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Disclosure of Interest

The authors report no conflict of interest.

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Abstract

BACKGROUND: Aphasia is an acquired language disorder that makes it difficult for people to produce and comprehend language, with every person with aphasia (PWA) demonstrating difficulty accessing and selecting words (anomia). While aphasia treatments typically focus on a single aspect of language, such as word retrieval, the ultimate goal of aphasia therapy is to improve communication, which is best seen at the level of discourse.

AIMS: This retrospective study investigated the effects of one effective anomia therapy, Phonomotor Treatment, on discourse production.

METHODS & PROCEDURES: Twenty-six PWA participated in 60 hours of Phonomotor Treatment, which focuses on building a person's ability to recognise, produce, and manipulate phonemes in progressively longer non-word and real-word contexts. Language samples were collected prior to, immediately after, and three months after the treatment program. Percent Correct Information Units (CIUs) and CIUs per minute were calculated.

OUTCOMES & RESULTS: Overall, PWA showed significantly improved CIUs per minute, relative to baseline, immediately after treatment and three months later, as well as significantly improved percent CIUs, relative to baseline, three months following treatment.

CONCLUSIONS: Phonomotor Treatment, which focuses on phonological processing, can lead to widespread improvement throughout the language system, including to the functionally critical level of discourse production.

Aphasia is an impairment of language comprehension and expression that impacts multiple linguistic levels: from lower levels of processing such as access to, or retrieval of, single words to higher, more complex levels such as syntax construction for single sentences to the even higher, more complex level of discourse processing. The hallmark of aphasia is anomia, or deficits in word retrieval. Anomia is believed to reflect damaged connections within and between semantic, lexical, and phonologic components in the language system (Dell, 1986; Nadeau, 2001). These impaired lexical processes are reflected in the incorrect retrieval of words, both in isolation and during discourse production (Fergadiotis & Wright, 2016).

Discourse is our primary means for conveying information in everyday situations. It is a complex process that integrates lexical (i.e., semantic, word form, and phonological), syntactic, and pragmatic information, and executive skills (Murray & Karcher, 2000; Pashek & Tompkins, 2002; Wilshire & McCarthy, 2002). Connectionist accounts of word retrieval at the discourse level highlight how lexical characteristics of target words interact with activated representations within and across different linguistic levels (e.g., phonological, semantic, syntactic; Bock, 1995; Dell, 1986; Dell, Chang, & Griffin, 1999; Dell, Martin, & Schwartz, 2007; Levelt, 1999; Levelt, Roelofs, & Meyer, 1999). In addition, several models emphasise the influence and relative strength of naturally occurring probabilistic constraints in language use (e.g., frequency effects, argument structure) on the activation of linguistic representations (e.g., MacDonald, 1994; Tabor, Juliano, & Tanenhaus, 1997). Moreover, discourse production entails the formulation and expression of a communicative intent within a specific context by translating conceptual knowledge into discourse structures that are appropriate for that particular communicative situation (Frederiksen, 1986). Along the same lines, Halliday and Hasan (1989) argued that the selection of lexical items is heavily influenced by contextual effects such as (i) the setting and the topic of discourse; (ii) the interlocutors, their relationship and objectives; and, (iii) the type of discourse being produced.

Improving discourse production has been identified as a primary goal for PWA and their families (Cruice, Worrall, Hickson, & Murison, 2003; Mayer & Murray, 2003), and has become increasingly recognised as an important target of aphasia treatment (Boyle, 2011). Recent data (2015) have shown that discourse gains observed in PWA who have received treatment equate to functional changes in daily communication for the participants and their families, as measured by the Stroke and Aphasia Quality of Life Scale (SAQOL; Hilari & Byng, 2001) and the Functional Outcomes Questionnaire (FOQ; Glueckauf et al., 2003), underlining the importance of addressing discourse in aphasia treatment. The many components of discourse outlined above may be variably impaired in aphasia, and a number of treatments have been devised to address the higher-level linguistic and cognitive aspects of discourse (Chapman & Ulatowska, 1992; Milman, Vega-Mendoza, & Clendenen, 2014; Peach & Reuter, 2010; Wambaugh, Nessler, & Wright, 2013). Lower level linguistic skills also play a central role in effective discourse production. When lexical retrieval is impaired, the speaker cannot retrieve the words needed to construct their message efficiently and effectively. As a result, even if other discourse elements (e.g., pragmatics, syntax, etc.) are intact, word retrieval impairments may result in pauses, jargon, substitutions, and the use of non-specific language, and can lead to retracings, revisions, reformulations, and circumlocutions. These behaviors can result in an unsuccessful communicative exchange. Said differently, accurate and efficient lexical retrieval is a fundamental and necessary component of discourse level communication. It may, therefore, be appropriate to treat at these lower linguistic levels, such as lexical retrieval, with an eye toward improving discourse.

