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# The role of intensity in constraint-induced language therapy for people with chronic aphasia

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*Background*: Studies of intensive aphasia treatments vary widely in terms of treatment focus, in patient population and, in particular, in definition of what is considered "intensive". Variability makes it difficult to compare among studies and to definitively determine whether more treatment is actually better. Constraint-induced language therapy (CILT) is one treatment that has been successfully replicated at approximately the same dosage with generally positive results.
*Aims*: The current study used a modified multiple baseline design across participants to investigate the administration of CILT at the standard intensive dosage of 30 hours over 2 weeks (CILT-I) compared to a more distributed dosage of 30 hours over 10 weeks (CILT-D).
*Methods & Procedures*: Eight participants with chronic aphasia participated in either CILT-I or CILT-D. Standardised and discourse measures were taken pre- and post-treatment and also 4 weeks after the completion of treatment. Discourse probes were administered after every 6 hours of treatment to assess change in productivity and efficiency over time.
*Outcomes & Results*: All of the participants who received CILT-I and CILT-D showed either an increased effect size on a discourse measure, a clinically significant change on a standardised battery or both. Gains were maintained in nearly all cases.
*Conclusions*: CILT administered in both intensive and distributed dosages resulted in positive changes in aphasia severity and discourse. This study adds evidence to the still inconclusive role of intensity to CILT.

**Keywords:** aphasia treatment; constraint induced; intensity; dosage

## Introduction

Constraint-induced language therapy (CILT), originally known as constraint-induced aphasia therapy (CIAT; Pulvermüller et al., 2001) and also referred to as intensive language action therapy (ILAT; Difrancesco, Pulvermüller, & Mohr, 2012), tends to produce consistently positive language changes as reported by numerous studies in the past 14 years (e.g., Johnson et al., 2014; Maher et al., 2006; Rose, Attard, Mok, Lanyon, & Foster, 2013; Sickert, Anders, Münte, & Sailer, 2014). The variables contributing to remediation, however, remain ambiguous. Restraining compensatory communication is a radical change for speech-language pathologists who have been trained to assist in the maximisation of functional communication. Therefore, before adopting such a paradigm shift, it is prudent to determine those factors contributing to the success of treatment seen following CILT.

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Several studies cite the importance of intensity of treatment for those with chronic aphasia; however, a systematic review of studies that controlled the treatment in order to compare intensive and non-intensive dosages found the results equivocal (Cherney, Patterson, Raymer, Frymark, & Schooling, 2010). Contributing to these results was a large randomised control study that demonstrated the rigours of an intensive program of 5 hours per week no more effective than the "standard" dosage which averaged less than 2 hours per week, both over a span of 12 weeks, for those with *acute* aphasia (Bakheit et al., 2007).[1] The authors noted that most of the patients allocated to receive 5 hours of treatment per week were too ill or refused treatment in the first four weeks. In addition, some studies reported treatment response that favoured a distributed plan of treatment (Ramsberger & Marie, 2007; Sage, Snell, & Lambon Ralph, 2011).

In the non-impaired population, it is distributed practice, also known as spaced repetition, that has been shown to be more effective *except* in the learning of complex tasks which requires more rigorous practice (Donovan & Radosevich, 1999). The practice required in order for language restitution to take place in an individual with chronic aphasia might be considered such a complex task and intensive training may be necessary to make continued changes to the cognitive-linguistic system.

Distributed practice has logistical advantages in aphasia rehabilitation in that it is the way treatment is currently scheduled in outpatient clinics, allowing a speech and language pathologist to see multiple clients per day. Repeated opportunities for language practice have potential advantages for the participant as well. By extending the treatment period, the person with aphasia (PWA) has multiple opportunities for adaptive neural change to occur.

Cherney and colleagues (Cherney, Patterson, Raymer, Frymark, & Schooling, 2008) provided a systematic review summarising evidence for intensity of treatment and for CILT on language and functional outcome measures. Data suggested that performance on language outcome measures was generally better and maintained longer following CILT than on other intensively administered treatments. Importantly, there are few studies that have specifically controlled for intensity. Maher et al. (2006) and Kurland, Pulvermüller, Silva, Burke, and Andrianopoulos (2012) each compared CILT to a group therapy encouraging multimodality communication, much like promoting aphasics' communicative effectiveness therapy (PACE; Davis, 2005), which promotes the use of all communicative modalities, including gesture, drawing, and writing. Improvements were noted in both groups but Kurland et al. (2012) reported better naming performance and Maher et al. (2006) reported better maintenance of gains following for those who received CILT. Most recently, Rose, Attard, et al. (2013) used multi-modality aphasia treatment (M-MAT), for which the goal was also verbal language production, but which allowed clinicians to use multimodal cues to facilitate production. Again, there was a positive change in aphasia severity in both groups and reported improvements in language production. Neither treatment was reported as having an advantage over the other. One study compared CILT to an individually tailored therapy (Barthel, Meinzer, Djundja, & Rockstroh, 2008) with, again, comparable results. In summary, results have tended to favour CILT over comparison treatments, marginally, but no study has yet found a clear advantage for it, suggesting that intensity may be a main contributor to positive outcomes following this treatment. When CILT was compared to "traditional treatment" performed at a less intensive schedule of ~30 hours over 3–5 weeks, significant gains were observed on standardised tests for those who participated in CILT (Pulvermüller et al., 2001). Gains were much less pronounced for those who received the "traditional treatment".

It is commonly recognised within the field that generalisation to overall improved communication is the goal of treatment, yet this is not captured on a standardised aphasia battery. Discourse performance may be the most direct measure of generalisation, but this outcome measure is rarely included in studies of CILT. In those that have, gains tend to be noted. For example, Maher and colleagues (2006) found increases in clinical judgment of narrative discourse, and Rose, Attard, et al. (2013) reported increases in the number of substantive nouns in conversational transcripts for some participants. Additional work is necessary to determine the impact of CILT on discourse performance.

The present study is a Phase II study (Robey, 2004) in which the treatment was controlled in order to analyse the contribution of intensity to CILT for eight individuals with chronic aphasia. Several outcome measures were used to assess change including generalisation to discourse. CILT was delivered in what is considered a standard dose at a Total Intervention Duration of 30 hours over 2 weeks (e.g., Kurland et al., 2012; Maher et al., 2006; Meinzer et al., 2004) to two dyads. The same treatment was also administered in a more traditional dosage schedule of 30 hours over 10 weeks to two additional dyads. This latter dosage schedule of 3 hours per week is more akin to what an individual might receive in a typical outpatient rehabilitation setting.

As in previous studies, standardised measures were used to assess change in aphasia severity over time. In addition, however, a measure of production of content in discourse (Nicholas & Brookshire, 1993) was selected to highlight potential changes in the productivity, as well as the efficiency and informativeness of language. Content measures have been used in the past to document productivity change for people with aphasia ranging from anomic to severe (e.g., Wambaugh, Wright, Nessler, & Mauszycki, 2014). Efficiency relates to how quickly the same content is relayed and has been used to assess change in people with more mild–moderate aphasia severity (e.g., Cameron, Wambaugh, Wright, & Nessler, 2006). An informativeness measure has been used for those whose aphasia is characterised by circumlocution and behaviours more in line with Wernicke's aphasia (e.g., Rogalski, Edmonds, Daly, & Gardner, 2013), but has value as a measure for all severity levels in quantifying the amount of information conveyed by a person with aphasia. Where productivity may be the most relevant measure for those with nonfluent aphasia, efficiency may be particularly important to measure for those with fluent aphasia types. Informativeness, however, is appropriate and valuable in objectively measuring discourse production from a heterogonous patient population.

