-handed as ascertained through administration of the Edinburgh Handedness Inventory (Oldfield, 1971) and were native English speakers. Participants must have had no history of drug or alcohol abuse within 6 months of starting the protocol or a history of vocational or social difficulty due to drug or alcohol abuse. There could be no history of treatment for major affective disorder or schizophrenia. Participants must have had no history of diagnosed learning disability, developmental language delays, or attention deficit disorder as ascertained through medical records or interview of the individual and a close relative.

Eighteen individuals were recruited to participate in the study. Nine potential participants met our inclusion criteria, and eight individuals completed the study. One participant withdrew from the study due to discomfort with fMRI scanning that occurred as part of a larger study. Demographic data are presented in Table 2.

Therapists

The study was conducted at two sites with one treating therapist at each site. The therapists were both ASHA-certified speech-language pathologists with at least 8 years of experience providing treatment to individuals with

Table 2. Participant demographics.

Participants	S1	S2	S3	S4	S5	S6	S7	S8
Gender	M	F	F	F	M	F	F	F
Age	47	65	45	80	61	52	37	65
Education (years)	15	18	14	14	15	12	16	18
Years post-CVA	2	3	7	2	11	5	2	3
BNT	4	11	23	43	10	39	4	33
WAB aphasia quotient	46.5	55	52	80.7	43.5	84.4	35.8	74
WAB classification	Wernicke's	Conduction	Broca's	Anomic	Wernicke's	Anomic	Broca's	Transcortical motor
Lesion location (arterial distribution)	L MCA	L MCA	L MCA	L MCA	L MCA	L MCA	L MCA	L MCA

Note. CVA = cerebrovascular accident; Boston Naming Test (Kaplan et al., 1983); WAB = Western Aphasia Battery (Kertesz, 1982); L MCA = left middle cerebral artery.

aphasia. Each participant received all therapy from the same therapist.

Treatment Design

Development of the treatment paradigm. The treatment paradigm was based on a protocol developed by Kendall and colleagues (Gilbert et al., 2009; Kendall et al., 2009 unpublished raw data). Black and white drawings of objects were presented on a laptop computer using Eprime 1.0 software (Psychology Tools, www.pstnet.com). All of the target pictures represented nouns in the semantic categories of animals, body parts, tools, electronics, containers, nature, clothing, toys, musical instruments, items related to particular occupations, furniture, vehicles, and buildings. The participant was asked to name each noun on eight consecutive occasions with a different cueing strategy for each presentation. The therapist delivered the following sequential cues: (1) independent naming (no cues), (2) orthographic cueing, (3) repeating, (4) naming after a 3 s delay, (5) semantic cueing, (6) phonological cueing, (7) repeating, and (8) naming after a 3-s delay. Figure 1 illustrates the sequential cues.

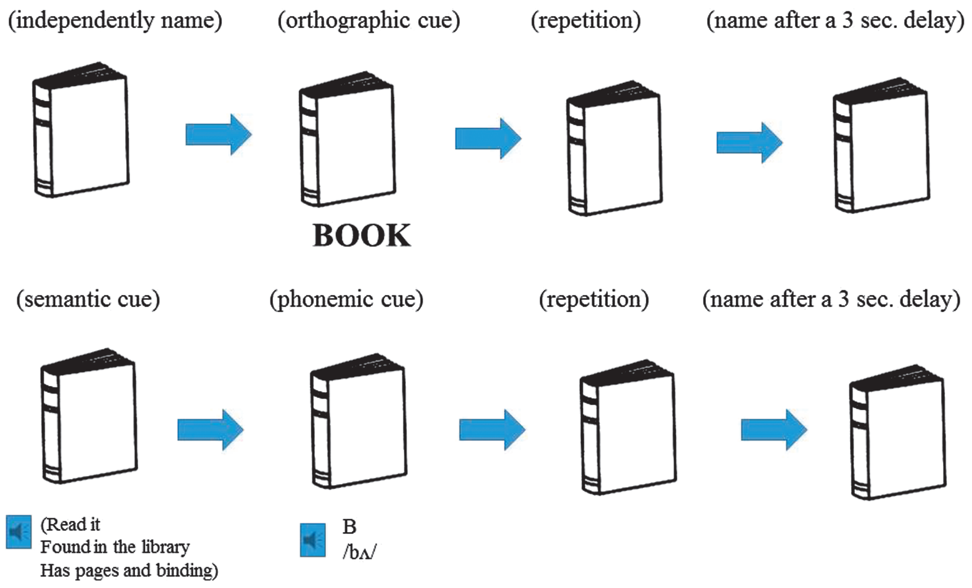
For each picture, the orthographic cue consisted of the entire word printed below the picture. The semantic cues were spoken aloud by the treating therapist and consisted of three semantic features of the words. When appropriate, the three features for each picture fell into the following categories: (a) what it does or where it is found, (b) what it's made of, and (c) distinctive visual characteristics. If these categories were not appropriate for a given picture, then other more salient semantic features were chosen. The phonological cueing consisted of the therapist speaking both the first letter and the first phoneme of the picture name.

Participants were always given the opportunity to name the item independently or after the cue, but in the event they were unable to produce the word after approximately 15 s, the therapist would say the word and ask the patient to repeat the word. The repetition initiated after incorrect responses was different than the repetition that occurred during the sequential cues in that the former occurred only after incorrect responses, whereas the latter was initiated regardless of the correctness of the participants' responses. Therefore, each participant attempted to name or repeat each word on every trial. The therapy progressed through each of the eight presentations regardless of the correctness of the participants' responses. In other words, even if the picture name was correctly provided upon initial presentation, the treatment progressed through the remaining seven presentations with cueing. This provided opportunity for multiple repetitions of the correct responses. Therefore, each participant attempted to name each of the 50 pictures a total of eight times during each treatment session.

The goal of the treatment was to provide maximum cues at a variety of stages in the naming process to increase the likelihood that the participants would be able to produce the item correctly sometime during the eight presentations. The intent of this study was not to create a new treatment for anomia and test its efficacy; rather, it was to use this cued picture-naming treatment as a platform for assessing dosage of aphasia treatment among other principles of neuroplastic changes. The rationale for this approach is that the act of "doing" or actually saying the words repeatedly strengthens the networks responsible for the different stages in these processes. From a practical standpoint, this treatment protocol facilitated collection of dosage data due to the clear number of teaching episodes that occurred during each treatment session. However, we did not investigate the specific effects of each type of cue that was provided, or each "active ingredient" of the therapy. Therefore, we are not able to make specific inferences about how each of the multiple active ingredients contribute to the treatment gains demonstrated by individual participants on the basis of their semantic, phonological, or orthographic abilities because we did not investigate the clinical utility of each of the cues for each participant. The goal of the study was to look at the collection of active ingredients in this treatment together as a platform or vehicle for learning in order to study how dosage impacts performance.