Treatments for lexical retrieval impairments are frequently implemented in aphasia, likely for two reasons: because anomia is ubiquitous among PWA and because lexical retrieval objectives and goals are generally more easily defined and measured in a clinical setting than more complex discourse objectives (e.g., it is simpler and more feasible to conceptualize and implement measurement of the percent of correctly named items as compared with the transcription, coding, and calculation needs of most discourse measures that include aspects of word retrieval, syntax, and micro- and macro-structure organization). A number of anomia treatment programs that address single word retrieval have shown generalisation to discourse production, the ultimate goal of any aphasia treatment, including Semantic Feature Analysis (DeLong, Nessler, Wright, & Wambaugh, 2015; Wallace & Kimelman, 2013; Wambaugh & Ferguson, 2007), Verb Network Strengthening Treatment (Edmonds, Nadeau, & Kiran, 2009), use of intentional gestures (Altmann et al., 2014), implicit treatment (Silkes, 2015; Silkes, Dierkes, & Kendall, 2013), and phonologic-semantic naming treatments (Conroy, Sage, & Lambon Ralph, 2009; del Toro et al., 2008). Despite these positive findings, though, not all studies examining generalisation of word-finding treatments to the level of discourse have found it (Boyle & Coelho, 1995; Nickels, 2002). Additionally, even in reports in which generalisation to discourse production has been demonstrated, studies reporting individual data have found effects to be inconsistent between participants (Conroy et al., 2009; del Toro et al., 2008; DeLong et al., 2015; Edmonds et al., 2009; Silkes, 2016, 2018; Wallace & Kimelman, 2013).

One lexical retrieval treatment that has been developed specifically to facilitate generalisation across linguistic levels, and has the potential to generalise to discourse, is Phonomotor Treatment (PMT; Kendall et al., 2015; Kendall et al., 2008). Phonomotor Treatment is an intensive treatment program designed to improve phonologic processes of PWA by training speech sounds in isolation before progressing to sound combinations and single words (Kendall et al., 2015). It involves a multi-modal approach, using a variety of tasks that involve orthographic, auditory, articulatory-motor, tactile-kinesthetic, visual, and conceptual information. In the first stage of Phonomotor Treatment, isolated sound training, sounds are trained multi-modally through both perception and production tasks including using (1) visual feedback and verbal descriptions of motor movements; (2) auditory perceptual discrimination tasks; (3) oral phoneme productions; and (4) grapheme-to-phoneme matching. Once sounds are mastered in isolation, the same procedures are used in the second stage to train sound combinations, progressing to 1-, 2-, and 3-syllable phoneme sequences in both non-word combinations and real words.

Data have shown that Phonomotor Treatment leads to improved lexical retrieval for naming both trained and untrained pictures immediately post-treatment and three months after treatment ends, as well as continued improvement one year post-treatment for many PWA (Kendall et al., 2015; Kendall et al., 2008). Phonomotor Treatment has also been shown to lead to improved reading (Brookshire, Conway, Pompon, Oelke, & Kendall, 2014) and to changes in the way that PWA process linguistic information, as reflected by changes in types of naming errors over the course of treatment (Kendall, Hunting Pompon, Brookshire, Minkina, & Bislick, 2013; Minkina et al., 2016). These findings of generalisation to untrained items and tasks are consistent with the distributed model of language that motivated PMT's design. Phonomotor Treatment is grounded in a neurally-plausible theoretical model that proposes that every level of language processing is fundamentally integrated with and linked to every other level (Nadeau, 2001); therefore, improving representations and processes at a basic level, such as phonology, should support functioning at all higher levels. In addition, generalisation beyond trained items and trained levels of processing are predicted. Given the model-driven prediction for generalisation and the evidence of generalisation for single-word naming tasks, the next important step in understanding the effects of Phonomotor Treatment is to determine whether generalisation occurs in aspects of language function even farther removed from phonologic processing than single word retrieval, such as discourse.