This study aimed to add evidence for the role of intensity in CILT for people with chronic aphasia. CILT has been shown to improve language outcomes, but a main element of this treatment is the restriction of alternate communicative modalities, including gesture, which is considered beneficial for some in augmenting traditional therapy (for review, see Rose, Raymer, Lanyon, & Attard, 2013). Therefore, testing of the factors contributing to positive change is warranted. Variable response to treatment was anticipated, consistent with heterogeneous participant characteristics; however, gains in discourse productivity and on standardised tests were predicted for individuals who received the intensive training (CILT-I). Given the success seen following both CILT and other intensive aphasia treatments, including those with that did not constrain participants to the verbal modality of language, it was hypothesised that those who received a more standard distribution of treatment (CILT-D) were less likely to demonstrate and maintain change on these measures when compared to their pre-treatment performance. Each participant served as his or her own control and was qualitatively compared to other participants in order to begin an investigation of differences based on (1) outcomes on standardised tests and on performance on treatment materials, (2) generalisation of treatment effects to discourse, and (3) maintenance of treatment.

## Methods

### *Participants*

Eight participants were recruited from an aphasia group based at the University of Connecticut Speech and Hearing Clinic. Inclusion criteria included (1) a single left-hemisphere stroke, (2) onset of at least one year prior to participation in the study, (3) premorbid right-handedness, as confirmed by a spouse or family member, (4) no reported history of other neurological or learning disorders, (5) monolingual speakers of English, and (6) access to reliable transportation (see Table 1). All participants had adequate hearing and visual acuity, some with hearing aids or glasses, to participate in the study. Individuals' communicative deficits varied widely and six demonstrated some degree of concomitant apraxia of speech (AOS). Differential diagnosis of AOS is difficult, particularly for those with more severe aphasia deficits where symptoms of groping and variability of errors may be attributable to the aphasia (Duffy, 2012). AOS is generally thought to negatively impact aphasia treatment, but participants with AOS have been included in previous CILT studies with positive results (e.g., Kurland, Silva, Burke, & Iyer, 2011; Kurland et al., 2012; Maher et al., 2006), and thus AOS was not considered as criteria for exclusion.

While taking part in the study, from the time of baseline data collection to follow-up testing 4 weeks post-treatment, individuals did not participate in any other form of language rehabilitation, including social aphasia groups. Informed consent was obtained from all participants in the study, which was approved by the University of Connecticut Institutional Review Board.

### *Design*

This study used a modified multiple baseline design across subjects (McReynolds & Kearns, 1983) in order to detect potential changes in discourse production, the primary outcome variable of interest, resulting from treatment on a case-by-case basis. In this way, it was possible to track potential generalisation of treatment to connected speech across eight participants of varying aphasia severity. CILT, designed for small groups, is less conducive to the required staggering of baselines at the individual level. Since treatment for each dyad was conducted at different time periods (CILT-I dyads received treatment in July and August; CILT-D dyads received treatment from September to November), staggered and protracted baseline periods were possible at the small group level but would have required participants, all of whom relied on caregivers for transportation, to make several additional trips to the Speech and Hearing Clinic. This was not financially or logistically feasible for most of them. Instead, a minimum of three baselines was taken for each individual at least 24 hours between baselines. All of the participants in this study were at least 1 year post-CVA and none were receiving alternate therapy. Therefore, it is likely that any change following baseline is a result of treatment. Replication of results was demonstrated across participants following a relatively stable baseline defined here as a non-rising baseline for discourse informativeness.

Table 1. Characteristics of participants receiving intensive (I) and distributed (D) treatment.

| ID | I1 | I2 | I3 | I4 | D1 | D2 | D3 | D4 |
|---|---|---|---|---|---|---|---|---|
| Age | 26 | 53 | 67 | 72 | 63 | 47 | 51 | 77 |
| MPO | 67.2 | 18 | 134.4 | 42 | 96 | 13.2 | 21.6 | 13.2 |
| Years of education | 12 | 14 | 12 | 12 | 12 | 12 | 13 | 16 |
| Sex | M | F | M | F | M | M | F | M |
| Handedness | Right | Right | Right | Right | Right | Right | Right | Right |
| Hemiplegia | Mild | None | Severe | Severe | None | Severe | None | Moderate |
| Race/Ethnicity | Caucasion | Caucasion | Caucasion | African American | Caucasion | Caucasion | Caucasion | Caucasion |
| Previous employment | Cook, McDonalds | FAA- Technical Operations | Mechanic | Homemaker | Paving and construction | Window installation | Hospital food service | Computer aided design and manufacture |
| AOS | Mild | Severe | Mod | Mod | Severe | Mod | Mild | Mod |
| CADL | 90 | 90 | 40 | 8 | 26 | 35 | 81 | 77 |
| R-CPM | 95% | 95% | 25% | 5% | 50% | 95% | 95% | 50% |
| WAB-R AQ | 67.7 | 24.8 | 32.3 | 27.4 | 28.9 | 50.1 | 84.2 | 73.6 |
| Selected WAB-R AQ Subtests | | | | | | | | |
| Yes/No questions | 100.00% | 90.00% | 80.00% | 75.00% | 70.00% | 95.00% | 85.00% | 90.00% |
| Auditory-verbal comprehension | 100.00% | 81.67% | 45.00% | 11.67% | 60.00% | 95.00% | 93.33% | 98.33% |
| Word fluency | 30.00% | 0.00% | 10.00% | 10.00% | 0.00% | 10.00% | 60.00% | 20.00% |
| Object naming | 88.33% | 3.33% | 25.00% | 21.67% | 11.67% | 66.67% | 100.00% | 76.67% |
| WAB classification | Broca's aphasia | Not classifiable | Broca's aphasia | Global aphasia | Not classifiable | Broca's aphasia | Anomia | Conduction aphasia |

Note: ID: I, intensive; D, distributed; AOS, apraxia of speech; CADL, Communication Activities of Daily Living (Holland et al., 1999); R-WAB AQ, Revised Western Aphasia Battery Aphasia Quotient (Kertesz, 2006). WAB AQ subtest scores converted to per cent correct.

Standardised measures of aphasia, cognition, and functional communication were administered pre- and post-therapy and 1 month after the completion of treatment as additional measures of responsiveness to treatment.

### *Standardised assessments*

The Western Aphasia Battery-Aphasia Quotient (WAB-R AQ; Kertesz, 2006) and the Communication Activities of Daily Living-2 (CADL-2; Holland, Frattali, & Fromm, 1999) were administered pre-treatment, immediately post-treatment, and 1 month post-treatment. The WAB-R provides an AQ yielding an estimation of aphasia severity and classification parameters. The test has good test–retest reliability ($r = .88$, $p < 0.001$) and internal consistency ($r = .974$; Shewan & Kertesz, 1980), and a five point gain is thought to be *clinically significant* (Shewan & Donner, 1988). Clinical significance refers to the amount of improvement due to treatment that a clinician would judge as being relevant. Using guidelines by Katz and Wertz (1997) and precedent set by other experienced researcher-clinicians (Elman & Bernstein-Ellis, 1999), a 10% change was used when not otherwise specified. The object-naming subtest of the WAB was used to gauge potential treatment generalisation to untrained words.

The CADL provides a way to quantify the ability of someone with aphasia to communicate using their residual skills in day-to-day encounters. It also has good test–retest reliability ($r = 0.88$) and internal consistency ($r = 0.99$; Aten, Caligiuri, & Holland, 1982). The Quick Assessment for Apraxia of Speech (validity and consistency unavailable; Tanner & Culbertson, 1999) was completed pre-treatment only to help characterise the language deficits of the participants. When possible, AOS was distinguished from aphasia and classified as mild, moderate, or severe using differential diagnosis guidelines recommended by Duffy (2005, p. 422).

### *Baseline testing for generalisation to discourse*

Three to six baseline probes testing discourse production were administered on different days, always at least 24 hours apart, but within a 2 week time period during the period of pre-treatment testing. Treatment began once stability was achieved for the informativeness measure of correct information units (CIUs): word count (WC). Stability was defined as a lack of consistent increase or decrease in slope though day-to-day performance variation, not unusual for PWAs, was evident for several participants. CIUs/min were calculated for each picture description (see section on *data analysis*, for details on this discourse analyses) and averaged with the other two for each baseline point as well as for subsequent probes during and following treatment.