Treatment item selection. Individually tailored stimulus sets were created for each participant because there is large interindividual variability in the ability to name objects, and picture-naming treatments tend to result in item-specific treatment effects with little if any generalization to untrained items (Maher & Raymer, 2004). Participants were each asked to name a corpus of 575 pictures over two sessions that

Figure 1. Cued picture-naming treatment.



were 2–4 hr in length. Then, the same pictures were presented a second time over two sessions that were 2–4 hr in length. Forty pictures that were named incorrectly on both occasions were selected for training in addition to 10 pictures that were named correctly. The latter items were included to reduce frustration associated with repeated attempts at naming difficult items. The ability or inability to name items on both presentations was the only criterion for item selection. Thus, treatment items were not matched on any variables across participants. Due to the variability in the participants' severity of aphasia, it would have been difficult to have matched for psycholinguistic variables, such as word frequency or number of syllables for items chosen across participants. Moreover, because this was a single subject design study, our top priority was choosing the most appropriate stimuli for each participant on the basis of his or her treatment item selection assessment.

Probe lists. A picture-naming probe list was created to establish naming performance before, during, and after treatment. The probe list included a random sample of 20 items that were trained in treatment and 20 items that were untrained in treatment. Of the 20 items trained in treatment, 16 were items the person was not able to name during the treatment item selection process and four items were pictures the person was able to name during the treatment item selection process. The latter items were included to reduce frustration associated with repeated unsuccessful attempts at naming, especially during the initial treatment sessions. Untrained items were included to determine whether repeated exposure to probe items resulted in improved performance. This may indicate that the probe assessments themselves created an effect that was unrelated to the treatment. Trained and untrained items were matched for word frequency (Francis & Kucera, 1982), living versus nonliving items, number of syllables, and nonoverlapping semantic categories.

Black and white pictures were presented individually on a laptop using Eprime 1.0 software (Psychology Tools, www.pstnet.com). Pictures remained on the screen for 12 s, during which time the participant attempted to name them. A 12-s time limit was chosen on the basis of clinician and investigator judgment that 12 s would capture the vast majority of responses and reduce some of the frustration of continuing to try to name an item for longer periods (e.g., 20 s, as is standard with the BNT). If the item was named correctly within the 12 s, the therapist indicated so on the computer keyboard. If the response was incorrect, the therapist waited until the time elapsed to allow the participant to correct the response within the time limit. Responses that were initially incorrect but corrected by the participant were scored as correct. After the 12-s time limit elapsed, the picture disappeared and a white screen held the place in the program until the therapist advanced to the next picture. No cuing was provided during the probe lists, as the goal was to document independent naming abilities throughout the baseline, treatment, and posttreatment phases.

Each naming attempt was written verbatim on a score sheet by the therapist during the trial as a backup to the electronic tracking in the Eprime software. Feedback was not directly provided to the participant regarding the accuracy of responses but could be inferred on the basis of whether the therapist triggered the picture to disappear (for correct responses) or waited until the time elapsed (for incorrect responses).

Baseline phase. Prior to beginning treatment, each participant was asked to name the pictures from the picture-naming probe list. The entire list of pictures was presented at least eight times or until the *c* statistic (Tryon, 1982) indicated a stable baseline. The *c* statistic is a method that evaluates changes in serially dependent time-series data via upward or downward trends, or in the case of the present study: the stability of data in a baseline period based on the absence of upward or downward trends. Please see Tryon (1982) for more information on how to calculate the *c* statistic.

The baseline naming sessions of the probe list occurred on 2 to 4 days depending on scheduling and participant fatigue. Prior to each administration of the naming probe list pictures, individuals participated in the Spatial Span assessment from the Wechsler Memory Scales (Wechsler, 1997) in order to divert attention from the naming process to reduce the likelihood of mental rehearsal of the words prior to beginning the next administration of the naming probes.

Treatment phase. Prior to each treatment session, the entire picture-naming probe list was presented. Treatment occurred for approximately 1 hr, 4 days per week, for 2 weeks. All 50 treatment items were presented in random order on a laptop computer using Eprime 1.0. Each item was presented for eight consecutive naming trials using the cued picture-naming treatment described above. The therapist provided encouragement and feedback during the treatment-naming attempts, which included phrases such as "Nice try"; "This was a difficult item for you. Let's try it again"; and "That's it!" We highlight that this encouragement was provided during the treatment phase because we did not provide this type of explicit feedback while presenting the picture-naming probe items.

Post-treatment phase. After 2 weeks of therapy were finished, the picture-naming probes were assessed four times on 1 to 2 days depending on scheduling and participant fatigue. The Spatial Span from the Wechsler Memory Scale (Wechsler, 1997) was administered before each probe list to divert attention from the naming task in order to reduce the likelihood of mental rehearsal of the word from trial to trial. The probe list was administered in the same fashion as during the baseline phase.

Follow-up phase. At approximately 60 days posttreatment, the picture-naming probe list was readministered to each participant. The data presented herein were part of a larger study with a second block of aphasia treatment. The picture-naming probe list was administered eight times or until the C-statistic indicated stability, but for the purpose of determining maintenance effects in the present study, the first four probes from this second baseline phase will be used as 60-day follow-up data to indicate maintenance of treatment effects.

It is worth noting that although the participants received no language therapy between the posttreatment phase and the follow-up phase, they did undergo an exercise intervention of either biking on a stationary bicycle or stretching with a physical therapist or therapy assistant. Hence, there is a chance that follow-up phase data are affected by the exercise intervention or interaction with a physical therapist. No language treatment goals were addressed in the exercise intervention; however, physical exercise or interactions with a physical therapist could have been influential on their language scores because the participants (a) began a new exercise regimen, which may have impacted overall cognitive or language functions; and (b) interacted with a physical therapist three times per week for 6 to 8 weeks prior to follow-up phase testing. Participants 1, 2, 3, 4, 5, and 7 received the biking intervention. Participants 6 and 8 received the stretching intervention.