There seems to be a general consensus in recent empirical investigations that, while performance on typical confrontation naming tests for the assessment of word level production is related to discourse-level performance, analyzing discourse directly provides unique and useful clinical insights not gained via such tests (Fergadiotis & Wright, 2016; Hickin, Best, Herbert, Howard, & Osborne, 2001; Mayer & Murray, 2003; Pashek & Tompkins, 2002). The purpose of the retrospective analysis presented here, therefore, is to directly explore the effects of Phonomotor Treatment on discourse production. Specifically, we analyzed language samples collected from PWA whose response to treatment, as measured by changes in picture naming and performance on several standardised language tests, has been previously reported (Kendall et al., 2015). This prior study showed generalisation beyond treated items in the form of improved confrontation naming of untrained nouns three months post-treatment, relative to baseline, and on measures of phonological processing. The research question for the present analysis was whether Phonomotor Treatment led to changes in the informativeness (i.e., how much information is conveyed) and efficiency of discourse production immediately and three months post-treatment.

Method

Study Design

The analysis presented here was based on data collected from the 26 participants reported in Kendall et al. (2015). Because the participants, protocol, and stimuli have been detailed in this previous publication, they are only briefly summarised here.

Participants

Participants were recruited from the VA Puget Sound Health Care System and the University of Washington Aphasia Registry and Repository. Twenty-eight individuals with chronic aphasia due to damage to the left hemisphere due to a single stroke were recruited. CT and MRI scans and/or reports were used to document the presence of the stroke, with 26 individuals completing the entirety of treatment and returning for maintenance testing three months after completion of treatment (see Table 1 for a summary of participant characteristics). The severity of aphasia were determined based on criteria presented by McNeil and Pratt (2001) and the Western Aphasia Battery Aphasia Quotient (WAB AQ; Kertesz, 1982). Anomia was quantified using the Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983). The presence of phonologic impairment was verified by performance on the Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010). Scores on these measures were not the only criteria to determine eligibility for this study. Instead, study personnel used clinical judgment to determine the presence of aphasia with anomia and phonological processing impairment by a) examining scores on the standardized measures mentioned above as well as b) assessing performance on nonstandard naming probes and conversational discourse, particularly for participants with milder impairment. Trained speech-language pathologists (SLPs) administered all standardised assessments to participants. Participants were excluded if they exhibited severe apraxia of speech (AOS), as determined by three SLPs using speech samples from the evaluation. Apraxia of speech was defined by a slowed speaking rate (prolonged sounds and/or intersegment durations), distortions and/or distorted substitutions, and prosodic abnormalities during discourse production, repetition of words and nonwords, and naming tasks. Additional exclusion criteria included major depressive or psychiatric illnesses, degenerative neurological diseases, severe chronic illnesses, and severe and/or uncorrected vision or hearing impairments.

[INSERT TABLE 1 ABOUT HERE]

Treatment

Participants were randomly assigned to one of two treatment delivery groups: immediate treatment or delayed treatment (to control for history, maturation, and repeated testing effects). The immediate treatment group began to receive Phonomotor Treatment in the week following completion of initial testing. The delayed treatment group underwent initial testing and then waited for six weeks before receiving Phonomotor Treatment, during which time they were permitted to participate in conversational group treatments, and other support activities, but no individual speech-language therapy. Testing with the primary outcome measure (confrontation naming of nouns not trained during the treatment program) was then repeated and Phonomotor Treatment was initiated.

All participants received 60 hours of Phonomotor Treatment, provided two hours per day, five days per week for six weeks. The research SLPs that implemented Phonomotor Treatment were trained on the treatment protocol by the last author. To ensure treatment administration fidelity, each SLP administering treatment was randomly observed by another trained SLP during approximately 10% of their treatment time to assure that treatment was appropriately incorporating multi-modality phonological processing tasks, with Socratic questioning as the primary method of facilitation. Because of the intensive training that the SLPs providing therapy had received (as described by Kendall et al., 2015) fidelity issues were rarely identified. Further, study staff met weekly throughout the course of treatment to discuss issues related to treatment delivery and participant performance.

Treatment stimuli

Phonomotor stimuli have been previously published (Kendall et al., 2015) and were the same for all participants, consistent with the basic principles of PMT that emphasise training all sounds in the language at all levels. Briefly, stimuli comprised single sounds in isolation as well as 1-, 2-, and 3-syllable phoneme sequences in non-word and real word combinations. To enhance word learning (Storkel, Armbruster, & Hogan, 2006), real words and trained non-word phoneme sequences comprised low phonotactic probability and high neighborhood density, as determined through online databases and calculators (Vaden, Halpin, & Hickok, 2009; Vitevitch & Luce, 1999). A total of 83 real words (42 trained and 41 untrained) and 145 nonwords (72 trained and 73 untrained) were selected and incorporated into this protocol, with trained items incorporated across the wide variety of PMT tasks. For real word stimuli, the MRC Psycholinguistic Database (Coltheart, 1981; available at http://websites.psychology.uwa.edu.au/school/MRCDatabase/uwa_mrc.htm) was also used to determine written frequency, imageability, age of acquisition, syllable number, syllable complexity, and semantic category for each real word. Color photographs were also used during treatment to represent the real word stimuli.