Baseline testing was always completed first, prior to any other testing scheduled for that day. In order to control for potential learning effect, 10 different Rockwell prints were used to stimulate language production throughout all baseline, treatment, and post-treatment probes. Three Rockwell prints were shown to each participant at each probe and for each they were prompted with “Can you tell me what is happening in this picture?” The next three prints from the 10 were administered at the next baseline, keeping the same 10 pictures in rotation for all subsequent baseline probes, treatment probes, and follow-up probes. Ten pictures were chosen and presented in succession to decrease chance of a learning effect and since connected speech resulting from multiple stimuli are said to be more representative of change due to treatment (Brookshire & Nicholas, 1994). No time limit was given for responses.

### *CILT intervention*

Assignment to CILT-I or CILT-D was based on participant availability. Then, dyads were created by best matching PWAs with comparable aphasia severity according to performance on the pre-treatment testing measures. Aphasia severity was defined by the WAB-R AQ but was not an ideal indicator of severity for those participants with more severe apraxia of speech since only oral responses are scored. This was considered when pairing participants and clinical judgment was used to create the best pairings within groups. Four participants (two male, two female) received intensive CILT (CILT-I) and four participants (three male, one female) received distributed CILT (CILT-D) (see Table 1). The treatment for each level of intensity was identical.

Traditional CILT according to the protocol initially described by Pulvermüller and colleagues (2001) and with further refinement from Maher et al. (2006) was administered to both groups. CILT has been described in even more detail and gesture restrictions have been further clarified in Difrancesco and colleagues (2012). The activity central to treatment is, essentially, the well-known "Go Fish" game in which one participant asks another for a card that matches one of those he has been dealt. If the person has the requested card, it is surrendered; if not, the requestor must "go fish" or draw from the deck. The activity continues until one player is holding no remaining unmatched cards. In our rendition of CILT, as in a typical game of Go Fish, the player with the most pairs wins the round.

There are several levels of task difficulty as outlined by Maher et al. (2006). Level One required a single word response given a deck of high frequency words. Level Two was the same but required introduction of the carrier phrase, "John, do you have the…" Level Three required use of an adjective, "Do you have the green pear", and Level Four required the use of two adjectives, "Do you have the sliced, green pear?" Criterion was reached when both participants in a dyad achieved fluidity or approximately 80% accuracy at a level. Since the same stimuli were used for Level One and Level Two, these two levels could be trained simultaneously by setting different production targets for each individual.

Participants who received CILT-I attended treatment for a session duration[2] of 3-hours, Session Frequency of 5 days per week, for a total number of 10 sessions over a total intervention duration of 2 weeks. After the first 90 minutes, they received a 10-minute break to stretch and have a snack. Treatment then continued for an additional 90 minutes. Those who received CILT-D participated in 1-hour sessions, 3 days a week, for 10 weeks. No breaks were provided within the 1-hour sessions. Card sets were created to include nouns of high- and low-frequency occurrence and items of varying number and colour.

Central to CILT is the employment of *forced use* of the verbal modality and *restraint* of all communication modalities except for oral verbal language. All participants were required to produce and respond to verbal communication regularly throughout the session. Each participant understood that the "rules" of the game required no use of alternative communicative modalities such as writing or gesture. Vague gesticulations accompanying verbal productions were accepted, but gesturing as a means of communication was discouraged as outlined in the clarification of CILT methods (Difrancesco et al., 2012). Shaping was also a component of treatment requiring increasingly more challenging linguistic goals. For example, the single word, "brush" or even an approximation such as /brə/ was acceptable in the beginning, but with each success new goals were created toward the goal of a full sentence consisting of a carrier phrase plus the requested item, "John, do you have the paint brush?" Participants were instructed on individual linguistic targets (word approximation, single word or introduction of the carrier phrase) prior to each session and the clinician provided cueing as necessary in order that a correct response was elicited and the production of errors was avoided (errorless learning). This took no more than a minute prior to the initiation of treatment each day and was often the same as the day before, in which case no further instruction was provided. The clinician, a licensed SLP and the first author of this manuscript, participated in game play and modelled expected requests and responses for each participant. Cardholders were provided for individuals with hemiplegia who could not hold at least five cards fanned out and for any other participant who chose to use one.

### *Treatment stimuli*

Treatment stimuli were created by the first author for each level of treatment, described above. They consisted of 120 full colour stimulus items per level, which were divided into four 30-card decks. Word frequency data were derived from the MRC psycholinguistic database (Coltheart, 1981). This large number of stimuli relative to those from other studies is based on evidence that the goal of treatment is not word learning but rather neuroplastic brain remodelling as has been documented following intensive aphasia treatments (e.g., Crosson et al., 2009; Meinzer et al., 2004; Schlaug, Marchina, & Norton, 2009). Results from intensive studies demonstrating generalisation to untrained stimuli suggest that it is possible to regain access to abilities lost following neuronal death and diaschisis. Greater numbers of stimuli have been demonstrated to result in increased word production with equal durability than shorter lists of stimuli for both individuals with severe and those with mild naming impairments (Snell, Sage, & Ralph, 2010).

### *Discourse probes of generalisation*

Discourse probes identical to those administered at baseline were also administered after every 6 hours of treatment in order, resulting in a total of five probes per participant. Participants were scheduled to arrive 30 minutes early in order to complete probe testing prior to that day's treatment session. Treatment probes were also administered during post-treatment follow-up sessions.

### *Data analysis*

Results of the WAB-R AQ and the CADL-2 along with changes in discourse performance were each analysed and described to assess each individual's response to treatment. All discourse elicitation and standardised assessment administration were digitally video-recorded. Discourse measures were then transcribed verbatim and analysed for CIU count by the first author, according to the procedure developed by Nicholas and Brookshire (1993). CIUs are words and intelligible paraphasias that are relevant to the picture being described. Words do not need to be used in a grammatically correct manner in order to be included in the CIU count, but if they did not accurately describe the picture, they were not counted. For example, if the picture was of a boy falling off a stool and the participant said, "She is falling off the table", no credit would be given for "she" or for "table". False starts, revisions and extraneous commentary such as "I don't know how to say it but", were also not included. CIUs provide a measure of productivity and is most relevant for with more moderate-severe aphasia deficits. For those with milder deficits, efficiency of verbal production was more relevant and CIUs per minute were calculated. CIUs as a proportion of total WC were calculated as a measure of informativeness, relevant for all. All three measures were calculated for each participant.

Ten per cent of the transcripts were re-analysed by the first author and the second author for reliability of CIU counts. Both inter- and intra-rater reliability calculations were generated 6 months after initial counts were made. Point-to-point intra-rater agreement of 95.7% was performed by the first author. Point-to-point inter-rater agreement between the first and second authors was 91.3% and differences were resolved by discussion so that final agreement was 100%. The CIU/min is a calculated measure combining CIU count and time. Its reliability is affected by the reliability of the CIU count discussed earlier.

Effect sizes (ES) were calculated in order to avoid the Type I error that often occurs with visual inspection alone (Beeson & Robey, 2006). The $d$ statistic was calculated as described by Busk and Serlin (1992, pp. 197–198, as cited in Beeson & Robey, 2006) by subtracting the mean of the baseline probes from the mean of the two final probe scores and dividing the result by the standard deviation of the baseline scores. In the calculation of Total CIUs for participant I4, the first treatment probe was included in the baseline mean due to no baseline variability for this participant. Strength of effect benchmarks (large = 10, moderate = 7, small = 4) were based on the reports of Beeson and Robey (2006). In this calculation, ES are strongly influenced by baseline variability and thus are interpreted in conjunction with visual inspection.

## Results

Due to the heterogeneity of the participants, results are summarised and interpreted individually, each participant acting as his or her own control. Participants who received CILT-I (I1, I2, I3, I4) received 30 hours over 2 weeks and are described first. Those who received CILT-D (D1, D2, D3, D4) received 30 hours of treatment over 10 weeks and are described next. Results of treatment performance, standardised testing, and discourse measures are discussed.

### *CILT-I participants*

#### *Treatment performance*

Of all eight participants, I1 was the least motivated and often arrived late to treatment sessions. Despite this, I1 progressed through Level One by the end of the first week. He was producing full carrier phrases plus a high frequency word (Level Two) with only minimal cueing needed to initiate the carrier phrase by the end of the treatment duration.