Reliability

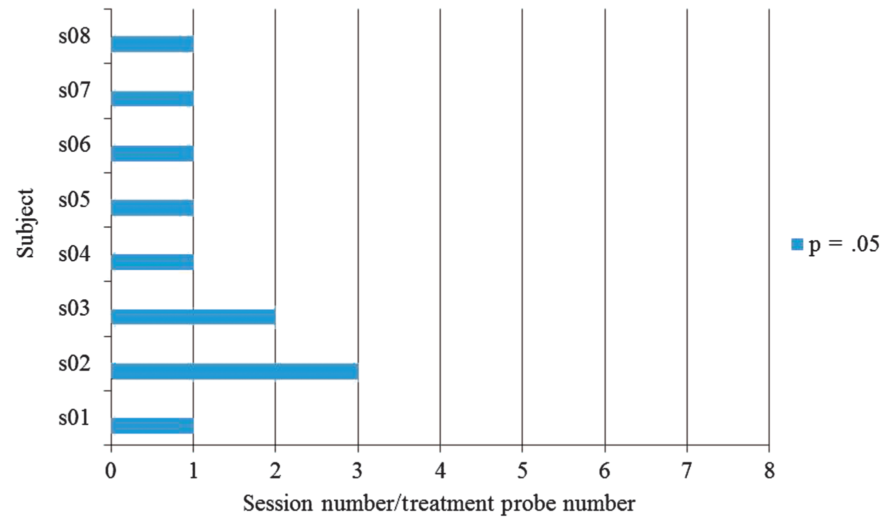
Intra- and interrater reliability were scored by watching videos of 15% of the probe sessions. Due to issues related to placement of the video recorder, only approximately 15% of the probe sessions were suitable for reliability analyses because of the inability to see the probe pictures that were presented on the laptop screen. Of the 15% of sessions that were rated for reliability, probe sessions from six of the eight participants were represented. Intrarater reliability was assessed by the treating therapist reviewing videos and rescoring the probe sessions without access to previous data sheets. Intrarater reliability was 98.6%. Additionally, a speech-language pathologist who did not participate in delivery of the treatment watched videos and scored the naming responses as correct or incorrect. Interrater reliability was 98.0%. Discrepancies were evaluated by comparing the original data collection sheets with the reliability data collection sheets. It was determined that most of the discrepancies were related to whether a participant said a correct response within the time limit or after the time elapsed. Original data collection sheets indicated that a correct response was made after time elapsed, but the video recordings proved more difficult to determine the time limit. Therefore, original scores were included for those items. Any additional discrepancies were discussed and determined by consensus.

Results

Data were analyzed on an individual participant basis. The *M* and *SD* of baseline naming abilities were calculated from baseline naming probes delivered until the *c* statistic indicated stability of naming performance. Stability was achieved in nine to 13 probe sessions for all participants. We used the baseline *M* and *SD* to define a point at which patients exceeded a certain number of *SD*s above the *M*. To define the point at which change could be considered significant, we used the critical thresholds for the *t* distribution. We evaluated whether performance after each session (or each 400 teaching episodes) was significantly greater than baseline, using the critical values for the *t* distribution as a threshold, for two consecutive sessions ($p = .05$). If two consecutive sessions were significantly greater than baseline, we indicated the first session as the point of increase. See Figure 2 for individual rates of significant change from baseline.

Results revealed that six out of eight participants achieved significant increases from baseline on trained items after 400 teaching episodes (i.e., after the first treatment

Figure 2. First treatment probe showing significant change from baseline.



session, which lasted approximately 1 hr), and the remaining two participants achieved significant increases from baseline after 1200 teaching episodes (i.e., after the third treatment session). Untrained pictures were also included in the naming probe list. Three participants showed significant increases in naming untrained probes after treatment sessions two, four, and six (on the 16th, 18th, and 20th attempt at naming untrained probes, respectively), potentially due to repeated exposure of the stimuli during probe sessions.

To determine whether frequent probing of untrained items contributed to possible increases in the participants' abilities to name these items, we also included a list of untrained probe items that were only probed before and after treatment for six of the eight participants. This list consisted of 20 untrained items; four of which were correct on pre-treatment assessment and 16 that were incorrect. Two of the six participants showed increases in the number of pictures they could name out of 20. The raw naming scores for the untrained, rarely probed items before and after treatment are presented in Table 3.

Maintenance probe data were collected 8 weeks after finishing treatment for seven out of eight participants. By comparing probe data collected approximately 2 months after completion of therapy with critical values for the *t* distribution, we determined whether maintenance data were significantly greater than baseline. For items that were trained in therapy, six of seven participants maintained significant improvement from baseline for at least two consecutive probes out of the four probes delivered at follow-up. For untrained items, two of seven participants showed significant improvement from baseline.

Naming performance for each of the probe sessions during baseline, treatment, and posttreatment phases were plotted for each of the participants; see Figures 3–10. We used the conservative dual-criterion (CDC) method (Fisher, Kelley, & Lomas, 2003) to objectively analyze the treatment effects. Each treatment graph included a mean line and a trend line that was adjusted upward by .25 *SD*s. Treatment effects were determined by evaluating each data set to determine whether it met criterion set in the CDC method for minimum number of data points above both the mean and trend lines. Seven of the eight participants (all but S07) demonstrated a positive treatment effect according to the CDC method.

Individual effect sizes were calculated for each participant by subtracting the *M* of the baseline probes from the *M* of the posttreatment probes and dividing by the *SD* of the baseline probes. The effect sizes are presented in Table 4 (Robey & Beeson, 2005). According to benchmarks based on a review of 12 studies on treatment of lexical retrieval deficits (Robey & Beeson, 2005), effects sizes of 4.0, 7.0, and 10.1 correspond with small, medium, and large effects, respectively. Two participants demonstrated treatment gains consistent with a large effect size, one demonstrated a medium effect and five showed gains consistent with small effect sizes.

Discussion

Most studies of aphasia treatments describe "dosage" in terms of number of hours spent in treatment with little to no discussion of the number of therapeutic events that occur during the sessions. In a recent review article on intensity of aphasia treatment, Cherney (2012) proposed that inconsistent use of dosing terminology in aphasia treatment studies may explain some of the differences in treatment effects. She suggested that documenting dosage of aphasia treatment with greater precision will more accurately reflect effects associated with a particular treatment. Here, we provided an example of how to document dosage in an aphasia treatment

Table 3. Raw scores on untrained, rarely probed items.

Participant	Pretreatment total (n = 20)	Pretreatment correct (n = 4)	Pretreatment incorrect (n = 16)	Posttreatment total (n = 20)	Posttreatment correct (n = 4)	Posttreatment incorrect (n = 16)
S01	5	4	1	5	4	1
S02	3	2	1	4	3	1
S03	5	4	1	5	4	1
S04	12	4	8	10	3	7
S05	9	3	6	8	3	5
S06	10	4	6	13	4	9

Note. Pretreatment and posttreatment correct items refer to items that were selected because they were named correctly by that participant on two occasions during a pretreatment assessment of naming abilities. Pretreatment and posttreatment incorrect items refer to items that were selected because they were named incorrectly by that participant on two occasions during a pretreatment assessment of naming abilities.

study, using terms proposed by Warren et al. (2007). We found that most individuals with anomia were able to show significant gains in reacquiring problematic words after only approximately 1 hr of a cued picture-naming treatment that incorporated eight teaching episodes per word, or a total of 400 teaching episodes for all 50 trained words. This saturated context of training may be useful in a clinical setting when the amount of time a patient spends in therapy is limited.

All eight participants demonstrated significant increases from baseline after only three sessions of treatment (approximately 3 hr of therapy, or 1200 teaching episodes). Although three of the participants also showed significant increases in untrained items, individual effect sizes indicated that the effects for untrained items were much smaller than for trained items. All eight participants showed at least a small effect size for trained items, whereas all but one participant showed no significant treatment effect for untrained items, as determined by the benchmarks outlined in Robey and Beeson (2005).