Outcome Measure Description

Discourse language samples were collected and audio recorded for all participants pre-treatment, immediately post-treatment, and at maintenance through a structured, face-to-face interview between the participant and the research SLP who had conducted treatment with that participant. Interview prompts included "What illnesses or medical problems do you have?", "How has your stroke affected your life?", and "Describe a typical day." If a participant provided only a cursory response, general prompts were provided to encourage further elaboration. After language samples were collected, two graduate students used Computerized Language Analysis (CLAN; MacWhinney, 2000) to transcribe the samples.

Outcome Measure Analysis

All standardised assessments and outcome measures were repeated immediately after treatment (immediately post-treatment) and three months after treatment (maintenance). Kendall et al. (2015) reported no significant differences in the accuracy of the primary outcome measure for the pre-treatment performance in the immediate treatment group as compared with post-delay-phase performance in the delayed treatment group. Therefore, similarly to Kendall et al. (2015), both groups' data for all outcome measures for this study were combined and analyzed following a single group design with repeated sampling. Only discourse data are discussed here; the remainder of the outcome data have been previously reported elsewhere (Kendall et al., 2015).

On average, the length of the language samples was approximately 387, 244, and 255 words at pre-, post-, and three months post-treatment, respectively. None of the pairwise differences in mean length of the samples were statistically significant when assessed via paired sample t-tests and adjusting for multiple comparisons using the Bonferroni correction. Language samples were analyzed using two established measures of discourse: percent Correct Information Units (CIUs), and CIUs per minute (Nicholas & Brookshire, 1993). CIUs are defined as words used in connected speech that are "intelligible in context, accurate in relation to the picture(s) or topic, and relevant to and informative about the content of picture(s) or the topic" (Nicholas &

Brookshire, 1993, p. 350). Percent CIUs, calculated as the number of CIUs in the language sample divided by the total number of words within the sample, reflects the overall informativeness of a message (Cameron, Wambaugh, & Mauszycki, 2010; Carlomagno, Giannotti, Vorano, & Marini, 2011; Doyle, Tsironas, Goda, & Kalinyak, 1996). CIUs per minute reflects the efficiency of communication (Cameron et al., 2010; Matsuoka, Kotani, & Yamasato, 2012).

CIUs were calculated for all discourse samples across all three time points according to the standard CIU protocol developed by Nicholas and Brookshire (1993). Scoring was completed by two trained graduate students and one trained undergraduate student, all of whom were blinded to the time period at which each discourse sample was taken. Students who participated in CIU analysis underwent an initial two-hour training in CIU analysis based on the established CIU scoring guidelines outlined by Nicholas and Brookshire (1993). The training consisted of a PowerPoint presentation outlining rules for CIU identification followed by a guided scoring practice. As part of the guided scoring, raters scored two to six sample transcripts (retrieved from AphasiaBank for the purposes of training; MacWhinney, Fromm, Forbes, & Holland, 2011) and then discussed their errors with the second author, who provided feedback. Students were trained to criterion (demonstrated 90% agreement in practice samples) prior to analyzing the samples for this study. Two scores were found per transcript related to CIU production in structured discourse: CIUs per number of words (% CIUs) and CIUs per minute. Rules for scoring language samples were based on the well-defined criteria presented in Nicholas & Brookshire (1993). Scorers were instructed to follow these procedures and criteria as closely as possible and discussed issues as they arose to ensure consistency throughout the scoring of samples.

Reliability

Ten percent of the language samples were re-scored by the CIU scorers; specifically, two samples were randomly selected per time point. The inter-rater reliability for re-scoring these transcripts, as quantified by point-to-point agreement, was above 90%. In addition, Cohen's kappa estimates ranged from .71 [95%CI: .59, .83] and .76 [95%CI: .61, .92], which suggest substantial agreement (Fleiss, 1981).