I2 was highly motivated to improve verbal production. Due to severe AOS, this participant relied on writing to communicate; therefore, constraint to the verbal modality was particularly challenging for her. I2 could not produce or repeat a single word at the start of treatment and at the end could name approximately 20 words with cueing, including reminders of articulator placement. She never achieved criteria (80% accuracy) for Level One.

I3 presented with moderate AOS though in this case, AOS was more difficult to diagnose due to severity of aphasia in which all communicative modalities were severely impaired. This participant made greater gains in treatment performance than any other participant, notable due to the fact that he was 11.2 years post stroke. He could not independently name one item prior to treatment and by the end could name most of the trained items with a minimal visual or phonemic cue and could name 31 items independently. I3 did achieve 80% accuracy on Level One by the end of treatment.

I4 presented with more severe aphasia deficits than any of the other participants in both expressive and receptive language. Though initially very motivated and upbeat, she struggled through the treatment sessions and became very frustrated by the end of the 2 weeks, having made little progress. I4 could not spontaneously name one item prior to treatment, and unlike I3, she did not demonstrate similar growth and nearly all words required a phonemic cue or full model to elicit production. I4 could name five words independently at the end of 2 weeks and did not achieve Level One criteria.

### *Standardised tests*

Results of standardised tests for I1, I2, I3, and I4 appear in Table 2. The five WAB-R AQ subtests shown are those for which the greatest change was observed among those who demonstrated change compared to the other subtests. Pre-treatment, I1 scored near ceiling levels on the CADL, demonstrating good use of residual language and functional communication. WAB-R scores were high in auditory comprehension subtests and lower for oral verbal language production. Following 30 hours of treatment, I1 made an 8.4-point change on the WAB-R AQ attributable to naming and word repetition subtests. Smaller gains were also observed on the CADL. I1 did not return for follow-up testing, thus treatment maintenance could not be examined for this participant.

Pre-treatment, I2 also scored near ceiling levels on the CADL, demonstrating good use of functional communication despite almost no oral verbal language. She effectively used writing and gesture to communicate. WAB-R scores were moderately high in auditory comprehension subtests and very low for oral verbal language production, consistent with her severe AOS. Following 30 hours of treatment, I2 made an 8.2 point change on the WAB-R AQ attributable to auditory comprehension subtests. No gains were observed on the CADL immediately post-treatment. Small gains were seen on the CADL and the WAB-R AQ at follow-up testing one-month post-treatment. Again, gains were most marked in auditory comprehension measures, but there was a small gain in object naming at this time point as well.

Pre-treatment, I3 scored in the 40th percentile on the CADL. Many errors were judged to be a result of auditory comprehension deficits. An initial WAB-R AQ of 32 was comprised of auditory comprehension subtest scores that declined as complexity increased and generally low scores on oral verbal language production subtests. Following 30 hours of treatment, I3 made a 14 point change on the WAB-R AQ with gains in several areas but most pronounced on auditory comprehension subtests. A 25% gain was also observed on the CADL. As with his Treatment Performance, I3's gains on standardised tests exceeded that of all other participants. All gains were maintained at follow-up testing 1-month post-treatment and I3 demonstrated increased gains on object naming subtests.

I4 scored 8% on the CADL pre-treatment as auditory deficits precluded understanding of most of what was presented in this test. An initial WAB-R AQ of 27.4 comprised auditory comprehension subtest scores that declined as complexity increased and generally low scores on oral verbal language production subtests. Following 30 hours of treatment, I4 made a 3.3-point change on the WAB-R AQ, which would not be considered clinically significant; however, the 30% gain in auditory word recognition was notable. An 11% gain was also observed on the CADL. All gains were maintained at follow-up testing 1-month post-treatment.

Table 2. CILT-I summary of assessment scores at each testing period.

| | I1 | | | | | I2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change |
| CADL-2 | 90.00% | 96.00% | 6.67% | NS | NS | 90.00% | 90.00% | 0.00% | 96.00% | 6.67% |
| WAB-R AQ | 67.72% | 76.10% | 12.37% | NS | NS | 24.80% | 32.60% | 31.45% | 33.00% | 33.06% |
| | | | | | WAB AQ Subtests | | | | | |
| *Yes/no questions* | 100.00% | 95.00% | −5.00% | NS | NS | 90.00% | 90.00% | 0.00% | 85.00% | −5.56% |
| *Auditory word recognition* | 100.00% | 100.00% | 0.00% | NS | NS | 81.67% | 86.67% | 6.12% | 95.00% | 16.33% |
| *Sequential commands* | 90.00% | 100.00% | 11.11% | NS | NS | 43.75% | 45.00% | 2.86% | 61.25% | 40.00% |
| *Object naming* | 88.33% | 100.00% | 13.21% | NS | NS | 3.33% | 3.33% | 0.00% | 10.00% | 200.00% |
| *Fluency* | 30.00% | 50.00% | 66.67% | NS | NS | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | **I3** | | | | | **I4** | | | | |
| ID | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change |
| CADL-2 | 40.00% | 65.00% | 62.50% | 57.00% | 42.50% | 8.00% | 19.00% | 137.50% | 21.00% | 162.50% |
| WAB-R AQ | 32.30% | 46.00% | 42.41% | 47.70% | 47.68% | 27.40% | 30.70% | 12.04% | 32.10% | 17.15% |
| | | | | | WAB AQ Subtests | | | | | |
| *Yes/no questions* | 80.00% | 90.00% | 12.50% | 90.00% | 12.50% | 75.00% | 70.00% | −6.67% | 65.00% | −13.33% |
| *Auditory word recognition* | 45.00% | 70.00% | 55.56% | 70.00% | 55.56% | 11.67% | 41.67% | 257.14% | 43.33% | 271.43% |
| *Sequential commands* | 20.00% | 40.00% | 100.00% | 46.25% | 131.25% | 8.75% | 31.25% | 257.14% | 32.50% | 271.43% |
| *Object naming* | 25.00% | 36.67% | 46.67% | 51.67% | 106.67% | 21.67% | 23.33% | 7.69% | 30.00% | 38.46% |
| *Fluency* | 10.00% | 5.00% | −50.00% | 10.00% | 0.00% | 10.00% | 15.00% | 50.00% | 10.00% | 0.00% |

Note: I1 did not return for the 1-month post follow-up assessment. CADL-2, Communication Activities of Daily Living; WAB-R AQ, Western Aphasia Battery Aphasia Quotient. All raw and standard scores have been converted to per cent correct.

Like I2 and I3, I4 also demonstrated increased gains on object naming subtests at this time point. In the case of all three participants, the gains from pre-treatment to follow-up treatment *exceeded* those observed from pre-treatment to immediately follow-up treatment. Maintenance data for I1 is not available, as he did not perform follow-up testing.

### *Probes of generalisation to connected speech*

Visual inspection reveals a slight upward trend of CIUs for I1 as a proportion of total words from pre-treatment to 1 week post-treatment (see Figure 1, I1); however, ES were minimal or nonexistent on all measures. ES for total CIUs (productivity), the proportion of CIUs to total word count (CIUs:WC) (informativeness), and CIUs per min (CIUs/min) (efficiency) were as follows: 0.72, 1.5, and 2.2.

For I2, visual inspection shows a slight increase in slope for productivity, and ES for this measure was large (8.0) (see Figure 1, I2). It should be noted that productivity was at its peak 1 week post-treatment and, unlike standardised measures, this was not maintained 1 month post-follow-up. Discourse informativeness, or the proportion of CIUs to total words, increased most significantly as repeated single words (this, this, this) were replaced with content words, resulting in a large ES of 26.3. There was no effect (1.5) for the efficiency measure of CIUs/ minute.

Visual inspection for I3 shows a slight increase in slope for productivity but did not yield a significant ES (1.5) (see Figure 1, I3). Informativeness (CIU:WC) increased as repeated single words (here, here, here) were replaced with content words, though baseline variability for this measure was too great to yield a significant ES (3.2). There was no significant ES (1.8) for the efficiency measure of CIUs/ minute as was predicted for this participant.