Although significant naming accuracy gains occurred for all participants within three sessions of therapy, the individual effect sizes were relatively modest for most individuals. The issue may come down to statistical significance versus clinical significance. A statistically significant change in daily probes was determined using critical values for the t distribution. This measure provides us with the probability that the change in accuracy of naming performance from one day to the next is due to something other than chance, presumably the treatment. The individual effect size benchmarks outlined in Robey and Beeson (2005) provide us with standards to determine the clinical significance of the magnitude of change in naming performance, so that we may be able to compare magnitude of change across studies and treatments. All of the participants in this study

Figure 3. Percent correct of probe items per session with conservative dual criterion (CDC) lines shown for trained items for S01.

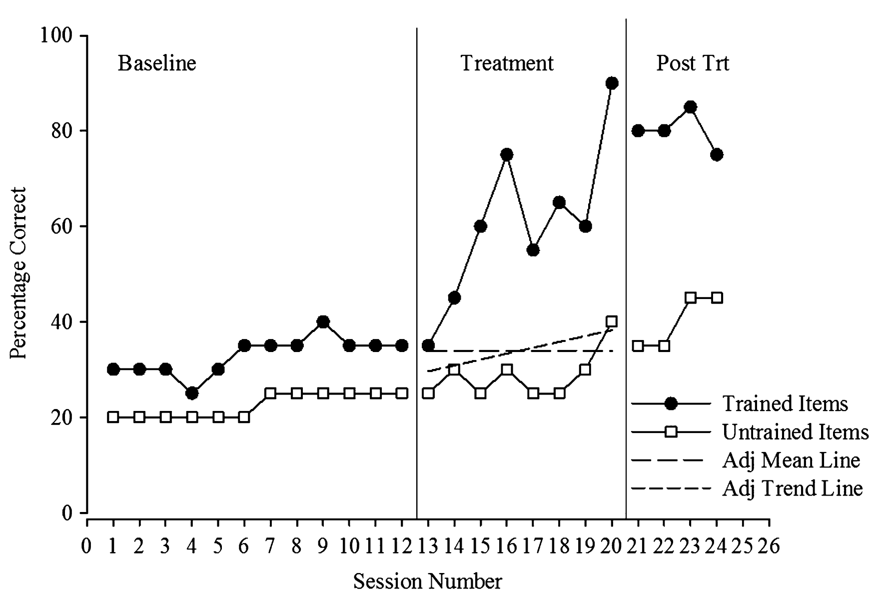
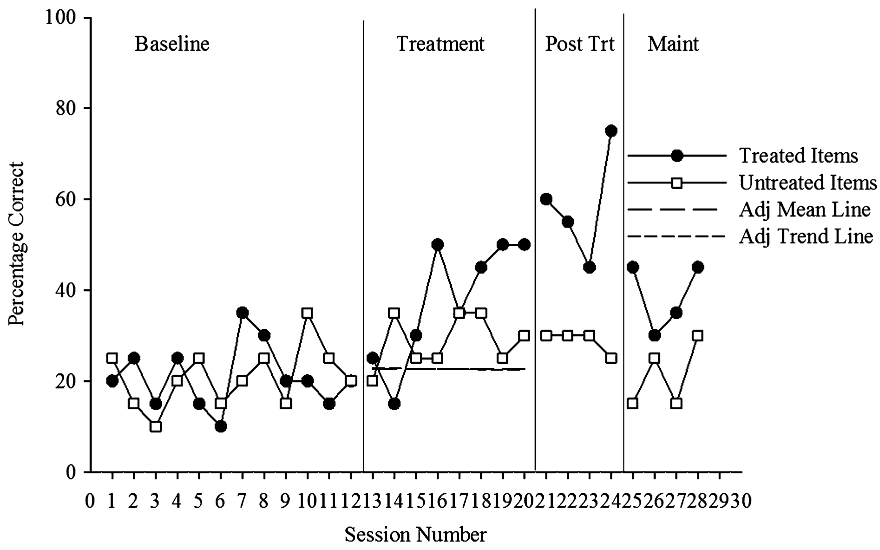


Figure 4. Percent correct of probe items per session with CDC lines shown for trained items for S02.



demonstrated statistically significant changes in naming performance relatively quickly that were likely not due to chance. On the basis of prior literature of treatments for lexical retrieval (Robey & Beeson, 2005), we determined that two of the participants demonstrated clinically significant gains in naming performance consistent with a large effect size. One participant demonstrated a medium effect size and five showed a small effect size. The clinical utility of this treatment approach in changing word retrieval performance may be evaluated by comparing the individual effect sizes with those of other treatments for word retrieval deficits.

Individual participant data were also graphed and analyzed according to the CDC method (Fisher et al., 2003). Using the criterion set with this method, seven of eight participants demonstrated statistically significant treatment effects. The other analyses we conducted on these data (i.e., using critical values for the *t* distribution and individual effect size calculations from Robey & Beeson, 2005) showed significant effects in all eight participants. We feel the discrepancy is because the CDC method adjusts the trend lines upward to .25 *SD*s in order to reduce type I error. In other words, it is a more conservative method of analysis.

Figure 5. Percent correct of probe items per session with CDC lines shown for trained items for S03.

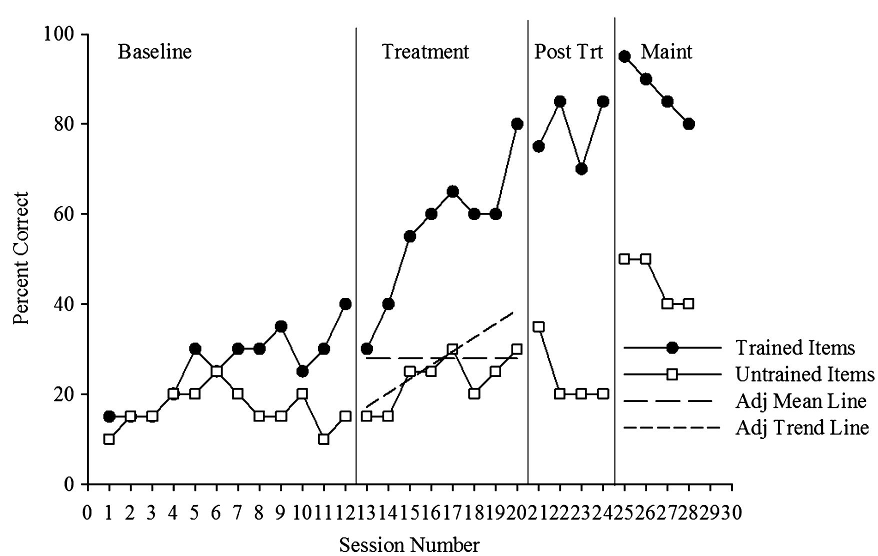
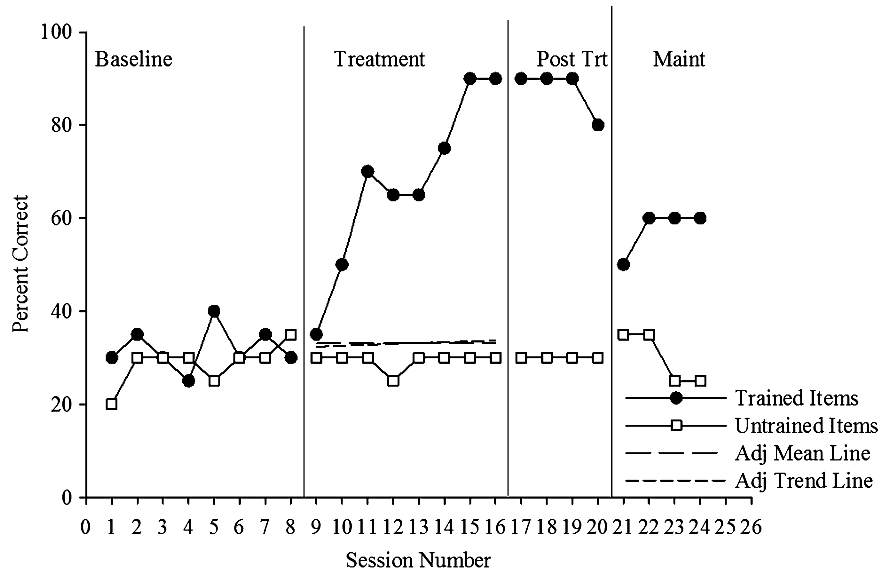