Preliminary data analysis

Data were screened for missing values and two cases were identified with missing recordings at post-treatment and three months post-treatment. No univariate or multivariate outliers were identified using z scores and Mahalanobis's distance, respectively. Further, Mauchly's test suggested that the assumption of sphericity held for our dataset both with respect to % CIUs, Mauchly's W = .89, $\chi 2(2) = 2.55$, p = .28, as well as for CIUs per minute, Mauchly's W = .80, $\chi 2(2) = 4.97$, p = .08. Finally, visual inspection of the distribution of the dependent variables at each time point did not suggest any marked violations of the assumption of normality.

Results

CIUs per Number of Words

A repeated measures ANOVA was conducted to explore the effects of the treatment on the percent of CIUs produced by participants pre-treatment, immediately post-treatment, and at maintenance (see Figure 1, and see Table 2 for descriptive statistics for both study variables). There was a statistically significant effect of time as computed using a multivariate approach, Wilks' lambda = .693, $F(2, 22) = 4.876$, $p = .018$, partial eta squared = .307. The significant finding was followed up by pairwise comparisons using the Bonferroni correction to adjust for multiple comparisons. Two cases for whom maintenance data were missing due to recording error were excluded analysis-by-analysis to retain as many data points as possible.

There was a statistically significant difference between the percent of CIUs produced pre-treatment and at maintenance, $t(23) = 3.167$, $p = .012$. The average percent CIUs pre-treatment was 70.68% and at maintenance it was 75.33%. The difference between the percent CIUs pre-treatment and immediately post-treatment was not statistically significant, $t(23) = 1.952$, $p = .18$, despite the average percent CIUs immediately post-treatment (75.24%) being very similar to the mean percent CIUs at maintenance. Further, the difference between immediately post-treatment and maintenance was not statistically significant, t(23) = .25, $p = .806$.

[INSERT FIGURE 1 AND TABLE 2 ABOUT HERE]

CIUs per Minute

A second repeated measures ANOVA was conducted to explore the effects of the treatment on the number of CIUs produced by the participant as a function of time (i.e., CIUs per minute; see Figure 2). Based on the multivariate approach, there was a statistically significant effect of time, Wilks' lambda = .559, F(2, 22) = 8.681, $p = .002$, partial eta squared = .441. The significant finding was followed up by pairwise comparisons using the Bonferroni correction to adjust for multiple comparisons. Again, two cases for whom maintenance data were missing due to recording error were excluded analysis-by-analysis to retain as many data points as possible. Both the immediately post-treatment (63.23) and maintenance (62.33) average CIUs per minute were significantly higher than the average CIU's per minute before treatment (56.68), $t(25) = 2.943$, $p = .021$ and $t(23) = 3.515$, $p = .006$, respectively. The difference between immediately post-treatment and maintenance was not statistically significant, $t(23) = .04$, $p = .969$.

[INSERT FIGURE 2 ABOUT HERE]

Discussion

This study explored whether Phonomotor Treatment, a multimodal phonological treatment that has been shown to improve word retrieval abilities in people with aphasia (Kendall et al., 2015), generalised to discourse production in the same study sample. More specifically, we asked if treatment led to changes in the informativeness (percent CIUs) and efficiency (CIUs per minute) of discourse production immediately post-treatment and at maintenance. Immediately post-treatment, efficiency was significantly improved relative to pre-treatment, but informativeness was not. At maintenance, both informativeness and efficiency were significantly improved. These findings suggest that improving single word retrieval through Phonomotor Treatment can lead to improved discourse production.

The finding that informativeness and efficiency improved at different rates is consistent with the underlying mechanisms of change postulated for PMT. The tasks involved in Phonomotor Treatment are designed to strengthen multimodal phonologic representations and improve the ability to manipulate them. In the context of network models of phonology and language (Dell, 1986; Nadeau, 2001), this treatment should lead to greater activation of representations, with more linguistic information available and able to reach threshold levels for selection (Kendall et al., 2015). Immediately post-treatment, this greater activation and availability of linguistic elements may lead to fewer pauses, fillers, and non-word responses. These changes would all increase the number of CIUs per minute, presumably reflecting improved efficiency of communication, while not altering percent CIUs, reflecting no change in informativeness of the words produced. As the system continues to change and consolidate learning through continued daily use of language over time (Kendall et al., 2008), the improved network connections within the language system could lead to more accurate word retrieval. This would lead to fewer word substitutions and less need for repetitions, increasing the percentage of language that is appropriate, and reflected in a higher percentage of CIUs at maintenance testing. It is also possible that the language processing system improves enough during treatment to support improved single word retrieval, the primary outcome measure in the Kendall (2015) study, but that the improved processes that support these gains in word retrieval require additional time to develop further before they manifest in the more complex context of discourse.