For I4, visual inspection shows a consistent increase in slope for productivity and ES for this measure was large (9.1) (see Figure 1, I4). Informativeness increased most significantly as repeated single words were replaced with some content words, though baseline variability for this measure was too great to yield a significant ES (.81). There was a small-moderate ES (5.7) for the efficiency measure of CIUs/ minute. Productivity gains began to decay 1-week post-treatment and continued to show decline at 1-month post-treatment.

## ***CILT-D participants***

### *Treatment performance*

D1 demonstrated severe impairment in both expressive and receptive language. D1 participated willingly but relayed low expectation for his progress. Though errorless learning was emphasised in this treatment for all participants, D1 demonstrated consistent impulsivity and did not wait for cues before producing incorrect responses. The clinician instituted a hand signal to alert him when it was his turn to talk, but this was only mildly effective. D1 made little progress in treatment progressing from independent production of two words to eight by the end of the 10 week treatment duration.

D2 put forth maximal effort during all treatment sessions, was responsive to cueing, and made slow but incremental progress throughout treatment. Though he did not meet criteria for Level One completion, he independently named 22 words by the end of treatment compared to five words on day one of treatment.

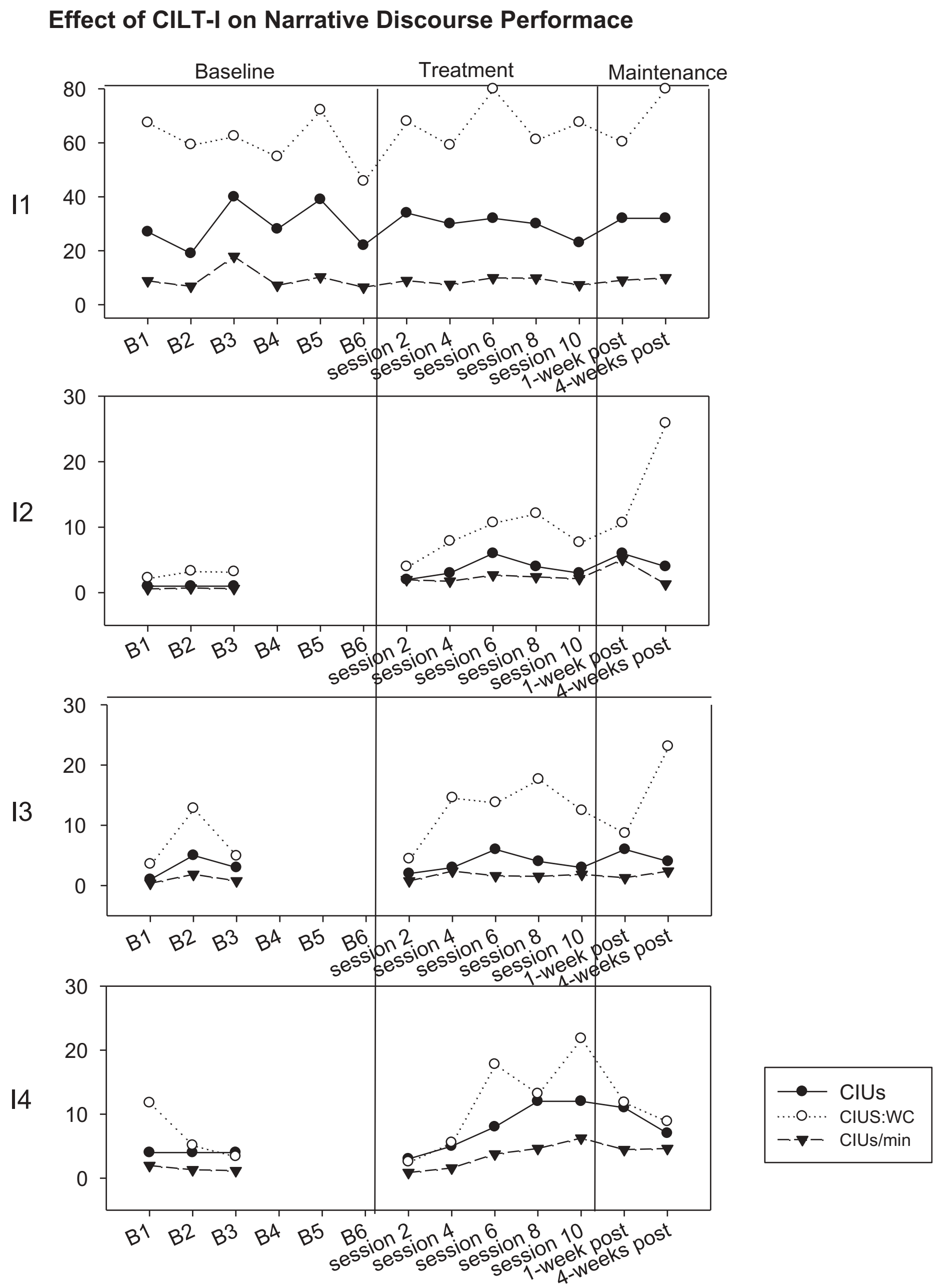


Figure 1. Mean CIUs and CIUs/min are reported at each probe period for each participant who received CILT-I. The proportion, CIU:WC, is shown as the per cent CIUs of total words.

Of the eight participants, D3's expressive language was the least impaired. She began at Level Three (carrier phrase plus low frequency word) and quickly increased to Level Five (carrier phrase plus object requiring two adjectives: "John, pass me the sliced green pear" when there were also cards with two green pears, a single green pear and pears of other colour and number within the same deck.) Though her expressive language exceeded that of the other participant in the group (D4), she found it more difficult to keep track of who was holding the card of interest and therefore rarely "won" a game in the first few weeks. Attention and memory were not tested prior to treatment, but appeared to be an area of deficit for this participant based on her game performance. She progressed throughout the treatment period but won rounds infrequently.

It was not possible to assist D4 in order to achieve errorless production. Neither phonemic or semantic cueing nor repetition was effective in shaping participant's production accuracy. Given enough time, he could often produce the phrase but, like D2, he was not able to benefit from the errorless production aspired to with all participants. Despite this, he made progress within treatment sessions beginning at Level Three (carrier phrase plus low frequency word) and quickly increased to Level Five along with D3 (carrier phrase plus object requiring two adjectives).

### *Standardised tests*

Results of standardised tests for D1, D2, D3, and D4 appear in Table 3. The five WAB-R AQ subtests shown are those for which the greatest change (negative or positive) was observed among those who demonstrated change compared to the other subtests. Pre-treatment, D1 scored 26% on the CADL, demonstrating good use of gesture to convey some answers, though auditory comprehension was again a barrier for success on this test. An initial WAB-R AQ of 28.9 was notable for auditory comprehension subtest scores that declined as complexity increased and generally low scores on oral verbal language production subtests. Following 30 hours of treatment, D1 made a 2.1 point change on the WAB-R AQ, which would not be considered clinically significant; however, 28.5% increases were noted on fluency and on yes/no questions. These gains were offset by declines in auditory word recognition and sequential commands. Other measures tended to be nearly unchanged post-treatment. The decline in sequential commands was recovered at the 1-month follow-up period with additional increases observed in fluency (5%) and object naming (10%). An additional 10% decline was observed in auditory word recognition at this time point.

Pre-treatment, D2 scored 35% on the CADL, demonstrating general confusion with how to answer questions despite several attempts to model the expected response. An initial WAB-R AQ of 50.1 revealed generally intact oral verbal comprehension for simple yes/no questions and at the word level with breakdown at the sentence level. Following 30 hours of treatment, D2 made an 11.5-point gain (23% change) on the WAB-R AQ, which is considered clinically significant. A 100% and 25% increase were noted on fluency and object naming subtests, respectively. Of significance, D2 gained 43 points on the CADL immediately post-treatment with an additional 11-point gain on this measure at 1-month post-treatment, yielding a 154.3% change from pre-treatment. No other participant in the study demonstrated a gain this size on any measure. Gains in object naming decreased 1-month post-treatment but exceeded pre-treatment scores.