Figure 6. Percent correct of probe items per session with CDC lines shown for trained items for S04.



Nevertheless, seven of eight participants still demonstrated significant treatment effects using the CDC method.

Trained and untrained items were carefully matched so that they consisted of items with similar word frequencies, the same number of syllables, the same number of living versus nonliving items, and nonoverlapping semantic categories. We matched these items so that (a) trained and untrained items were relatively similar in terms of difficulty to produce, and (b) we would limit generalization that may occur within a semantic category. The fact that three individuals did show a statistically significant increase in naming untrained items from baseline, presumably as a result of repeated exposure to the untrained stimuli during probe naming sessions, is something that warrants future investigation. Because untrained items were included to control for the effects of repeated exposure to stimuli, this may indicate a loss of experimental control. However, for the five participants who did not show significant differences

Figure 7. Percent correct of probe items per session with CDC lines shown for trained items for S05.

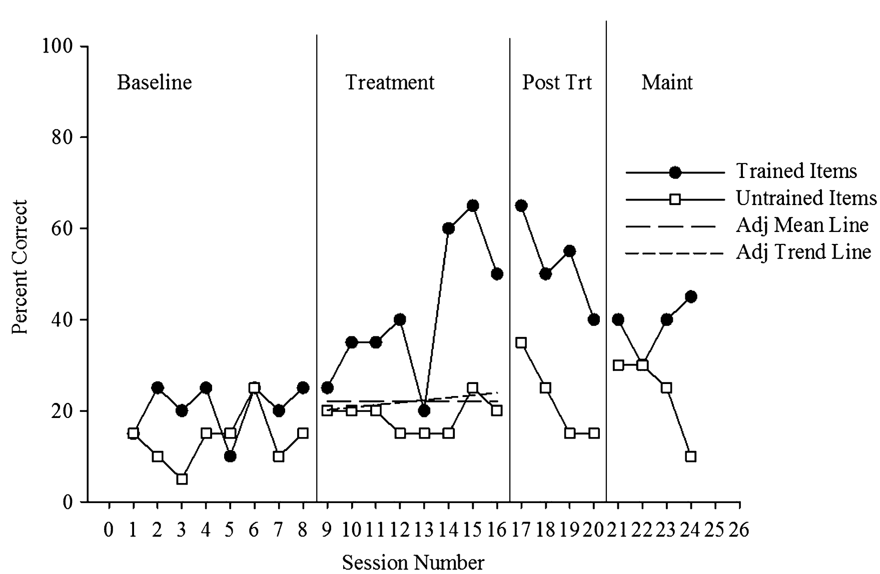
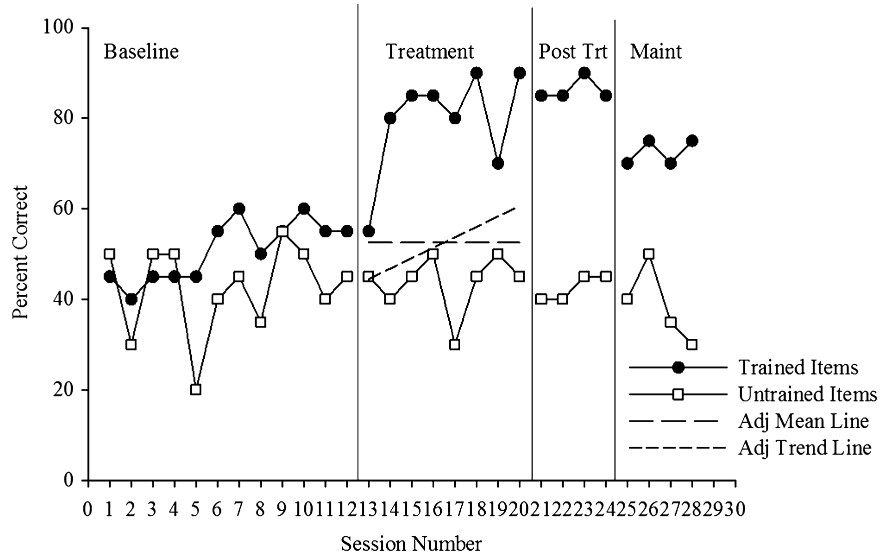


Figure 8. Percent correct of probe items per session with CDC lines shown for trained items for S06.



from baseline in naming untrained items, we can be reasonably sure that the effects demonstrated on trained items were a result of the cued picture-naming treatment and not the repeated exposure to the probes. For the three participants who did show this statistically significant increase from baseline on naming untrained items, we must interpret the treatment effects for trained items with caution because we cannot be sure to what extent the repeated exposure to the probe stimuli contributed to the effect.

An idea of relevance here is that repeated exposure to probe stimuli may produce an effect that does not represent generalization of trained items to untrained items (Howard, 2000; Nickels, 2002). In essence, chance correct productions of untrained stimuli result in activation of semantic and phonological representations for that picture, thereby strengthening the mapping of the word and increasing the likelihood that it will be produced correctly on subsequent presentations (Nickels, 2002). It does not represent generalization; rather, it is a result of repeated attempts at naming probe items.

In order to determine whether performance on untrained probe items increased as a result of repeated exposure to the probe stimuli or possible generalization, we examined

Figure 9. Percent correct of probe items per session with CDC lines shown for trained items for S07.