This study has a few limitations. We only probed discourse through a single language elicitation task that used open-ended questions. Findings may have been different if a variety of communicative contexts and tasks had been used. Further, given the longitudinal nature of the design, the repeated sampling of discourse using the same stimuli may have contributed to the treatment effects observed in this study. However, the considerable time (three months) between the post-treatment sampling and the sampling at the maintenance phase should have moderated any repeated sampling effects. Nonetheless, to minimise such threats to internal validity, future studies should elicit discourse using different materials at each time point, making sure that they have been equated for difficulty. Similarly, other measures of discourse production that reflect changes in sample length or lexical diversity may have provided different insights. Another potential concern may be that several of the participants in this study had relatively high level language skills, so there was a risk of ceiling effects limiting the amount of improvement that may be seen. However, given that the average % CIUs at three months post-treatment was approximately 75%, and that the distribution of scores around that mean was normally distributed, it does not seem that ceiling effects played a major role in the results. In a related issue, participant characteristics such as age, time post-onset, aphasia severity, as measured by the WAB, and naming ability, as measured by the BNT, may have provided an interesting lens to view and evaluate generalization to discourse production, but these characteristics were not analyzed in the present study. These factors, however, and their contributions to Phonomotor Treatment outcomes for this participant sample, have been examined and were reported by Hunting Pompon and colleagues (2017). Finally, the discourse samples were elicited by the treating clinicians, due to resource limitations. While outcomes may have been different had they been elicited by an unfamiliar communication partner, we believe this concern is mitigated by having the analysis completed by unfamiliar listeners who were blinded to the time period of each discourse sample.

Conclusion

This study has demonstrated that Phonomotor Treatment generalises to discourse production, similarly to how it has been shown to generalise to lexical retrieval for untrained words (Kendall et al., 2015; Kendall et al., 2008) and to reading (Brookshire et al., 2014). This finding is important for a number of reasons. First, generalisation to discourse has long been the "holy grail" of aphasia treatment. Given this, and given the priority that PWA and their families place on discourse, determining that a treatment can make a positive impact on discourse is significant. Second, aphasia treatment has often involved treating a single language skill or domain in isolation, with hopes for generalization to more contextualized, functional communication (Threats, 2007). In contrast with that approach, these results suggest that model-driven treatments can predict, plan for, and facilitate generalisation. The study presented here has demonstrated that this is true for Phonomotor Treatment, but it is possible for other treatment approaches, as well. Importantly, further understanding of which treatments lead to generalisation for which clients will allow clinicians to be more efficient in their treatments, choosing therapy approaches to maximise gains in the minimum amount of time.

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Table 1. Demographic and clinical characteristics of the patient sample (adapted from Kendall et al, 2015)

Participant	Age (years)	Sex	Education level (years)	Duration post-onset (months)	WAB-AQ (out of 100)	BNT (out of 60)	SAPA (number correct out of 151)
1	49	M	16	21	87.5	37	96
2	26	M	16	45	94.2	57	128
3	48	M	13	16	94.6	52	131
4	27	M	13	17	51.1	44	74
5	67	F	14	162	84.5	36	94
6	53	M	19	81	63.9	13	64
7	63	M	16	15	37.6	1	53
8	64	M	20	52	76.3	9	80
9	57	F	14	38	52.6	5	61
10	47	F	16	11	84.6	50	123
11	62	M	15	29	96.1	57	115
12	74	F	18	8	91.3	51	105
13	30	F	14	14	50.8	5	50
14	60	F	18	65	59.5	15	81
15	57	M	16	24	82.0	31	102
16	72	M	18	211	69.8	34	76
17	67	M	16	104	81.1	56	103
18	68	M	23	14	92.0	57	109
19	33	F	15	31	78.2	31	65
20	70	M	16	10	94.7	43	114
21	45	F	12	14	85.2	22	124
22	78	M	13	41	90.2	46	105
23	61	F	16	15	95.0	50	110
24	67	M	15	20	86.6	18	124
25	61	F	18	155	92.0	32	109
26	51	F	13	22	74.3	41	96
AVERAGE	**56**	**N/A**	**16**	**48**	**78.7**	**34.3**	**95.8**
SD	**15**	**N/A**	**3**	**53**	**16.5**	**18.1**	**24.1**

Note. WAB-AQ – Western Aphasia Battery Aphasia Quotient; BNT = Boston Naming Test; SAPA = Standardized Assessment of Phonology in Aphasia