Pre-treatment, D3 scored 81% on the CADL, demonstrating general aptitude with using residual language for functional communication. An initial WAB-R AQ of 84.2 revealed mild deficits in both expressive and receptive language. Following 30 hours of treatment, D3 did make changes of greater than 10% on some subtests of the WAB-R but gains and declines were about equivalent resulting in little overall change. A 17% decline on the CADL may be attributed to this participant's high day-to-day variability in overall performance as the change was largely reversed at the 1-month post-treatment follow-up. A six-point decline

Table 3. CILT-D summary of assessment scores at each testing period.

| | D1 | | | | | D2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change |
| CADL-2 | 26.00% | 29.00% | 11.54% | 23.00% | −11.54% | 35.00% | 78.00% | 122.86% | 89.00% | 154.29% |
| WAB-R AQ | 28.90% | 31.00% | 7.27% | 34.70% | 20.07% | 50.10% | 58.70% | 17.17% | 61.60% | 22.95% |
| WAB AQ Subtests | | | | | | | | | | |
| *Yes/no questions* | 70.00% | 90.00% | 28.57% | 75.00% | 7.14% | 95.00% | 95.00% | 0.00% | 90.00% | −5.26% |
| *auditory word recognition* | 60.00% | 58.33% | −2.78% | 48.33% | −19.44% | 95.00% | 95.00% | 0.00% | 93.33% | −1.75% |
| *Sequential commands* | 46.25% | 23.75% | −48.65% | 48.75% | 5.41% | 73.75% | 66.25% | −10.17% | 70.00% | −5.08% |
| *Object naming* | 11.67% | 15.00% | 28.57% | 25.00% | 114.29% | 66.67% | 83.33% | 25.00% | 78.33% | 17.50% |
| *Fluency* | 0.00% | 10.00% | >100% | 15.00% | >100% | 10.00% | 20.00% | 100.00% | 20.00% | 100.00% |

| | D3 | | | | | D4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change | Pre-treatment | Post-treatment | Pre-post- treatment % change | Follow-up 1 month | Pre-post follow-up % change |
| CADL-2 | 81.00% | 67.00% | −17.28% | 78.00% | −3.70% | 77.00% | 65.00% | −15.58% | 62.00% | −19.48% |
| WAB-R AQ | 84.20% | 83.90% | −0.36% | 78.10% | −7.24% | 73.60% | 74.70% | 1.49% | 73.00% | −0.82% |
| WAB AQ Subtests | | | | | | | | | | |
| *Yes/no questions* | 85.00% | 95.00% | 11.76% | 90.00% | 5.88% | 90.00% | 85.00% | −5.56% | 85.00% | −5.56% |
| *auditory word recognition* | 93.33% | 98.33% | 5.36% | 98.33% | 5.36% | 98.33% | 96.67% | −1.69% | 98.33% | 0.00% |
| *Sequential commands* | 83.75% | 81.25% | −2.99% | 60.00% | −28.36% | 53.75% | 65.00% | 20.93% | 62.50% | 16.28% |
| *Object naming* | 100.00% | 88.33% | −11.67% | 85.00% | −15.00% | 76.67% | 85.00% | 10.87% | 75.00% | −2.17% |
| *Fluency* | 60.00% | 80.00% | 33.33% | 45.00% | −25.00% | 20.00% | 15.00% | −25.00% | 15.00% | −25.00% |

Note: CADL-2, Communication Activities of Daily Living; WAB-R AQ, Western Aphasia Battery Aphasia Quotient. All raw and standard scores have been converted to per cent correct.

was also noted on the WAB-R AQ at 1 month post treatment, which is worth highlighting since equal increases are considered clinically significant. Decline in the sequential commands subtest were noted as well as lesser declines in score in fluency and in naming. Overall, D3's performance at 1-month post-treatment was less than that was observed pre-treatment introducing the possibility of this treatment having had a potential negative impact.

Pre-treatment, D4 scored 77% on the CADL, demonstrating general aptitude with using residual language for functional communication. An initial WAB-R AQ of 73.6 revealed deficits understanding complex sentences (sequential commands) and on several expressive language subtests. Following treatment, D3 did not demonstrate a change in overall AQ but did increase by 10% on the sequential commands subtest. Like D3, his performance on the CADL declined post-treatment; but unlike D3, this decrease was not reversed at the 1-month post follow-up. D4's overall performance at 1-month post-treatment was identical to that observed pre-treatment on the WAB-R.

### *Probes of generalisation to connected speech*

Despite lack of progress on treatment materials and standardised measures, some mild improvement was noticed in D1's productivity and efficiency of language as shown in Figure 2, D1. Visual inspection shows a consistent increase in slope for all three measures of discourse. Gains in all three measures began to decay following treatment with continued drop off at 1 month post-treatment, resulting in nonsignificant ESs of .58, .97, and 2.7 for total CIUs, CIUs as a proportion of word count, and CIUs per minute, respectively.

D2 demonstrated improvement in productivity, as shown in Figure 2, D2. Visual inspection shows a consistent increase in slope for this measure that dips only slightly at 1 week and 1 month follow-up, testing yielding an ES of 4.0 (small). Although a small ES was calculated for CIUs/minute (5.9), this is not supported by visual inspection and is likely inflated due to near perfect stability of baseline. Nonsignificant ES (2.4) was seen for the informativeness measure of CIUs as a proportion of total words.

D3 also showed improvement in productivity (see Figure 2, D3; approaching a small ES of 3.5) and also in informativeness with a small ES of 5.09 for CIUs as a proportion of word count. No significant effect was seen for efficiency—CIUs per minute (0.53). Producing more content words per minute means she was using fewer fillers and choosing more appropriate words—a good outcome for D3, despite her performance on standardised tests. Negligible ES was seen for the efficiency measure of CIUs as a proportion of total words.

D4's productivity was very high with a total of approximately 150–250 CIUs per story (see Figure 2, D4) which increased to approximately 400 by the final treatment session. D4 was overly productive, as he discovered a strategy by which extensive circumlocution often, eventually, helped to produce the word he was working towards. Therefore, efficiency was the outcome measure of interest (CIUs/min) for this participant. ES for all measures were not significant (0.87, 0.82, and 2.32 for total CIUs, proportion of CIUs to total word count, and for CIUs per minute, respectively).

## ***Summary of results***

Eight participants attended all 30 hours of treatment, pre-treatment assessment and baseline testing, and post-treatment testing, and seven of them also participated in follow-up testing. Follow-up data were obtained at 1-month post-treatment. Participant I1 was often 20–30 minutes late for sessions and did not return for 1-month follow-up testing. Most