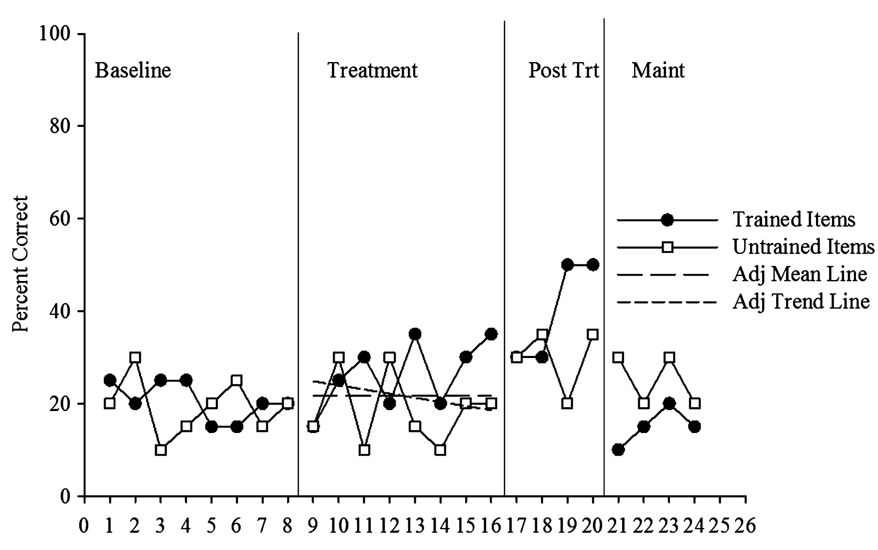
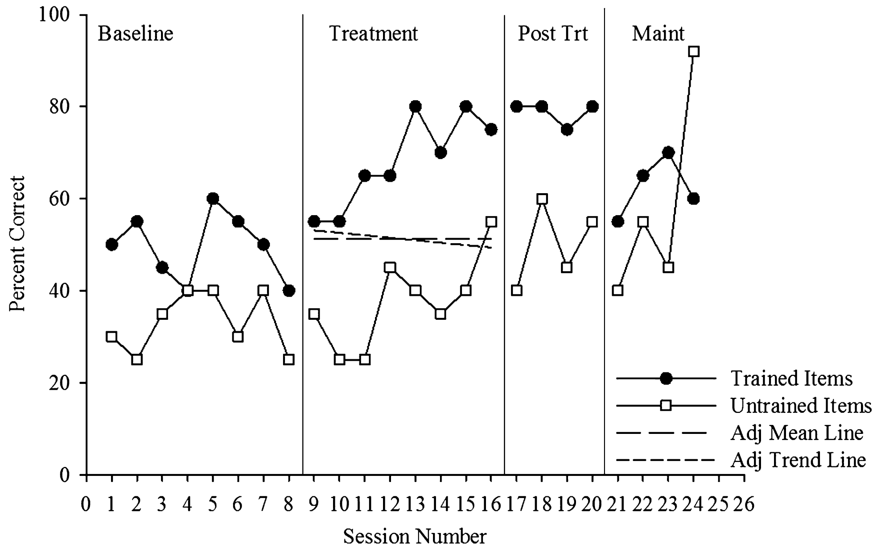


Figure 10. Percent correct of probe items per session with CDC lines shown for trained items for S08.



an additional set of untrained, rarely probed items that were collected for five of the seven participants. This was a list of 20 items, four of which were named correctly on our pre-treatment naming task and 16 that were named incorrectly on our pretreatment naming task. These probes were assessed only once before beginning treatment and once after treatment ended. Thus, they should not show the effects of repeated exposure to the extent of the probe list given before each treatment session. Results demonstrated that only two of five participants showed slight increases (addition of one or three correctly named items) in naming these untrained, rarely probed items after treatment. One of the two participants also showed increases in naming items that were probed often. These data lend support to the hypothesis that for two of the three individuals who showed increases in untrained items that were probed frequently, the effect was likely due to repeated exposure of probe items. If it truly represented generalization, we would likely have witnessed the same effect with untrained items that were probed less frequently in these participants.

Table 4. Individual effect sizes for cued picture-naming treatment gains.

Participant	Trained probes	Effect size	Untrained probes	Effect size
S1	*d* = 11.75	large	*d* = 5.67	small
S2	*d* = 9.86	medium	*d* = 1.33	n/a
S3	*d* = 6.63	small	*d* = 1.75	n/a
S4	*d* = 11.2	large	*d* = 0.25	n/a
S5	*d* = 5.33	small	*d* = 1.5	n/a
S6	*d* = 5	small	*d* = 0	n/a
S7	*d* = 4.75	small	*d* = 1.83	n/a
S8	*d* = 4.29	small	*d* = 2.43	n/a

Although unlikely, it is *possible* that the increases in naming untrained items could represent generalization of treatment gains to items that were untrained. The plausibility of this hypothesis depends on the mechanism by which we would or would not expect to see this effect. For example, if we explicitly or implicitly taught a word-retrieval strategy that the participant was able to independently apply to untrained stimuli, then we could reasonably assume that generalization may have occurred. The treatment paradigm that we employed in the present study included item-specific cues such as semantic cues, phonemic cues, orthographic cues, repetition, and naming after a delay. There was no explicit training on how to internally apply these cues to untrained items (e.g., Try to think of the first letter of the word. Try to think of physical properties or functions of the word.). It is within the realm of possibility that these three participants were better able to self-cue for untrained items after participating in therapy during which they received cues from the therapist on trained items. The individual effect sizes were much smaller for these untrained items such that only one of the participants showed a statistically significant effect size (Robey & Beeson, 2005), which may be consistent with gains from a self-cueing strategy as opposed to the larger effect sizes demonstrated after therapist-delivered cues.

Another possible mechanism for generalization would be if there were linguistic properties of the trained and untrained items that would facilitate generalization. Kiran and Thompson (2003) demonstrated that gains for trained items may generalize to untrained items in the same semantic category. Similarly, trained items that are more complex may generalize to items in that semantic category that are less complex (Kiran, 2007). In our opinion, it is unlikely that semantic relationships can account for generalization to untrained items for the present study because we chose stimuli that included nonoverlapping semantic categories between trained and untrained items. However, it is possible that there were other linguistic properties that we have not identified that could account for this generalization. Nonetheless, even the most optimistic assessment would indicate that generalization is sporadic at best in this sample.

Although feedback was not directly provided to the participants regarding the accuracy of responses during probe sessions, it may have been inferred on the basis of whether the therapist triggered the picture to disappear (for correct responses) or waited until the time elapsed (for incorrect responses). It is possible that this implicit feedback impacted the performance of participants who showed increases in naming untrained items. We recommend that future studies control for this indirect feedback by maintaining the picture on the screen for all 12 s regardless of the correctness of the participants' responses.