Table 2 – Descriptive statistics for percent of Correct Information Units (CIUs) and CIUs per minute

	M	*Range*	*SD*
% CIUs			
Pre-Tx	70.68%	42.36% - 91.27%%	12.35%
Post-Tx	75.24%	55.39% - 91.36%	9.70%
3 Months Post-Tx	75.33%	57.00% - 90.41%	7.75%
CIUs per Minute			
Pre-Tx	56.68	18.38% - 111.38%	22.44
Post-Tx	63.24	22.31% - 130.53%	27.21
3 Months Post-Tx	62.34	20.75% - 103.55%	21.45

Note. All statistics were estimated based on N = 26 except for data at 3 Months Post-Tx, which were based on 24 data points.

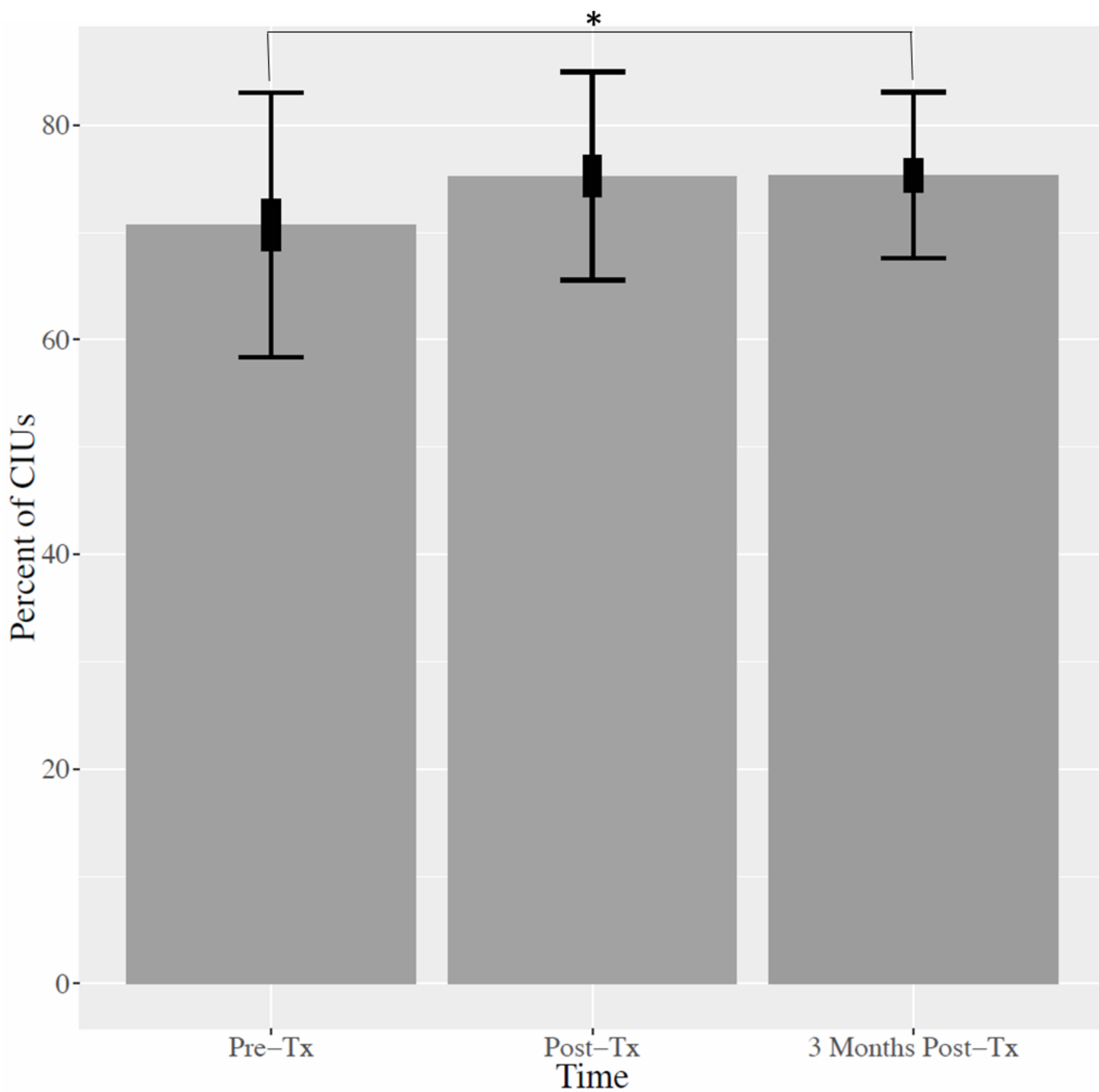

Figure 1. Differences on percentage of Correct Information Units pre-, post-, and 3 months post-treatment. *SD* (thin bars) and *SEM* (thick bars) are depicted. * indicates a significant difference between conditions.