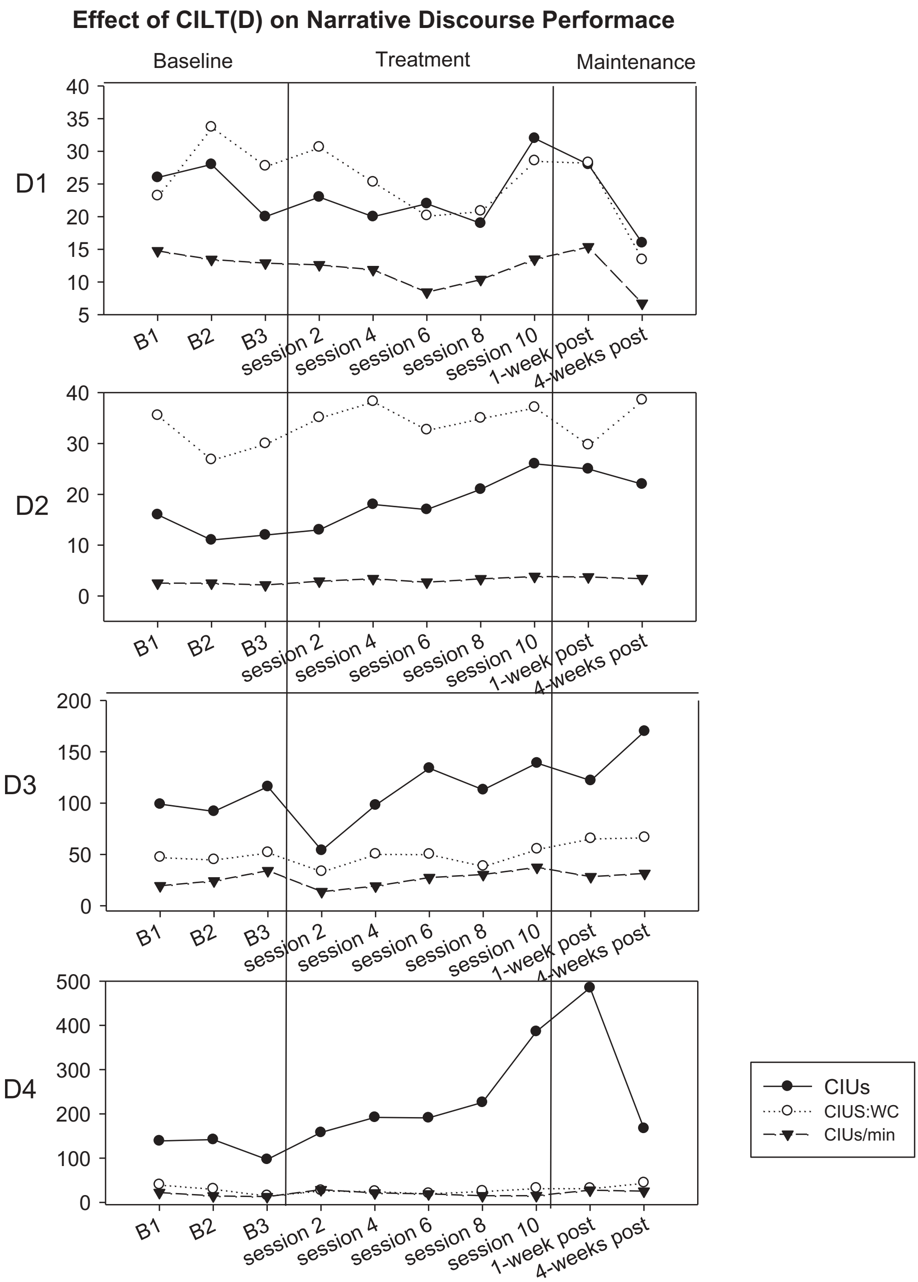


Figure 2. Mean CIUs and CIUs/min are reported at each probe period for each participant who received CILT-D. CIU:WC are reported as the per cent CIUs of total words.

participants made gains on either one of the standardised measures or on the primary outcome variable of interest in this study—that is the generalisation of treatment to either discourse productivity or efficiency, depending on pre-treatment discourse patterns. I2, I3, I4, D1, and D2 each improved on at least two outcome measures (see Table 4).

Table 4. Summary table of performance on standardised batteries and discourse measures.

| | | WAB-R-AQ | | CADL-2 | | CIUs | | CIUs/min | | CIUs:WC (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID | Aphasia severity | SSC | % change | SSC | % change | Pre-post change | ES | Pre-post change | ES | Pre-post change | ES |
| I1 | Mild–mod | 8.4 | 12.4 | 6.0 | 6.7 | 7.3 | 0.7 | 16.2 | 2.2 | 2.4 | 1.5 |
| I2 | Mild–mod | 8.2 | 33.1 | 6.0 | 6.7 | 4.5 | 8.0 | 15.4 | 1.5 | 2.7 | 26.3 |
| I3 | Severe | 15.4 | 47.7 | 25.0 | 62.5 | 4.0 | 1.5 | 8.8 | 1.8 | 1.9 | 3.2 |
| I4 | Severe | 4.7* | 17.2 | 13.0 | 162.5 | 6.0 | 9.1 | 4.8 | 5.7 | 3.4 | 0.8 |
| D1 | Severe | 5.8 | 20.1 | 3.0 | 11.54** | 2.7 | 0.6 | −3.4 | 2.7 | −1.2 | 1.0 |
| D2 | Severe | 11.5 | 23.0 | 54.0 | 154.2 | 10.5 | 4 | 10.7 | 5.9*** | 1.2 | 2.4 |
| D3 | Mild–mod | −2.6 | −7.2 | −3.0 | −3.7 | 25.5 | 3.5 | 16.9 | 0.5 | 2.7 | 5.1 |
| D4 | Mild–mod | 1.1 | 1.5 | −12.0 | −15.6 | 22.0 | 0.9 | 10.3 | 2.3 | 4.9 | 0.8 |

Note: SSC, standard score change from pre- to post-treatment. %change = (standard score post-treatment- standard score pre-treatment)/standard score pre-treatment. When the 1-month follow up score was higher than immediate post, that value was used. Shaded boxes refer to a clinically or statically significant change (at least five points on WAB-R AQ; 10% change on standardised batteries; minimum effect sizes on discourse measures). Effect sizes were calculated by subtracting the mean of the baseline probes from the mean of the two final probe scores and dividing the result by the standard deviation of the baseline scores (see Beeson & Robey, 2006). Boxed scores refer to significant negative change.
*Approaching clinical significance; **Clinically significant change not maintained at follow-up; ***Significant effect size not corroborated by visual inspection

*Treatment performance*

All eight participants were fully engaged throughout all 30 hours of treatment and improved on trained materials to varying degrees. For those with more moderate to severe aphasia deficits (I3, I4, D2), treatment progress was seen within Level One. For the participants with severe AOS (I2 and D1), very little treatment progress was observed. Participants with mild–moderate aphasia and no more than mild AOS (I1, D3, D4) made the best progress through the treatment materials.

*Standardised measures*

All four of the participants who received CILT-I and two who received CILT-D demonstrated a greater than five point gain on the WAB-R AQ, either at post-treatment testing or at follow-up testing. The object naming subtest of the WAB-R was examined for treatment generalisation to untrained words. All but one participant (D3) had increased object naming scores in post-treatment tests. I2, I3, I4, and D1 demonstrated their largest gains on this subtest at the 1-month follow-up. I1 did not return for follow-up testing. WAB-R AQ gains were maintained for five (I2, I3, I4, D1, and D2) of the seven participants who returned for follow-up testing 1-month post-treatment. Two participants (D3 and D4) did not make gains on the WAB-R AQ.

Three participants (I3, I4, and D2) demonstrated an increase of two standard deviations on the CADL-2. Two who did not show demonstrable gains were those whose pre-treatment scores were at or close to ceiling (I1 and I2) and two demonstrated decreases, one of which persisted at the 1-month follow-up (D4). Follow-up data showed that gains were maintained on this measure and, for I4 and D2, continued to increase at the 1-month follow-up.

*Probes of generalisation to connected speech*

Productivity, efficiency, and informativeness of discourse were measured for all eight participants over time, and both visual inspection and calculation of ES were used to gauge responsiveness to treatment. *Increased productivity* indicated more words that were directly relevant to the pictures being described. *Increased informativeness* indicated increased self-monitoring, resulting in fewer repeated words, false starts, irrelevant and filler words. *Increased efficiency* indicated better self-monitoring, faster rate of word retrieval, or both.

I2, I4, D2 each demonstrated an effect of treatment on productivity; I4 and D2 also showed an effect on efficiency. I2 and D3 each demonstrated an effect of treatment in informativeness. Calculated ES for informativeness for participant I3 yielded numbers just below the benchmark for "small" effect due to too much baseline variability, but there was an upward trend upon visual inspection. ES were generally maintained and in all cases, except D1, final data points exceeded pre-treatment scores.

## Discussion

This study was a preliminary investigation of individual responses to CILT delivered at two dosages for eight participants with chronic aphasia. In studies that have compared the results of CI type treatments with those of an equally intensive intervention that did not constrain the participant to the verbal modality of language, equally or nearly equally positive gains have been reported (Barthel et al., 2008; Kurland et al., 2012; Maher et al., 2006; Rose, Attard, et al., 2013). In the current study, therefore, it was predicted that intensity would be a main contributor to gains following CILT.