The present study demonstrated individual rates of increases in picture-naming performance during a cued picture-naming treatment that incorporated a high density of teaching episodes within the therapy session. The next step in this line of research will be to empirically test whether density of teaching episodes contributes to behavioral gains by comparing treatments with high and low density of teaching episodes. We acknowledge that it takes increased effort to document these parameters during treatment, and some treatments will lend themselves better to systematically evaluating dosage than others. However, dosage studies that carefully document the dosage parameters proposed in Warren et al. (2007) will allow for better treatment fidelity, replication of treatment studies, and better justification for session length in a clinical setting.

It should be noted that in the present study, the effects of each active ingredient (e.g., semantic cues, phonological cues, orthographic cues, etc.) were not assessed. We logged the teaching episodes, which included multiple active ingredients, but did not evaluate, for example, which cue assisted the participant most in speaking the target word. The goal of this treatment was to use various cues to assist the participant in speaking the target word and provide multiple opportunities for repetition of the word in order to strengthen its mapping so that the individual would have a higher likelihood of retrieving it in the future. Future research should investigate dosage parameters of each active ingredient of a treatment in order to hone in on the interaction between dosage and the most salient aspects of various treatment techniques. Moreover, due to the small sample size in this study, effects of this particular treatment should be interpreted with caution.

Conclusions

The present study investigated increases in picture-naming performance after a therapist delivered computerized picture-naming treatment for word-retrieval difficulties. We examined the number of sessions or teaching episodes required for each participant to demonstrate significant increases in picture naming. The high density of teaching episodes within the treatment session *may* have contributed to the statistically significant behavioral gains demonstrated by all participants in the study and the early treatment gains demonstrated by the majority of the participants after only approximately 1 hr of therapy due to the repeated practice of lexical retrieval; however, in order to substantiate this claim, future research will need to empirically test the effects of density of teaching episodes, or dosage rate, on word retrieval outcomes. Follow-up data indicated that six out of seven participants maintained significant improvements in naming abilities from baseline. This is consistent with a hypothesis by Monfils, Plautz, and Kleim (2005) and highlighted in Kleim and Jones (2008, p. S229), which states that "the plasticity brought about through repetition represents the instantiation of skill within neural circuitry, making the acquired behavior resistant to decay in the absence of training."

In summary, given an intensive and saturated context, individuals with anomia were surprisingly quick at relearning to produce words successfully. Many of the participants retained the gains. Future research may investigate the effects of dosage by comparing treatments with high and low dosage rate (i.e., number of teaching episodes per unit of time) in the treatment sessions. Similarly, investigation of manipulation of the number of practice sessions beyond the initial successful production of a word may provide insight into the extent to which "overlearning" assists with retention.

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References

Baker, E. H. (2012). Optimal intervention intensity. *International Journal of Speech-Language Pathology, 14,* 401–409.

Barthel, G., Djundja, D., Meinzer, M., Rockstroh, B., & Eulitz, C. (2006). Aachener Sprachanalyse (ASPA): Evaluation bei Patienten mit chronischer Aphasie [Aachen language analysis (ASPA): Evaluation in chronic aphasia] [German]. *Sprache · Stimme · Gehör [Language · Voice · Hearing], 30,* 103–110.

Barthel, G., Meinzer, M., Djundja, D., & Rockstroh, B. (2008). Intensive language therapy in chronic aphasia: Which aspects contribute most? *Aphasiology, 22,* 408–421.

Basso, A. A., & Caporali, A. (2001). Aphasia therapy or the importance of being earnest. *Aphasiology, 15,* 307–332.

Byl, N. N., Pitsch, E. A., & Abrams, G. M. (2008). Functional outcomes can vary by dose: Learning-based sensorimotor training for patients stable poststroke. *Neurorehabilitation and Neural Repair, 22,* 494–504.

Cherney, L. R. (2012). Aphasia treatment: Intensity, dose parameters, and script training. *International Journal of Speech-Language Pathology, 14,* 424–431.

Cherney, L. R., Patterson, J. P., Raymer, A., Frymark, T., & Schooling, T. (2008). Evidence-based systematic review: Effects of intensity of treatment and constraint-induced language therapy for individuals with stroke-induced aphasia. *Journal of Speech, Language, and Hearing Research, 51,* 1282–1299.

Fisher, W. W., Kelley, M. E., & Lomas, J. E. (2003). Visual aids and structured criteria for improving visual inspection and interpretation of single-case designs. *Journal of Applied Behavior Analysis, 36,* 387–406.

Francis, W. N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and Grammar*. Boston, MA: Houghton Mifflin.

Gilbert, J., Kendall, D. L., Raymer, A., Rose, M., & Gonzalez Rothi, L. (2009, May). *Treatment of word retrieval deficits in aphasia: A phase I investigation*. Paper presented at the Florida Association of Speech-Language Pathologists and Audiologists Annual Convention, Marco Island, FL.

Harnish, S. M., Neils-Strunjas, J., Lamy, M., & Eliassen, J. C. (2008). Use of fMRI in the study of chronic aphasia recovery after therapy: A case study. *Topics in Stroke Rehabilitation, 15,* 468–483.

Hinckley, J. J., & Carr, T. (2005). Comparing the outcomes of intensive and non-intensive context-based aphasia treatment. *Aphasiology, 19,* 965–974.

Hinckley, J. J., & Craig, H. K. (1998). Influence of rate of treatment on the naming abilities of adults with chronic aphasia. *Aphasiology, 12,* 989–1006.

Howard, D. (2000). Cognitive neuropsychology and aphasia therapy: The case of word retrieval. In I. Papathanasiou (Ed.), *Acquired neurogenic communication disorders: A clinical perspective* (pp. 76–100). London, England: Whurr.

Humm, J. L., Kozlowski, D. A., James, D. C., Gotts, J. E., & Schallert, T. (1998). Use-dependent exacerbation of brain damage occurs during an early post-lesion vulnerable period. *Brain Research, 783,* 286–292.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *Boston Naming Test*. Philadelphia, PA: Lea & Febiger.

Kendall, D. L., Gonzalez Rothi, L., Raymer, A., & Rose, M. (2009). [Semantic platform treatment]. Unpublished raw data.

Kertesz, A. (1982). *Western Aphasia Battery*. New York, NY: Grune & Stratton.

Kiran, S. (2007). Complexity in the treatment of naming deficits. *American Journal of Speech-Language Pathology, 16,* 18–29.

Kiran, S., & Thompson, C. K. (2003). The role of semantic complexity in treatment of naming deficits: Training semantic categories in fluent aphasia by controlling exemplar typicality. *Journal of Speech, Language, and Hearing Research, 46,* 608–622.

Kleim, J. A., Barbay, S., Cooper, N. R., Hogg, T. M., Reidel, C. N., Remple, M. S., & Nudo, R. J. (2002). Motor learning-dependent synaptogenesis is localized to functionally reorganized motor cortex. *Neurobiology of Learning and Memory, 77,* 63–77.