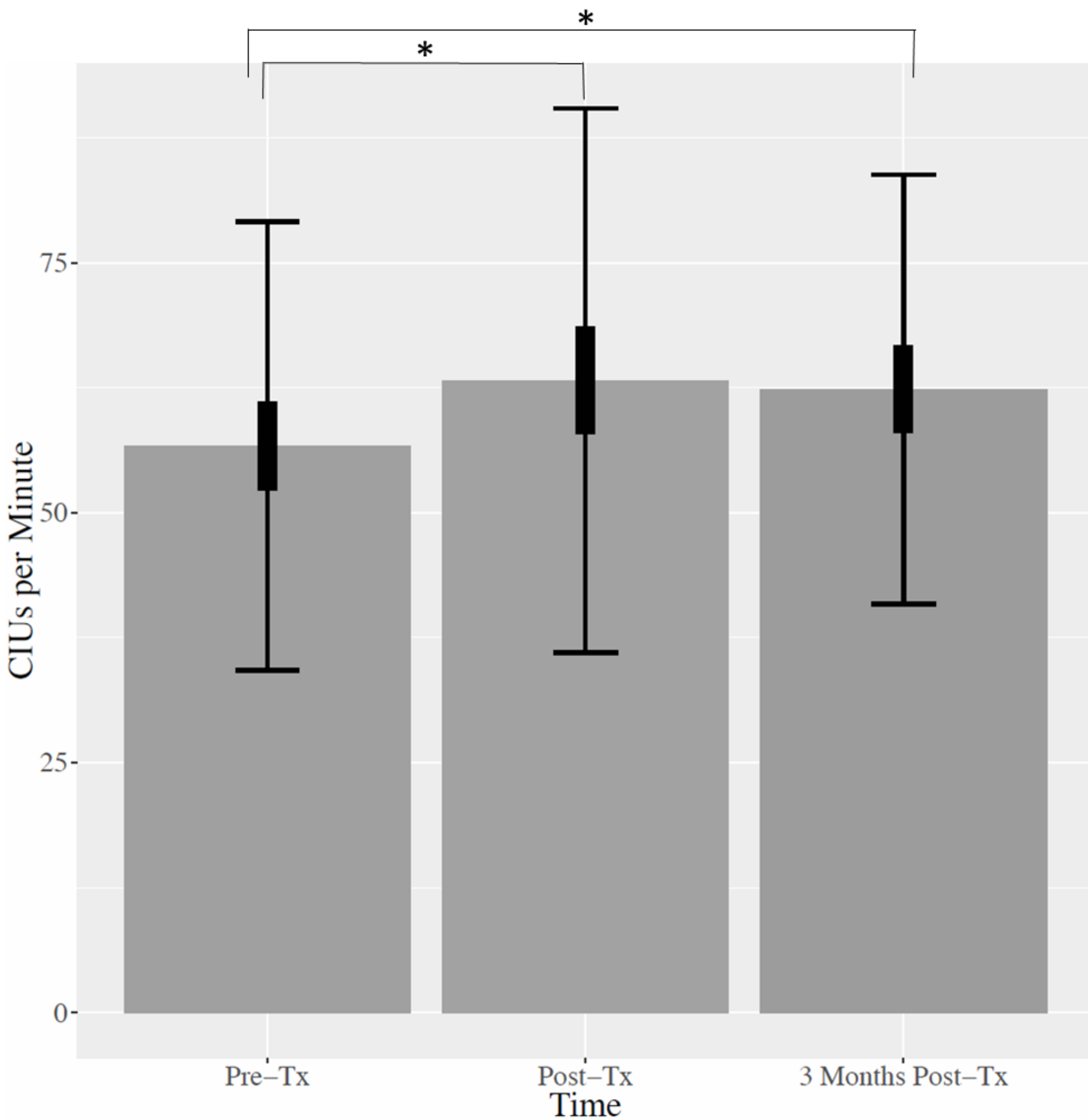

Figure 2. Differences on Correct Information Units as a function of time pre-, post-, and 3 months post- treatment. *SD* (thin bars) and *SEM* (thick bars) are depicted. * indicates a significant difference between conditions.