### *Efficacy of CILT-I and CILT-D*

Outcomes resulting from CILT-I and CILT-D were both similar to outcomes seen in other investigations of CILT. Positive gains were seen in all participants, with more consistent changes seen on standardised tests for those who received the intensive dose. Six participants demonstrated a reduction in aphasia severity as measured by WAB-R AQ, including four who received CILT-I (range of 5.4–15 point gain on WAB-R AQ) and two of the four participants who received CILT-D (increase of 5.8 and 11.5). All participants who made gains on the WAB-R immediately post-treatment maintained them or continued to show improvement post-treatment 1-month post-treatment. Functional communicative performance as measured by the CADL was improved and maintained for the four PWAs who received CILT-I (range of 6.7%-162% change). Improvements were also recorded for two who received CILT-D (11%-154% change), but the improvement was only maintained in one case. Two participants who received CILT-I and two who received CILT-D also showed an effect of treatment on discourse measures.

#### *Generalisation to discourse*

While gains on standardised batteries were predicted in response to an accumulating literature following CILT, it was uncertain whether these gains would be observed with objective measures of discourse productivity for any participant. Findings were, however, consistent with data presented resulting from other intensive treatment studies, including one using objective measures by Rose, Attard, et al. (2013). Two of the four who received CILT-I and two of the four who received CILT-D demonstrated a treatment effect of narrative discourse improvement with fair maintenance for all. A third from CILT-I showed gains but did not reach the minimum ES required to be considered significant. Overall, gains varied across participants and performance did not appear to be influenced by dosage.

#### *Candidacy for CILT*

At this time, much of the CILT research to date has included participants of varying severity and results tend to be most consistent for those with moderate–severe deficits and least for those with mild aphasia and apraxia of speech. Meinzer, Elbert, Djundja, Taub, and Rockstroh (2007) analysed data from their various CILT studies and demonstrated that the results of the 38 of 44 who made improvements on standardised tests were correlated with initial severity of aphasia. This appears to have been the case in the current study given that the two participants (D3 and D4) with the highest initial WAB-R AQs did not improve on standardised tests. However, one of them did show improvement on discourse measures, suggesting it is too soon to determine that people with mild aphasia cannot benefit from CILT but rather that more sensitive outcome measures are used for this population.

It should be noted here that on the CADL, multimodal responses are encouraged in order to answer questions. On this measure, these same two participants demonstrated what would be considered a clinically significant *negative change* on this assessment. This may have been coincidental and in line with these two participants' day-to-day performance variability but the following possibility must also be considered—that constraint to the oral verbal modality could potentially negatively impact the use of alternate modalities (gestures, writing) for functional communication.

In a study by Kurland and colleagues (2011), the treatment effects reported for people with severe AOS following CILT was noted to be weaker and less stable for the individual with the greater apraxia severity of the two. Kurland et al. (2011) noted that when the severity of AOS greatly limits the practice of accurate productions, a traditional articulatory-kinematic treatment might be more effective in a goal of accuracy of production. In the current study, the two participants with the most marked AOS characteristics (I2 and D1) made minimal progress within treatment sessions as well as on most WAB-R subtests of oral verbal production. I2 (the one with greater AOS severity, of the two) did demonstrate a large change in discourse productivity, however, as well as on subtests of auditory comprehension where D1 did not. The large ES was observed due to a very stable baseline and a small number of new spontaneous word productions. Whether this progress translates to functional change is questionable but again highlights the utility of the sensitivity of discourse measures in assessing change.

#### *Rationale for success seen following CILT-D*

Three of the four participants made gains on at least one outcome measure following CILT-D administration, suggesting the possibility that a treatment schedule of 3 hours per week distributed over 30 weeks may be intensive enough to achieve similar effects to a massed practice schedule (30 hours over 2 weeks). Patient heterogeneity and limitations of the study's treatment design make it impossible to know at this time.

For one participant in CILT-D (D2), outcomes equalled or exceeded outcomes of those who received CILT-I. D2's most notable change was on the CADL with gains on this measure above those demonstrated by any other participant. This participant did not have social contact outside of these treatment opportunities. It is conceivable then that the distributed treatment promoted growth in functional communication areas targeted in this measure. In studies that examined the effect of training volunteers to converse with PWAs, it was noted that PWAs increased participation in group settings and were rated as having overall better functional interactions (Kagan, Black, Duchan, Simmons-Mackie, & Square, 2001; Rayner & Marshall, 2003). Therefore, the byproduct of interacting with the clinic secretary, with other PWAs and with the clinician before and after treatment three days per week, may have itself been of clinical utility for this participant.

The benefit of social exposure in distributed treatment programs should not be overlooked when assessing dosage. This would appear to be particularly critical for those immediately post-stroke when visits to their speech pathologist may be their only form of social interaction, depending on premorbid social proclivity as well as the family's ability to support participation in other social endeavours.

### ***Maintenance of gains***

Results reported following CILT are compelling, but particularly so in the cases where positive gains continue past the treatment period (e.g., Johnson et al., 2014; Maher et al., 2006; Rose, Attard, et al., 2013; Szaflarski et al., 2008). Continued gains were also observed after an intensive study of melodic intonation therapy (e.g., Schlaug et al., 2009), indicating that benefits of intensive treatments extend beyond the treatment itself.

Though this phenomenon is not well studied, it seems likely due to the successful instantiation of neural change, enabling a participant to make functional use of language gains and thereby providing the practice necessary to maintain and even increase gains. All three of the participants who participated in follow-up testing following CILT-I and one of the four who received CILT-D increased on the naming subtest of the WAB by scores greater than that seen immediately post-treatment at the one-month post-treatment time. Continued treatment response well past treatment completion should be a target of future investigations.

### *Limitations*

This study provides new evidence that CILT administered in a distributed fashion can result in positive effects. When delivered intensively, as designed, the treatment appeared to have a slight advantage with more participants benefiting on more than one measure and with some evidence of better maintenance of effects, but it is premature to draw conclusions at this time. While a heterogeneous participant group is not unusual with this population, the current study included a particularly diverse membership. This including PWAs with severe AOS (I2, D2), one with global aphasia (I4), one who had very limited social exposure compared to the others (D2), and one who was much younger than the other participants (I1). Each of these factors likely contributed to individual outcomes. Some studies have attempted to deal with inter-participant variability by exposing each individual to two successive treatments types using a crossover single subject design (Kurland et al., 2012; Rose, Attard, et al., 2013); however, this method is also limited in that order of treatment is thought to play a significant role in treatment response. If intensive therapies provide a system boost to those with learned non-use in chronic aphasia as proposed by Kurland, Baldwin, and Tauer (2010); it follows that the greatest gains would be observed after whatever treatment is provided first. Additionally, the continued gains of some participants at 1 month post-treatment as described above might artificially inflate the response to the second treatment. Perhaps extending the period between treatment administrations would allow this very useful crossover design to be more illustrative in terms of treatment comparison in future studies.

### *Conclusions*

The present study shows that CILT administered in both intensive and distributed dosages resulted in positive changes on standardised measures as well as discourse measures. It is not clear, however, whether the highest performers would have been equally successful if they had received the alternate dosage or whether the lower performers would have benefited from the alternate. This study would benefit from replication with a larger and ideally more homogenous sample size using a cross-over design with a long gap between treatment administrations. The clinical implications are far reaching. There is a trend towards providing intensively administered treatments for those with aphasia. The National Aphasia Association lists 13 of them in the United States and Canada (www.aphasia.org). These programs tend not to be covered by insurance and are therefore expensive for some and inaccessible for others. Additionally, 3 hours per day for 10 days may be logistically difficult for patients' families and can be exhausting for participants. It is therefore critical to know whether a distributed version of CILT might be efficacious. However, it is possible that it is exactly this pushing of limitations that is necessary to instantiate lasting change, in which case dealing with logistical and financial burdens may be worthwhile and the pushing of insurance policy changes warranted.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Notes

1. A recent 100 participant randomised study designed to treat the *subacute* population (~1 month post) demonstrated an equally positive response to intensive CILT and intensive traditional group therapy for all participants (Sickert et al., 2014).
2. Dosage parameters (session duration, session frequency, intervention duration, and number of sessions) are those proposed by Warren and colleagues (2007) for investigations of treatment dosage in children with intellectual delays. These parameters were modified by Cherney (2012) for use in the aphasia literature. Reporting these parameters in each study will allow for easier comparison among studies claiming to provide intensive therapy.

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