Kleim, J. A., Hogg, T. M., VandenBerg, P. M., Cooper, N. R., Bruneau, R., & Remple, M. (2004). Cortical synaptogenesis and motor map reorganization occur during late, but not early, phase of motor skill learning. *The Journal of Neuroscience, 24,* 628–633.

Kleim, J. A., & Jones, T. A. (2008). Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. *Journal of Speech, Language, and Hearing Research, 51,* S225–S239.

Krakauer, J. W., Carmichael, S. T., Corbett, D., & Wittenberg, G. F. (2012). Getting neurorehabilitation right: What can be learned from animal models? *Neurorehabilitation and Neural Repair, 26,* 923–931.

Kurland, J., Baldwin, K., & Tauer, C. (2010). Treatment-induced neuroplasticity following intensive naming therapy in a case of chronic Wernicke's aphasia. *Aphasiology, 24,* 737–751.

Kurland, J., & Falcon, M. (2011). Effects of cognate status and language of therapy during intensive semantic naming treatment in a case of severe nonfluent bilingual aphasia. *Clinical Linguistics & Phonetics, 25,* 584–600.

Kurland, J., Pulvermüller, F., Silva, N., Burke, K., & Andrianopoulos, M. (2012). Constrained versus unconstrained intensive language therapy in two individuals with chronic, moderate-to-severe aphasia and apraxia of speech: Behavioral and fMRI outcomes. *American Journal of Speech-Language Pathology, 21,* S65–S87.

Lang, C. E., Macdonald, J. R., Reisman, D. S., Boyd, L., Jacobson, K. T., Schindler-Ivens, S. M., … Scheets, P. L. (2009). Observation of amounts of movement practice provided during stroke rehabilitation. *Archives of Physical Medicine and Rehabilitation, 90,* 1692–1698.

Lee, J. B., Kaye, R. C., & Cherney, L. R. (2009). Conversational script performance in adults with non-fluent aphasia: Treatment intensity and aphasia severity. *Aphasiology, 23,* 885–897.

Lisman, J., & Spruston, N. (2005). Postsynaptic depolarization requirements for LTP and LTD: A critique of spike timing-dependent plasticity. *Nature Neuroscience, 8,* 839–841.

Luke, L. M., Allred, R. P., & Jones, T. A. (2004). Unilateral ischemic sensorimotor cortical damage induces contralesional synaptogenesis and enhances skilled reaching with the ipsilateral forelimb in adult male rats. *Synapse, 54,* 187–199.

Maher, L. M., Kendall, D., Swearengin, J. A., Rodriguez, A., Leon, S. A., Pingel, K., … Gonzalez Rothi, L. J. (2006). A pilot study of use-dependent learning in the context of constraint induced language therapy. *Journal of the International Neuropsychological Society, 12,* 843–852.

Maher, L. M., & Raymer, A. M. (2004). Management of anomia. *Topics in Stroke Rehabilitation, 11,* 10–21.

Marcotte, K., Adrover-Roig, D., Damien, B., de Préaumont, M., Généreux, S., Hubert, M., & Ansaldo, A. I. (2012). Therapy-induced neuroplasticity in chronic aphasia. *Neuropsychologia, 50,* 1776–1786.

Marcotte, K., Perlbarg, V., Marrelec, G., Benali, H., & Ansaldo, A. I. (2013). Default-mode network functional connectivity in aphasia: Therapy-induced neuroplasticity. *Brain and Language, 124,* 45–55.

Meinzer, M., Rodriguez, A. D., & Gonzalez Rothi, L. J. (2012). First decade of research on constraint-induced treatment approaches for aphasia rehabilitation. *Archives of Physical Medicine and Rehabilitation, 93,* S35–S45.

Monfils, M. H., Plautz, E. J., & Kleim, J. A. (2005). In search of the motor engram: Motor map plasticity as a mechanism for encoding motor experience. *Neuroscientist, 11,* 471–483.

Nickels, L. (2002). Therapy for naming disorders: Revisiting, revising, and reviewing. *Aphasiology, 16,* 935–979.

Nudo, R. J. (2011). Neural bases of recovery after brain injury. *Journal of Communication Disorders, 44,* 515–520.

Nudo, R. J., Wise, B. M., SiFuentes, F., & Milliken, G. W. (1996, June 21). Neural substrates for the effects of rehabilitative training on motor recovery after ischemic infarct. *Science, 272,* 1791–1794.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia, 9,* 97–113.

Pulvermüller, F. B., Neininger, B., Elbert, T., Mohr, B., Rockstroh, B., Koebbel, P., & Taub, E. (2001). Constraint-induced therapy of chronic aphasia after stroke. *Stroke, 32,* 1621–1626.

Ramsberger, G., & Marie, B. (2007). Self-administered cued naming therapy: A single-participant investigation of a computer-based

therapy program replicated in four cases. *American Journal of Speech-Language Pathology, 16,* 343–358.
Raymer, A. M., Kohen, F. P., & Saffell, D. (2006). Computerised training for impairments of word comprehension and retrieval in aphasia. *Aphasiology, 20,* 257–268.
Robey, R. R., & Beeson, P. M. (2005, November). Aphasia treatment: Examining the evidence. Paper presented at the American Speech-Language-Hearing Association Annual Convention. San Diego, CA.
Rose, M. L. (2013). Releasing the constraints on aphasia therapy: The positive impact of gesture and multimodality treatments. *American Journal of Speech-Language Pathology, 22,* S227–S239.
Sage, K., Snell, C., & Lambon Ralph, M. A. (2011). How intensive does anomia therapy for people with aphasia need to be? *Neuropsychological Rehabilitation, 21,* 26–41.
Sickert, A., Anders, L.-C., Münte, T. F., & Sailer, M. (2014). Constraint-induced aphasia therapy following sub-acute stroke: A single-blind, randomised clinical trial of a modified therapy schedule. *Journal of Neurology, Neurosurgery, & Psychiatry, 85,* 51–55. doi:10.1136/jnnp-2012-304297
Tryon, W. W. (1982). A simplified time-series analysis for evaluating treatment interventions. *Journal of Applied Behavior Analysis, 15,* 423–429.
Vitali, P., Abutalebi, J., Tettamanti, M., Danna, M., Ansaldo, A.-I., Perani, D., … Cappa, S. F. (2007). Training-induced brain remapping in chronic aphasia: A pilot study. *Neurorehabilitation and Neural Repair, 21,* 152–160.
Warren, S. F., Fey, M. E., & Yoder, P. J. (2007). Differential treatment intensity research: A missing link to creating optimally effective communication interventions. *Mental Retardation and Developmental Disabilities Research Reviews, 13,* 70–77.
Wechsler, D. (1997). *WMS–III administration and scoring manual.* San Antonio, TX: The Psychological Corporation.
Wilson, K. R., O'Rourke, H., Wozniak, L. A., Kostopoulos, E., Marchand, Y., & Newman, A. J. (2012). Changes in N400 topography following intensive speech language therapy for individuals with aphasia. *Brain and Language, 123,* 94–103.